State of Louisiana
Coastal Protection and Restoration Authority

2016 Operations, Maintenance, and Monitoring Report

for

Mississippi River Sediment Delivery System−Bayou Dupont (BA-0039)

State Project Number BA-0039
Priority Project List 12

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Jefferson and Plaquemines Parishes

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Operations, Maintenance, and Monitoring Report

Mississippi River Sediment Delivery System−Bayou Dupont (BA-0039)

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Preface

Mississippi River Sediment Delivery System−Bayou Dupont (BA-0039) is funded through the Coastal Wetlands Planning, Protection, and Restoration Act (CWPPRA), with the United States Environmental Protection Agency (USEPA) as the federal sponsor and the Coastal Protection and Restoration Authority of Louisiana (CPRA) as the state sponsor. This project was included on the 12th CWPPRA priority project list (PPL 12). The 2016 Operations, Maintenance, and Monitoring (OM&M) Report for BA-0039 includes monitoring data collected from January 2010 −March 2016 and observations from the most recent operations and maintenance inspection that was conducted on May 24, 2016. This report is the second in a series of BA-0039 OM&M reports, with the first report written in 2013 and the final report tentatively scheduled for 2021. Operations, Maintenance and Monitoring reports, the monitoring plan, project completion report, and other documents and data pertaining to BA-0039 can be accessed through CPRA's Coastal Information Management System (CIMS) website at *http://cims.coastal.louisiana.gov.*

I. Introduction

The BA-0039 project used sediment hydraulically dredged and delivered via pipeline from the Mississippi River to build a marsh platform in an area that lies within a rapidly eroding and subsiding section of the Barataria Landbridge. The degraded condition and loss of marsh in this region is due to a combination of factors that include subsidence, lack of riverine sediment input (Baumann et al. 1984), the alteration of hydrology resulting from the dredging of oil and gas canals (Sasser et al. 1986), and sea-level rise (Penland and Ramsey 1990). The project area is located on the west bank of the Mississippi River in Jefferson and Plaquemines parishes, approximately 3.7 miles northwest of the town of Myrtle Grove, Louisiana (Figure 1). It is bordered on the east by the Plaquemines Parish flood protection levee, to the north by Cheniere Traverse Bayou, and to the west and south by pipeline canals. The BA-0039 project area is nested within the project boundary for another CWPPRA project—Naomi Outfall Management (BA-0003c), which was designed to manage the outflow of Mississippi River water from the Naomi siphons (Figure 1).

Mississippi River Sediment Delivery System−Bayou Dupont (BA-0039) was the first CWPPRA project that used sediment dredged from the Mississippi River to create marsh. Since the construction of BA-0039, three additional marsh creation projects that use river sediment have been completed or are in construction within four miles of the project area (Figure 1). The Bayou Dupont Marsh and Ridge Creation project (BA-0048) was constructed in 2015 along the southern shoreline of Bayou Dupont. This CWPPRA project, funded through the National Oceanographic and Atmospheric Administration, created 317 acres of marsh and 10 acres of ridge habitat. The Bayou Dupont Sediment Delivery Marsh Creation #3 (BA-0164), also funded through CWPPRA, is under construction immediately south of BA-0039 and will be completed in 2017. This USEPA-sponsored project is using river sediment to create 146 acres of marsh and is using sediment dredged from within the project area to create 10.5 acres of terraces. Construction of approximately 500 acres of marsh was completed in 2016 as part of Long-Distance Sediment Pipeline (BA-0043-EB) project that is funded using Coastal Impact Assistance Program (CIAP) and state surplus funds. The pipeline was used to construct BA-0048 and the marsh component for BA-0164. Information regarding these projects can be accessed through CPRA's CIMS website.

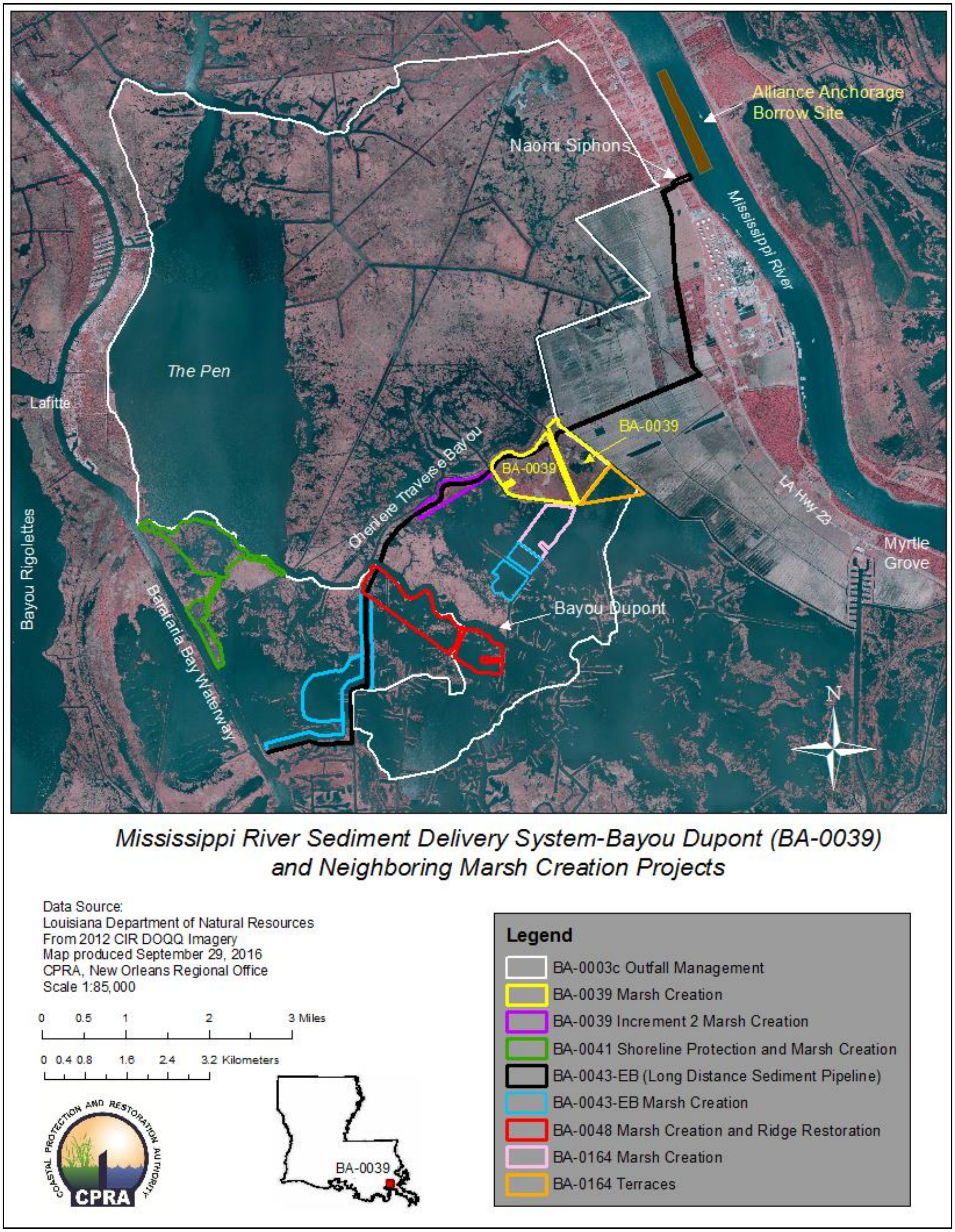


Figure 1. Location of the Mississippi River Sediment Delivery System−Bayou Dupont (BA-0039) project area and neighboring restoration projects.

Construction of BA-0039 began in April 2009, with pumping of dredged sediment into the project area starting on November 11, 2009. The final day of sediment delivery was March 15, 2010, and project construction was officially completed on May 10, 2010. Sediment was pumped to approximately +2.0 ± 0.3 feet NAVD88 (Geoid99) into both of the marsh creation cells (ABMB Engineers, Inc. 2011). This elevation is higher than the target elevation for the marsh due to the predicted rapid settlement of the dredged material that occurs during the first few years post-construction. A targeted marsh elevation of +1.3 feet NAVD88 (Geoid99) by year 10 was chosen based on observations of local, natural *Spartina patens* (saltmeadow cordgrass) marsh. This elevation should provide flooding conditions that are best-suited for sustaining healthy marsh vegetation in the project area (Thompson 2007).

<u>BA-0039 Project Features</u>

The as-built principal project features include the following, as reported in the project completion report (ABMB Engineers, Inc. 2011):

- Approximately 484 acres of marsh fill (Marsh Creation Area 1 and Marsh Creation Area 2)
- Approximately 25,935 linear feet of containment dikes
- One 95 linear foot, 48 inch diameter casing that was left in place as a crossing under the New Orleans & Gulf Coast Railroad for future use
- One 194 linear foot, 48 inch diameter casing that was left in place under Highway 23 for future use

The perimeter of the BA-0039 marsh platform was planted with approximately 5,000 *Paspalum vaginatum* (Brazoria seashore paspalum) plugs and 21,000 *Spartina alterniflora* (Vermilion smooth cordgrass) plugs between May 4, 2010, and June 3, 2010 (Faust 2010). Both species are used to stabilize soils for marsh creation projects constructed with dredged sediment (Fine and Thomassie 2000a, 2000b).

During construction, the sediment fill area of BA-0039 was expanded to the west through the addition of Increment 2 (Figure 1). Increment 2 was sponsored by NOAA and was funded by the American Recovery and Reinvestment Act (ARRA) through a grant administered by NOAA.

<u>BA-0039 Increment 2 Project Features</u>

The as-built principal project features include the following, as documented in the project completion report by ABMB Engineers, Inc. (2011):

- Approximately 84 acres of marsh fill
- Approximately 6,241 linear feet of containment dikes

II. Maintenance Activity

a. Project Feature Inspection Procedures

Annual project inspections are conducted to evaluate the constructed project features. Results of the inspection are included in an inspection report that details their condition and lists any recommended corrective actions. The inspection procedure consists of a site visit with a visual inspection of the project features. If corrective actions are needed, CPRA provides in the inspection report a detailed cost estimate for engineering, design, construction, supervision, inspection, and contingencies, and an assessment of the urgency of such repairs. The inspection report also contains a summary of maintenance projects and an estimated projected budget for the upcoming three years for operations, maintenance and rehabilitation.

b. Inspection Results

The most recent inspection of BA-0039 was conducted on May 25, 2016, by Peter Hopkins and Danielle Richardi of CPRA, and Brad Crawford of USEPA. There was a light wind and partly cloudy skies during the inspection. Photographs from this inspection are included in Appendix A. The OM&M budget with the upcoming three-year budget projection (2017–2020) is included in Appendix B, and the field inspection notes are included in Appendix C.

Marsh Creation Areas

The containment dikes and marsh creation areas are holding up well. The regions of the project area that were observed during the inspection were all heavily vegetated. The gaps along the project perimeter appear to be allowing tidal exchange in their immediate areas. Although not considered to be project features, the two landowner-maintained crossings between fill areas that were severely damaged by Hurricane Isaac have been replaced.

Railroad and Highway Crossings

The casings under the New Orleans & Gulf Coast Railroad and Highway 23 are currently in use by the Contractor for BA-0043-EB marsh creation and BA-0164. They are underground and are not visible for inspection.

c. Maintenance Recommendations

The BA-0039 project is performing as intended. No maintenance activities are recommended at this time.

Immediate Repairs

No immediate repairs are necessary at this time.

Programmed Maintenance

The condition of the fill areas and crossings of the highway and railroad will continue to be monitored.

III. Operation Activity

a. Operation Plan

There are no operations associated with BA-0039.

b. Actual Operations

There are no operations associated with BA-0039.

IV. Monitoring Activity

a. Monitoring Goals

The goals of BA-0039 are to restore/create approximately 372 acres and nourish approximately 99 acres of emergent marsh in an area that was mostly open water (USEPA, LDNR 2007). Nourishment refers to the light application of dredged sediment on top of the pre-existing marsh in the project area. Rather than filling directly over existing marsh, sediment is typically filled around it and allowed to flow over the surface to the as-built elevation, thereby supplementing the marsh with new sediment and nutrients.

The introduction and placement of sediments through the use of dedicated dredging is consistent with the Louisiana's Comprehensive Master Plan for a Sustainable Coast, specifically, the Barataria Marsh Creation Component (CPRA 2012).

b. Monitoring Elements

Monitoring includes three BA-0039 project-specific monitoring sites (BA39-01, BA39-02, and BA39-03) where data are collected to measure project success as based on project goals (Figure 2). Data collected from these sites are compared to data from nearby Coast-wide Reference Monitoring System-*Wetlands* (CRMS-*Wetlands*) sites and BA-0003c project-specific stations to compare characteristics between the created marsh and local, natural marsh (Figure 3). Data collection for Increment 2 ended in 2011 and all data were summarized and analyzed in the 2013 BA-0039 OM&M report.

<u>Land-Water Analysis</u>

Land-water analysis of aerial photography is used in conjunction with topographic surveys of the project area to evaluate the project's success of creating a sustainable marsh platform. Land to water ratios in the project area are determined using CRMS aerial photography (Z/I Imaging digital mapping camera) with 1-meter resolution. The photography is georectified using standard operating procedures described in Steyer et al. (2000). The initial aerial photography was collected on November 14, 2012, and the final photography is tentatively scheduled for fall 2021, dependent on the scheduling of CRMS coastwide flights.

Elevation (Topographic Surveys)

Data from topographic surveys are compared over time to determine if the created marsh platform is settling at the predicted rate and maintaining an elevation that supports emergent marsh vegetation. Post-construction topographic surveys (NAVD88, Geoid99) were conducted using Real Time Kinematic (RTK) surveying procedures in 2010 (as-built, in construction budget) and 2011 along transects spaced at intervals of 500 feet, with points taken approximately every 50 feet along the transects. The 2014 survey was conducted using aerial LiDAR (FLI-MAP 400 system), with supplemental RTK data collection along transects that were known to be inundated. The laser point density of the LiDAR system is 54 points per square meter at 200 m altitude and 20 m/s speed. The absolute accuracy of the data points is 15 cm horizontally and 10 cm vertically. Transect data were extrapolated from the LiDAR data field along the same transects that were surveyed using RTK in 2010 and 2011 in order to compare data between years. An additional ground-truthing RTK survey was performed in May 2015 along sections of transects where dense vegetation and/or flooding were suspected of producing erroneous LiDAR elevations. A final RTK elevation survey is scheduled for 2020.

Surface Elevation Change

A rod surface elevation table (RSET) is installed at each of the three BA-0039 monitoring sites to measure precise changes in marsh surface elevation over time relative to a fixed datum, NAVD88 (Cahoon et al. 2002a, 2002b) (Figure 2). Nine pins are extended through the horizontal table to the soil surface. The height that each pin extends above the table is measured during each sampling period to determine the elevation change at the station. RSET data have been collected and analyzed bi-annually in the spring and fall since station establishment in September 2010 and will continue to be collected through 2020 following CRMS methodology (Folse et al. 2014).

Accretion

Vertical accretion data are collected in conjunction with surface elevation change data at each of the three BA-0039 monitoring sites by measuring the accretion of sediment above a white feldspar marker horizon over time. Accretion is determined by extracting cryogenic soil cores from the marsh and measuring the depth from the soil surface to the feldspar layer (Cahoon et al. 1996). New sampling plots continue to be added every two years during the life of a station, due to the eventual degradation of the feldspar marker. The measurement of accretion in conjunction with surface elevation change allows for a differentiation between surface elevation change due to shallow subsidence and surface elevation change due to sediment accretion. Accretion data have been collected biannually in the spring and fall since 2011, and will continue to be measured through 2020 following CRMS methodology (Folse et al. 2014).

Vegetation

Vegetation data are used to assess how well the platform is being colonized by marsh vegetation and to compare the vegetation in the created marsh to that of local, natural marsh. Surveys of marsh vegetation are conducted at each of the three BA-0039 monitoring sites following CRMS methodology (Folse et al. 2014). The sites contain ten 2 m x 2 m vegetation stations located along a 288 m diagonal transect within a 200 m x 200 m square (Figure 2). Data collected at the stations include species composition, total percent cover, percent cover of each species and vegetation layer, average height of the dominant species and each vegetation layer, and the depth of water on the marsh surface. Vegetation sampling was conducted in the summer of 2010, 2011 and 2014 and is scheduled again for 2017 and 2021. Vegetation was also surveyed at six 2 m x 2 m stations in Increment 2 in 2010 and 2011 using funds provided through the ARRA grant. Data from the Increment 2 surveys are included in the 2013 OM&M report.

Soil Properties

Soil data are used to monitor changes in soil properties over time and to compare soil properties in the created marsh to those in local, natural marsh. Soil cores were collected and analyzed from each of the three BA-0039 monitoring sites in 2010, 2013 and 2015 and will be collected a final time in 2021 following CRMS methodology (Folse et al. 2014). Each soil core is taken from the surface down to 24 cm, with three replicate cores collected at each site. The cores are sliced every 4 cm into a total of six sections and soil properties are analyzed for each 4 cm increment (i.e. 0–4 cm deep, 4–8 cm deep…). The 2013 data were collected as part of a separate CPRA-funded project that examined soil development and carbon accumulation in created marsh (Holm et al. 2015). Soil properties analyzed and included in this OM&M report include percent organic matter and bulk density.

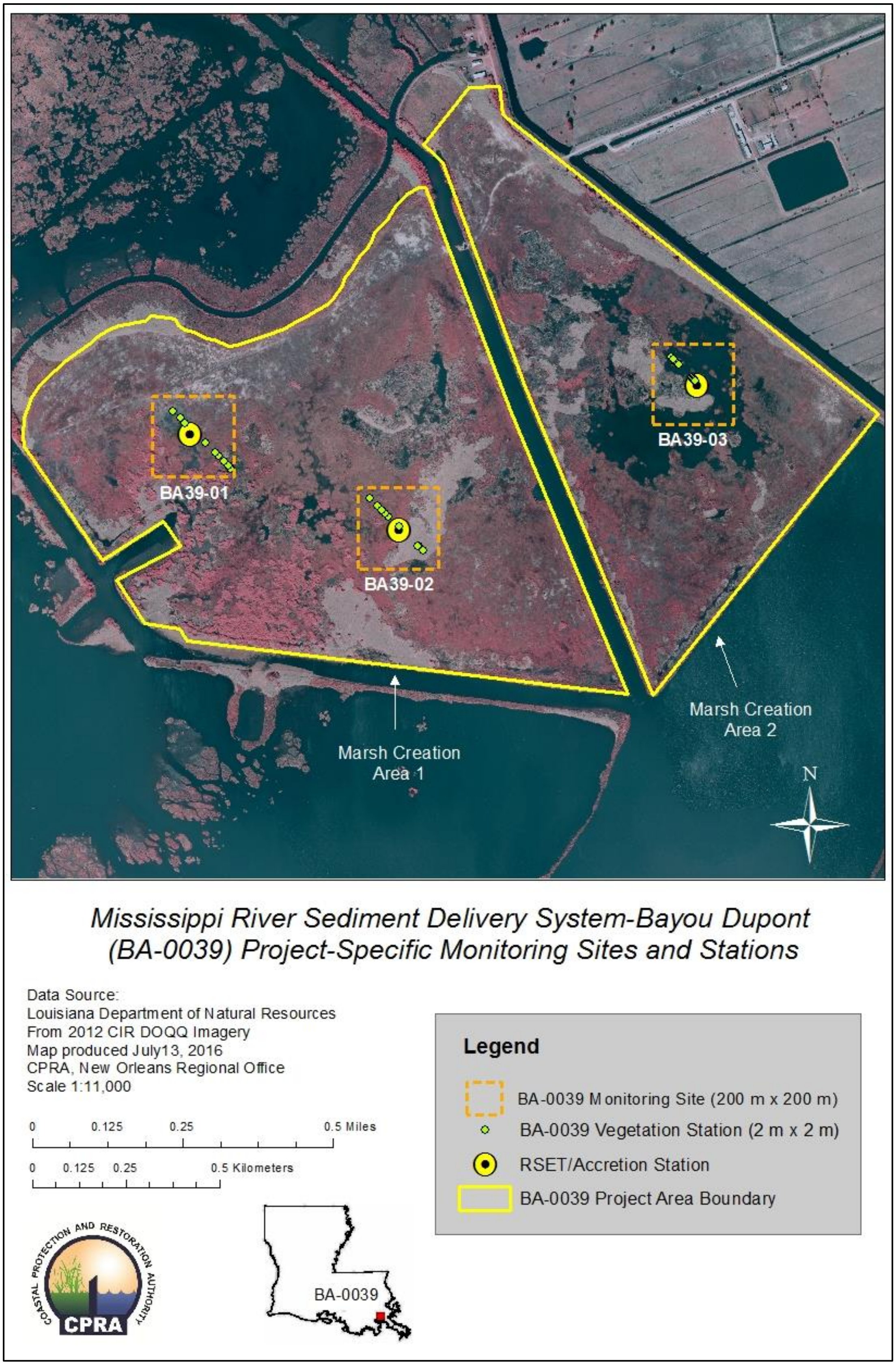


Figure 2. Location of BA-0039 project-specific monitoring sites and stations.

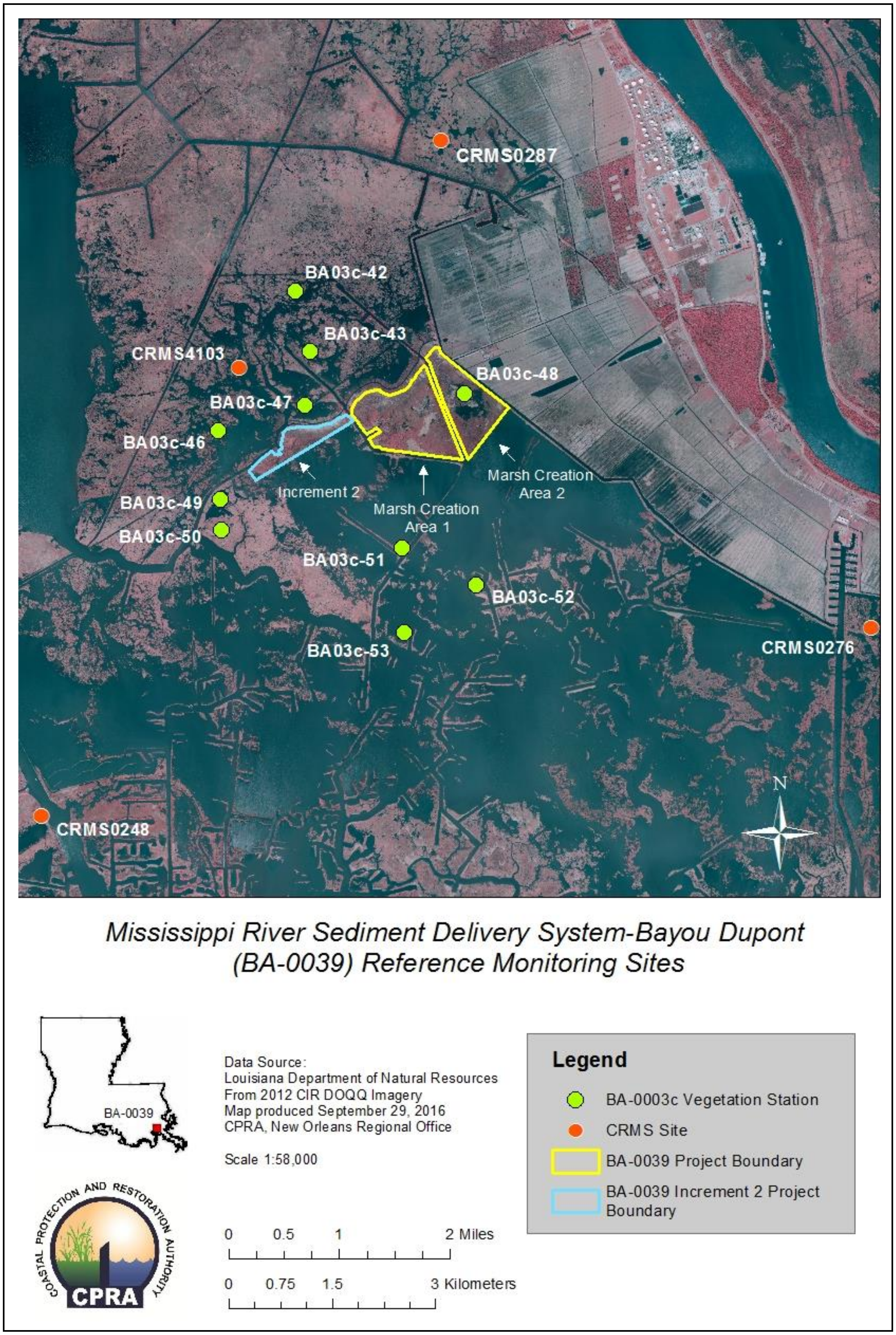


Figure 3. Location of neighboring CRMS sites and BA-0003c project-specific vegetation stations used as reference stations for BA-0039.

c. Monitoring Results and Discussion

i. Land-Water Analysis

The goals of BA-0039 are to restore/create 372 acres and nourish approximately 99 acres of emergent marsh in an area that was mostly open water (USEPA, LDNR 2007). Land-water analysis is a useful tool to measure the amount of land that has been created with a marsh restoration project and to track the sustainability of that land over the project's life. While habitat types such as emergent marsh and scrub-shrub are not differentiated from one another in this analysis, data collected during vegetation surveys can determine the predominant habitat types (p. 28).

Aerial imagery from October 11, 2007, shows the degraded condition of the project area prior to construction, with only a small amount of remnant marsh present in Marsh Creation Area (MCA) 1 and MCA 2 (Figure 4). Land-water analysis of post-construction aerial photography collected on November 14, 2012, indicates that the project area was predominantly land, with 458 acres of land and 37 acres of water (Figure 5). The project boundary used for land-water analysis contained an additional 24 acres than the 471 total acres listed in the project goals. These additional acres along the northeastern boundary of MCA2 appear to be land that was designated as "agricultural other" in the project area and were not used in the wetland value assessment or in the determination of project goals (USEPA, LDNR 2007).

The 37 acres of water are primarily due to ponding in areas of lower elevation. The area of shallow ponding in the center of MCA 2 has been a consistent feature of the project area since construction (Figure 5). Based on aerial imagery of the project area during and after construction, it appears as if sediment was not delivered as effectively to this area, which is located just south of remnant marsh. It is possible that this feature will prevent the attainment of 100% land classification in the project area; however, the shallow water area has provided increased habitat diversity. The area may also be providing habitat benefit for wildlife, as the landowner has reported that the shallow pond is utilized by waterfowl.

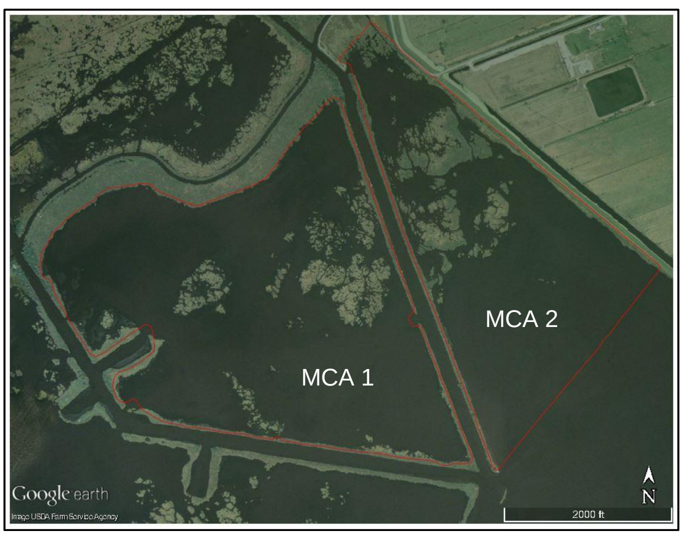


Figure 4. Google Earth aerial imagery of the BA-0039 project area acquired pre-construction on October 11, 2007, shows the majority of the project area as open water, with some remnant marsh.

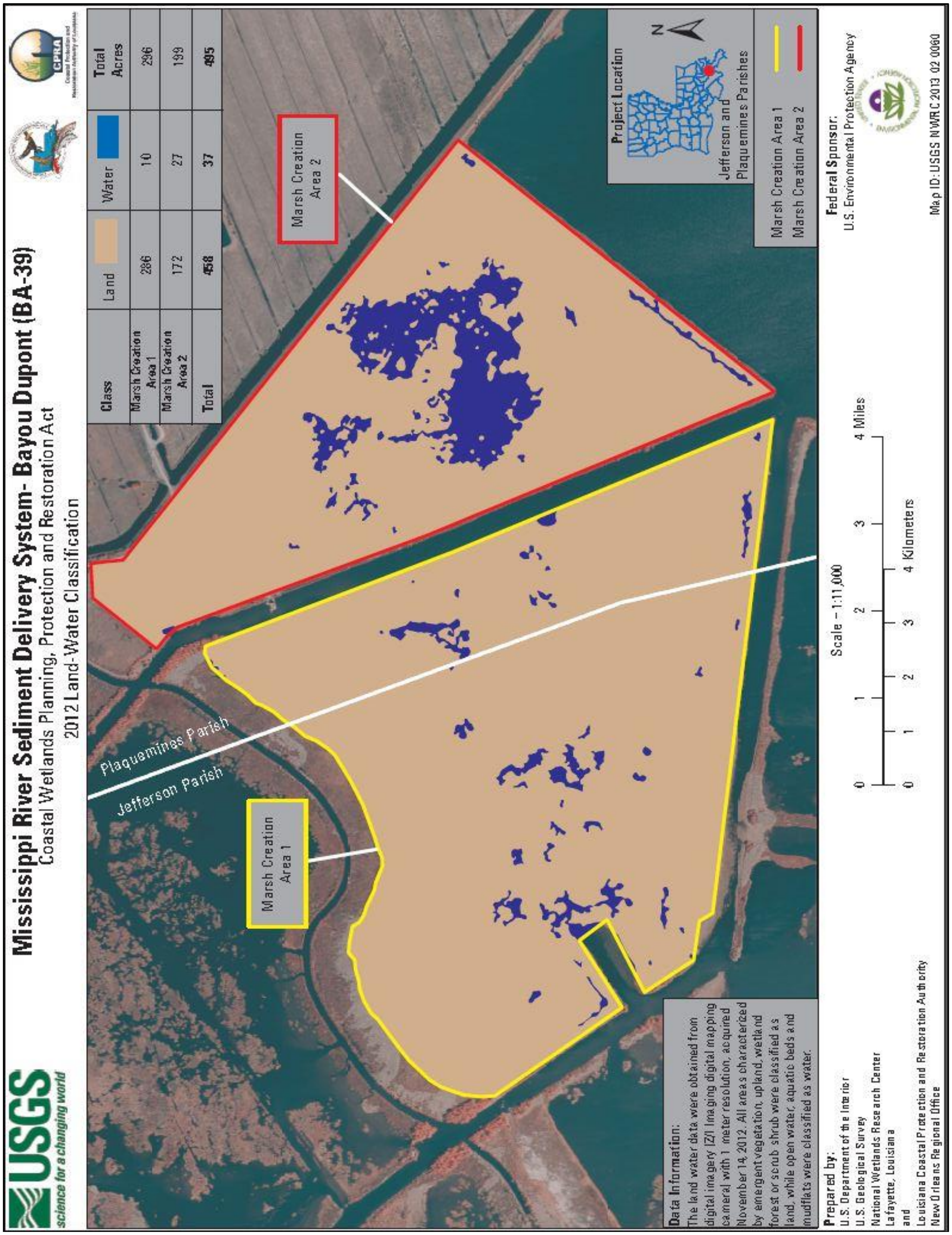


Figure 5. Land-water classification of the BA-0039 project area using CRMS aerial photography acquired on November 14, 2012.

ii. Elevation (Topographic Surveys)

Topographic surveys of marsh creation projects are typically done several times throughout the life of a project to monitor settlement and to determine if the platform was constructed to an elevation that is able to support emergent marsh vegetation throughout the life of the project. The BA-0039 project area has been surveyed three times since construction: January 2010 – April 2010 (as-built), October 2011 – January 2012 (year 2, hereinafter referred to as the 2011 survey), and October 2014 (year 5).

The first two surveys were conducted using Real Time Kinematic (RTK) surveying procedures. Two notable differences exist between these two surveys: 1) additional cross sections of the project's perimeter (containment dikes and pre-existing spoil banks and levees) were performed as part of the 2010 as-built survey, following CPRA's request (Figure 6A) and 2) sections of the transect lines in flooded areas were not completed during the year 2 survey (Figure 6B).

The 2014 survey was conducted using aerial LiDAR mapping with the FLI-MAP 400 system. Data points were selected from along the previously established transects to compare surveys between years. Due to the inability of LiDAR to map elevation in flooded environments, additional surveying was performed using RTK procedures in areas that were previously identified as being inundated (Figure 6C). The elevation of vegetation monitoring stations was also surveyed using RTK procedures (not represented in Figure 6C). After reviewing the LiDAR data, a supplemental RTK survey was performed on May 12, 2015, along select transects where data appeared suspect, likely due to dense vegetation or water on the surface.

Topographic contour maps were generated from the BA-0039 survey data (NAVD88, Geoid99) using ArcMap 10.2.1 to estimate surface elevation and settlement between years. ArcMap interpolates between survey points to create a surface elevation grid; therefore, the maps are a useful tool for assessing elevation, but they are dependent on the accuracy and robustness of the dataset. Areas where transect data are sparse will resultantly be subject to greater interpolation and may have greater error. Elevation data for Marsh Creation Area (MCA) 1 and MCA 2 have been analyzed together in this OM&M report (total project area), rather than separately as was done in the 2013 OM&M report.

Based on the predicted settlement for BA-0039, a target constructed elevation of +2.0 ± 0.3 ft NAVD88, Geoid99 was chosen to provide an initial marsh elevation that would settle into the intertidal zone and support emergent marsh vegetation through most of the project's 20-year CWPPRA life-span (Thompson 2007) (Figure 7). A target marsh elevation of +1.3 ft was chosen based on the average elevation of nearby *Spartina patens* (saltmeadow cordgrass) marsh. *Spartina patens* is found in intermediate to brackish marshes and has historically been the dominant local species. According to the predicted settlement for BA-0039, the target marsh elevation of +1.3 ft should be reached near year 10, with settlement to +1.2 ft near year 20 (Thompson 2007) (Figure 7).

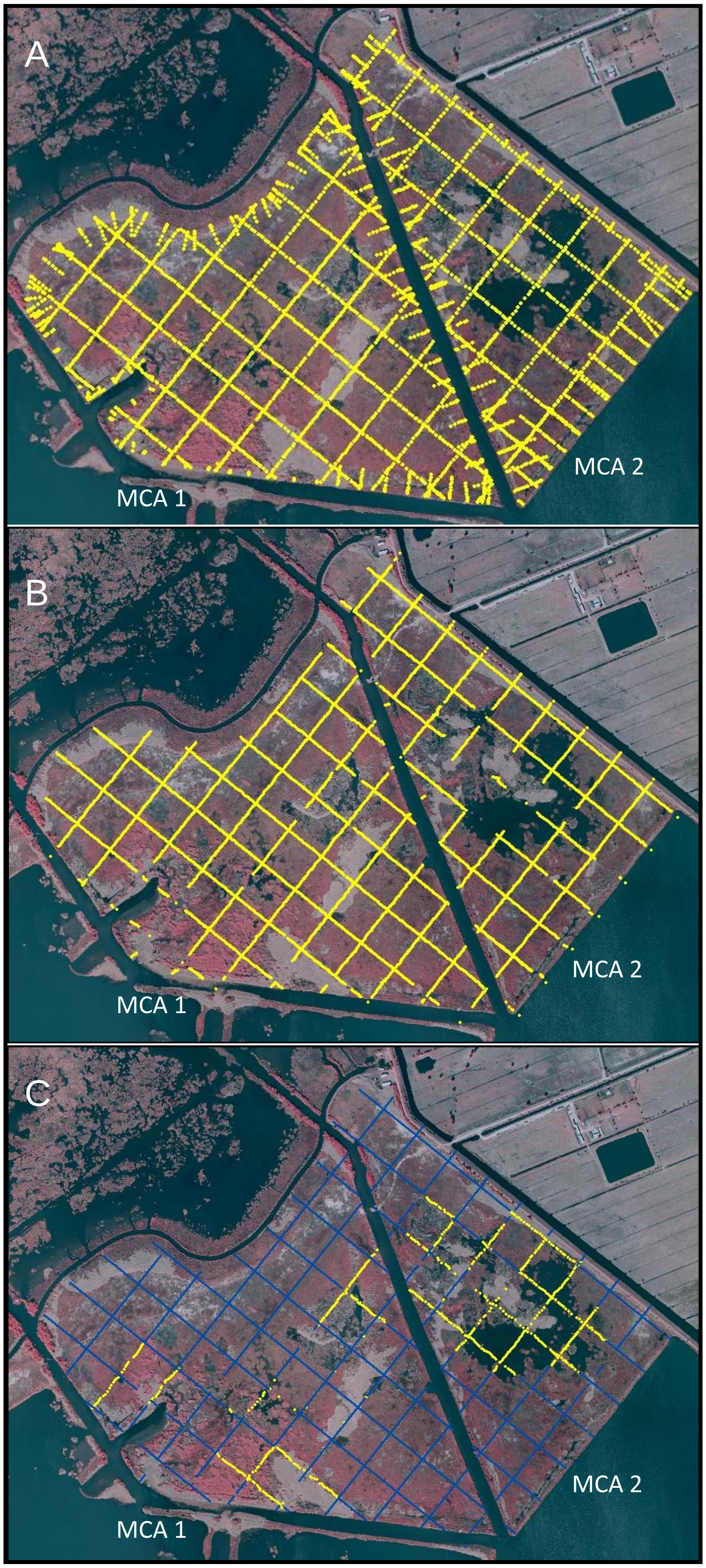


Figure 6. Completed transect lines for the **(A)** as-built, **(B)** year 2, and **(C)** year 5 BA-0039 elevation surveys. For the year 5 survey, the yellow lines represent the RTK data and the blue lines represent the LiDAR data used for analysis. MCA = Marsh Creation Area.

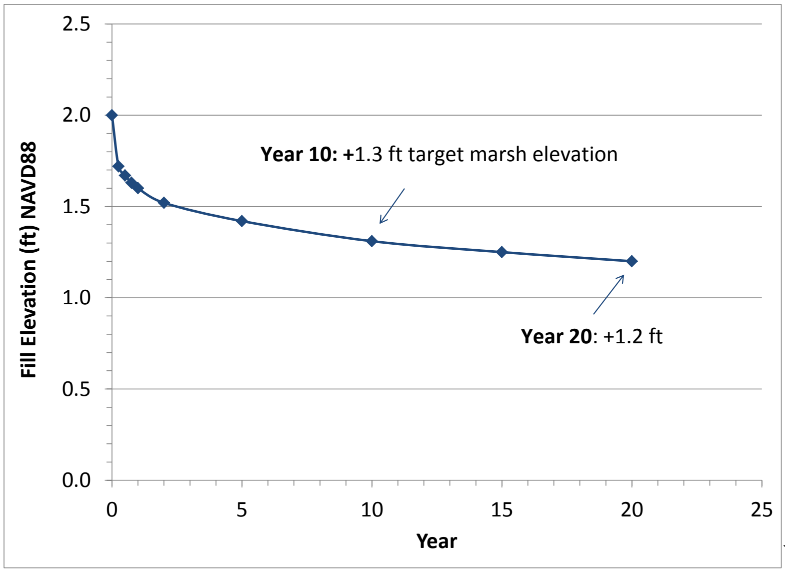


Figure 7. Predicted twenty-year settlement for BA-0039, based on a constructed marsh fill elevation of +2.0 ft NAVD88 (Geoid99).

The as-built (2010) survey data indicate that nearly half of the project area, 47.4%, was built within the targeted elevation of +2.0 ft ± 0.3 ft. That amount increases to 79.3% if the range is slightly expanded to include elevations between +1.5 ft and +2.5 ft, aligning with the 0.5 ft increments used for map generation (Figure 8). The majority of the project area (85.9%) was filled to an elevation greater than or equal to the +2.0 ft target, with the highest percentage of acres (66.7%) between +2.0 ft and +2.5 ft. Generally, the highest elevations were along the project's northern boundary and in the southern corners of each marsh creation area, adjacent to the canal that divides them. The lower elevations ran along a broad horizontal band through the center of the project area. Survey transects were established in the ponding area in MCA2, but due to their spacing and alignment, they failed to fully capture the extent of the lower elevations in the area (Figure 6A). The mean elevation of the project area as calculated from the marsh elevation survey points was +2.2 ft ± 0.0 SE (n = 2611).

Based on a constructed +2.0 ft elevation, the predicted elevation for the project area at year 2 was +1.5 ft (Figure 7). The year 2 (2011) survey data indicate that the majority of the project area (80.5%) was at an elevation ≥ +1.5 ft, with the highest percentage of acres (47.1%) between +1.5 ft and +2.0 ft. (Figure 9). It is not surprising that the year 2 elevations would be slightly higher than expected, due to the higher as-built elevation. The lower elevation areas between 0.0 ft and +1.0 ft in the center of MCA2 and below the cut along the western perimeter of MCA1 are in flooded areas where transects were not completed (Figure 6B). The calculated elevation of these areas is subject to a greater degree of interpolation than the rest of the dataset. The mean elevation of the project area as calculated from the marsh elevation survey points was +1.9 ft ± 0.0 SE (n = 6852).

The predicted elevation for the project area by year 5 (2014) was +1.4 ft, but the majority of the project area (≥ 84.3%) was surveyed at a higher elevation, with the highest percentage of acres (53.9%) between +1.5 ft and +2.0 ft. (Figure 10). Higher elevation can be expected due to the higher initial fill and significant sediment deposition from Hurricane Isaac, which is discussed in the Surface Elevation Change/Accretion section of this report (p. 22). The area of shallow water in the center of MCA 2, which had been excluded from the previous survey, was surveyed with RTK in 2014 and had elevations ranging from +0.5 ft to +1.5 ft. The mean elevation of the project area as calculated from the LiDAR and RTK marsh elevation survey points was +2.0 ft ± 0.0 SE (n = 31253), 0.1 ft higher than for the 2011 survey.

Contour maps were created to delineate the project area based on the elevation change that occurred between surveys. Between the as-built (2010) and year 2 (2011) surveys, the majority of the project area declined in elevation between 0.0 ft and -0.5 ft, with 50.9% of the project area settling within this range (Figure 11). The predicted amount of settlement by year 2 was -0.48 ft, which is just within the observed range (Figure 7). Areas of higher settlement in the center of MCA 2 and the along the western border of MCA 1 below the central cut are in areas where data were not collected during the 2011 survey; therefore, the calculation of settlement in these areas is based on highly-interpolated data. Average settlement in the project area calculated using the means of the 2010 and 2011 elevation survey points was -0.31 ft.

Between the year 2 (2011) and year 5 (2014) surveys, the largest percent of the project area (52.7%) declined in elevation between 0.0 ft and -0.5 ft (Figure 12). Settlement during this time was predicted to be only an additional -0.1 ft, with most of the settlement expected to occur by year 2. The second highest category of elevation change (40.5%) was between 0.0 ft and +0.5 ft, indicating a stabilization or slight increase in elevation. It should be noted that the settlement curve is based on the consolidation of sediment and does not include a prediction of sediment accretion. The average elevation change calculated using the means of the 2011 and 2014 elevation survey points showed little difference in elevation between years, with an increase of +0.04 ft.

Additional RTK ground truthing was conducted on May 12, 2015, along sections of transects where the LiDAR data appeared suspect after initial quality control. The data were questioned due to several reasons, including significant increases in elevation since the 2011 survey, a relatively constant elevation where previously there was greater variability, and suspicion of interference from dense shrub-scrub vegetation and flooding. The elevation data collected during the ground truthing RTK survey indicated that the LiDAR data were biased towards higher elevations. Therefore, during the final quality control of data, LiDAR data that appeared suspect in comparison to the overall 2014 dataset and previous surveys were deleted and RTK data were used in place of the LiDAR data when they were available. Despite apparent inaccuracies with the LiDAR data in select locations of the project area, a measured increase in elevation since the 2011 survey is likely justifiable in other locations based on rod surface elevation table (RSET) and accretion data. Results from these analyses are discussed in the Surface Elevation Change and Accretion section of this report (p. 22).

In the five years since project construction, the project area was predicted to settle -0.58 ft, from an as-built elevation of +2.0 ft, to an elevation at year 5 of +1.4 ft. Just over half of the project area (51.3%) settled between 0.0 ft and -0.5 ft (Figure 13). Greater settlement between -0.5 ft and -1.0 ft occurred in 35.2% of the project area. Average elevation change calculated using the means of the 2010 and 2014 elevation survey points was -0.27 ft.

Mississippi River Sediment Delivery System-Bayou Dupont (BA-0039)
2010 Elevation Survey

Data Source:
Louisiana Department of Natural Resources
From 2012 CIR DOQQ Imagery
Map produced July 05, 2016
CPRA, New Orleans Regional Office
Scale 1:11,000

Elevations are in NAVD88, Geoid99

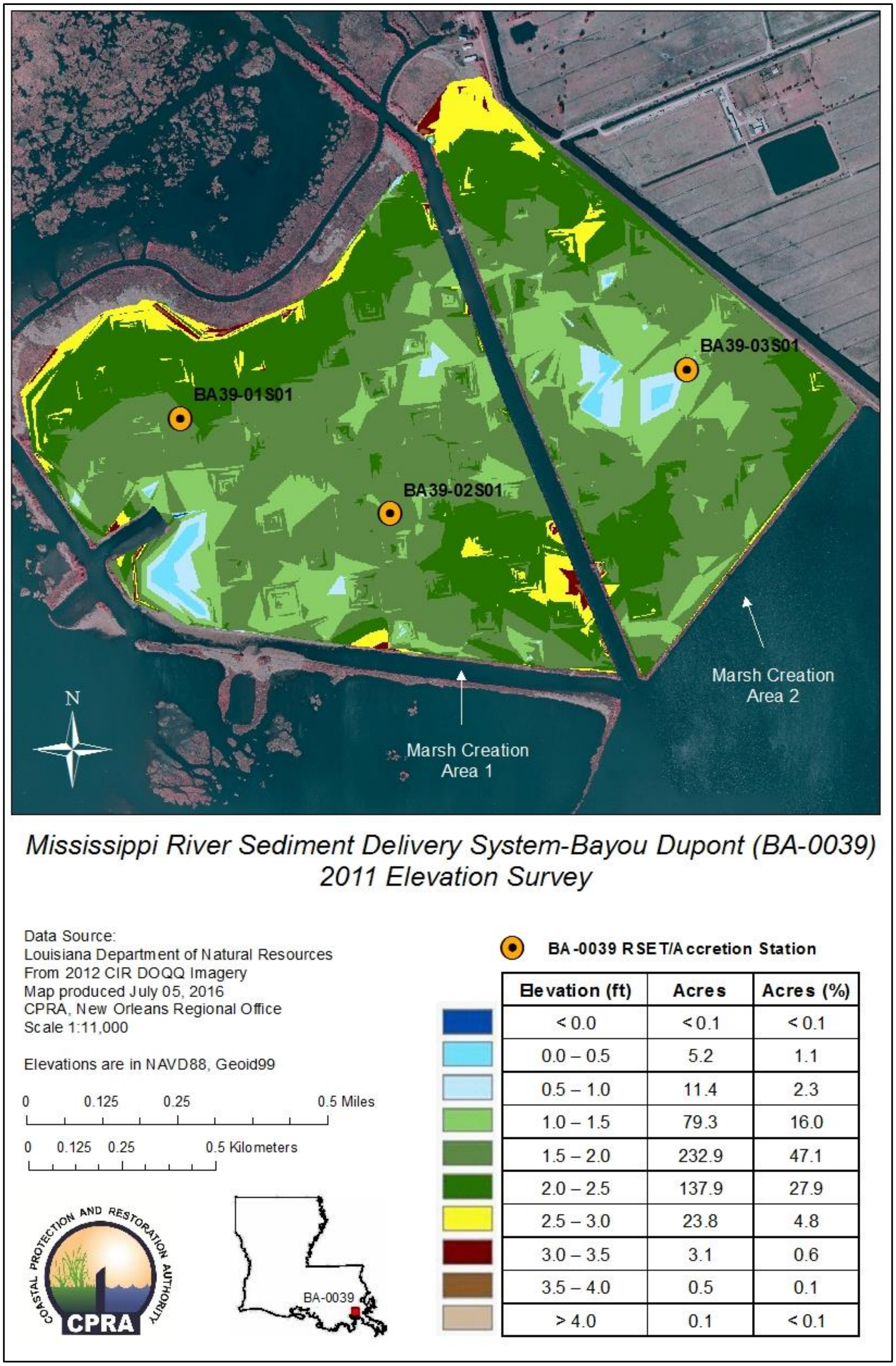
0 0.125 0.25 0.5 Miles

0 0.125 0.25 0.5 Kilometers

BA-0039 RSET/Accretion Station

Elevation (ft)	Acres	Acres (%)
< 0.0	0.5	0.1
0.0 – 0.5	0.3	0.1
0.5 – 1.0	0.8	0.2
1.0 – 1.5	5.9	1.2
1.5 – 2.0	62.2	12.6
2.0 – 2.5	329.6	66.7
2.5 – 3.0	84.2	17.0
3.0 – 3.5	6.7	1.4
3.5 – 4.0	2.3	0.5
> 4.0	1.7	0.3

Figure 8. As-built elevation of the BA-0039 project area as surveyed January 2010 – April 2010.



	Elevation (ft)	Acres	Acres (%)
	< 0.0	< 0.1	< 0.1
	0.0 – 0.5	5.2	1.1
	0.5 – 1.0	11.4	2.3
	1.0 – 1.5	79.3	16.0
	1.5 – 2.0	232.9	47.1
	2.0 – 2.5	137.9	27.9
	2.5 – 3.0	23.8	4.8
	3.0 – 3.5	3.1	0.6
	3.5 – 4.0	0.5	0.1
	> 4.0	0.1	< 0.1

Figure 9. Elevation of the BA-0039 project area as surveyed October 2011 – January 2012.

Mississippi River Sediment Delivery System-Bayou Dupont (BA-0039)
2014 Elevation Survey

Data Source:
Louisiana Department of Natural Resources
From 2012 CIR DOQQ Imagery
Map produced July 05, 2016
CPRA, New Orleans Regional Office
Scale 1:11,000

Elevations are in NAVD88, Geoid99

0 0.125 0.25 0.5 Miles

0 0.125 0.25 0.5 Kilometers

BA-0039 RSET/Accretion Station

Elevation (ft)	Acres	Acres (%)
< 0.0	0.2	< 0.1
0.0 – 0.5	0.5	0.1
0.5 – 1.0	12.3	2.5
1.0 – 1.5	64.1	13.0
1.5 – 2.0	266.3	53.9
2.0 – 2.5	127.9	25.9
2.5 – 3.0	19.5	3.9
3.0 – 3.5	2.7	0.5
3.5 – 4.0	0.7	0.1
> 4.0	0.2	< 0.1

Figure 10. Elevation of the BA-0039 project area as surveyed in October 2014 (LiDAR and RTK) with additional RTK data collection along select transects in May 2015.

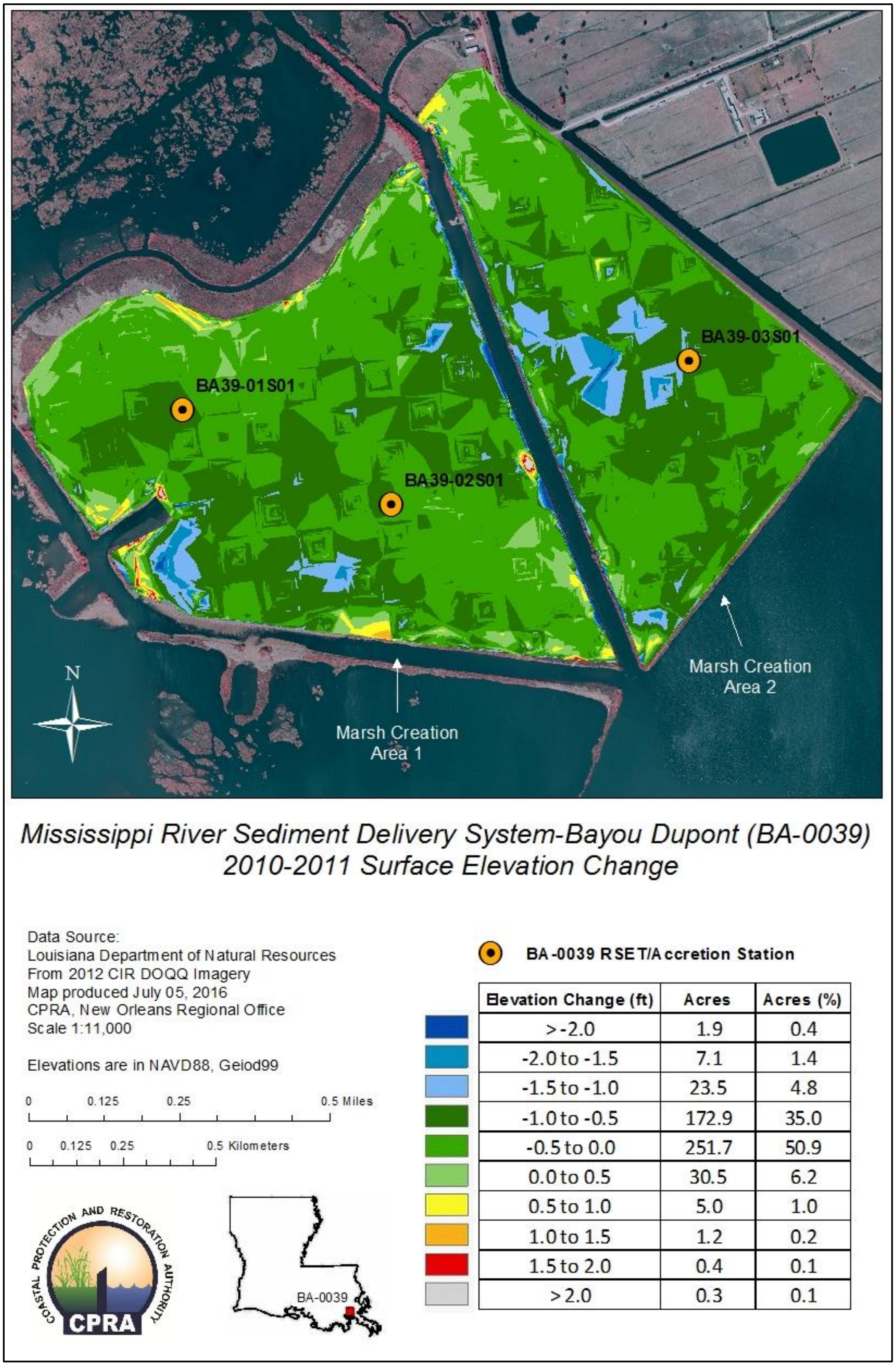


Figure 11. Surface elevation change of the BA-0039 project area between the as-built (2010) and year 2 (2011–2012) elevation surveys.

Mississippi River Sediment Delivery System-Bayou Dupont (BA-0039)
2011-2014 Surface Elevation Change

Data Source:
Louisiana Department of Natural Resources
From 2012 CIR DOQQ Imagery
Map produced July 05, 2016
CPRA, New Orleans Regional Office
Scale 1:11,000

Elevations are in NAVD88, Geoid99

0 0.125 0.25 0.5 Miles

0 0.125 0.25 0.5 Kilometers

BA-0039 RSET/Accretion Station

Elevation Change (ft)	Acres	Acres (%)
< -1.5	0.1	< 0.1
-1.5 to -1.0	0.5	0.1
-1.0 to -0.5	7.8	1.6
-0.5 to 0.0	260.6	52.7
0.0 to 0.5	200.1	40.5
0.5 to 1.0	20.5	4.1
1.0 to 1.5	4.0	0.8
1.5 to 2.0	0.7	0.1
> 2.0	0.1	< 0.1

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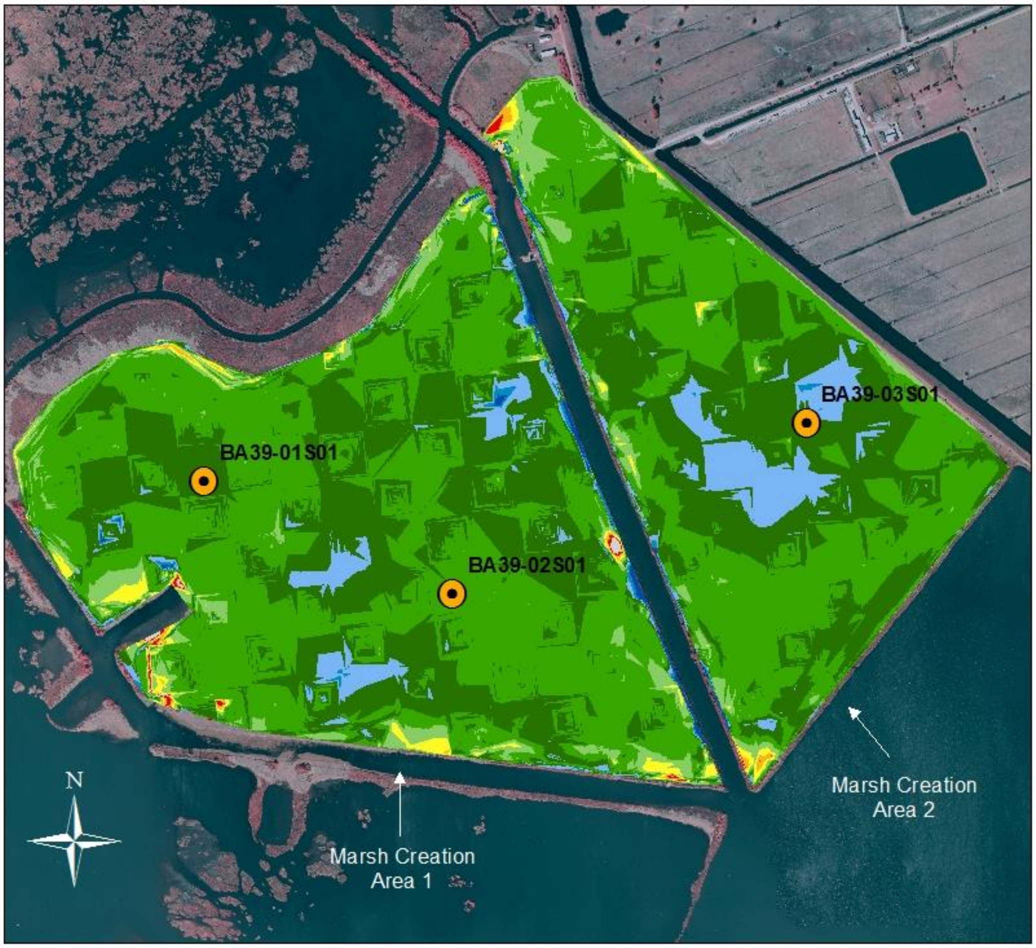
Figure 12. Surface elevation change of the BA-0039 project area between the year 2 (2011–2012) and year 5 elevation surveys.



Mississippi River Sediment Delivery System-Bayou Dupont (BA-0039)
2010-2014 Surface Elevation Change

Data Source:
Louisiana Department of Natural Resources
From 2012 CIR DOQQ Imagery
Map produced July 05, 2016
CPRA, New Orleans Regional Office
Scale 1:11,000

Elevations are in NAVD88, Geoid99

0 0.125 0.25 0.5 Miles

0 0.1 0.2 0.4 Kilometers

BA-0039 RSET/Accretion Station

Elevation Change (ft)	Acres	Acres (%)
>-2.0	1.6	0.3
-2.0 to -1.5	2.5	0.5
-1.5 to -1.0	27.3	5.5
-1.0 to -0.5	174.2	35.2
-0.5 to 0.0	253.6	51.3
0.0 to 0.5	26.4	5.3
0.5 to 1.0	6.4	1.3
1.0 to 1.5	1.4	0.3
1.5 to 2.0	0.6	0.1
> 2.0	0.4	0.1

Figure 13. Surface elevation change of the BA-0039 project area between the as-built (2010) and year 5 (2014) elevation surveys.

iii. Surface Elevation Change and Accretion

Since the rod surface elevation tables (RSETs) and initial accretion plots were established on September 21, 2010, data have been collected biannually in the spring and fall following CRMS methodology (Folse et al. 2014). Data were not collected in the BA-0039 project area in fall 2012 due to the difficulty in accessing the sites after Hurricane Isaac, which came ashore near the mouth of the Mississippi River on August 29, 2012. Surface elevation change and accretion data are analyzed in this report for the total monitoring period, as well as pre- and post-Hurricane Isaac time frames, in order to isolate the influence of the storm.

Surface Elevation Change

Surface elevation change is the measurement of elevation change on a specific date from the initial date when the RSET was installed. The rate of surface elevation change is obtained by calculating a linear regression between measurements over time. The average rate of elevation change in the BA-0039 project area prior to Hurricane Isaac was -5.55 cm/yr ± 2.01 SE (Table 1, Figure 14). Graphs for each station are included in Appendix D. The marsh surface was rapidly subsiding, as was predicted in the first two years after project construction due to surface and sub-surface compaction of sediments (Figure 7). For a comparison to nearby natural marsh, the elevation change rate at CRMS4103 during the same time period was noticeably less at -0.49 cm/yr ± 2.73 SE (Table 1, Figure 15).

The effect of Hurricane Isaac on surface elevation in the project area is evident with the first RSET measurements taken after the storm in April 2013. The surface elevation at BA-0039 stations increased an average of 4.31 cm ± 0.99 SE between the pre- and post-Isaac RSET readings due to sediment deposition from the storm surge (Figure 14). An even greater increase of 13.71 cm was recorded at CRMS4103, but this measurement was taken just two weeks after Hurricane Isaac, allowing little time for compaction of the newly-deposited sediment (Figure 15). Water level recorded at nearby CRMS4103 captured the storm surge, with the daily water elevation peaking at 5.56 ft NAVD88 (Geoid99) on 08/30/12 (Figure 16). Daily mean water elevation at CRMS4103 has averaged 1.22 ft ± 0.01 SE since project construction. Due to this station's proximity to the BA-0039 project area, water elevation at this site is likely representative of local hydrographic conditions.

The rate of surface elevation change at the BA-0039 RSET stations has slowed since Hurricane Isaac. After the initial rapid settlement post-construction, the surface elevation is forecast to continue to decline during the project's life, but at a greatly diminished rate (Figure 7). The average surface elevation change rate post-Isaac was -0.38 cm/yr ± 4.05 SE (Table 1, Figure 14). The surface elevation change rate at CRMS4103 post-Isaac has shown a steeper decline of -1.30 cm/yr ± 3.49 SE, but this rate is largely influenced by the high positive surface elevation change that was recorded two weeks after Isaac (Table 1, Figure 15). If these data are removed from the calculation, the surface elevation rate change is considerably lower at -0.10 cm/yr ± 2.93 SE.

The long-term trend in the project area shows an average positive rate of elevation change of +0.15 cm/yr ± 3.83 SE due to the significant boost in elevation that resulted from sediment deposition during Hurricane Isaac (Table 1, Figure 14). While stations BA39-02 and BA39-

03 both had a positive surface elevation change rate, station BA39-01 experienced a declining rate of -0.74 cm/yr ± 1.34 SE, likely due to it receiving less sediment during the storm than the other two stations. CRMS4103 also had a positive rate of elevation change of +1.21 cm/yr ± 4.20 SE over the total monitoring time period (Table 1, Figure 15).

As discussed in the Elevation section of this report, there was an increase in elevation along some BA-0039 transects between the 2011 and 2014 topographic surveys. The RSET data suggest that an increase in elevation was possible between surveys in areas that received significant sediment input from Hurricane Isaac. Using the linear regression equation for the surface elevation change rate post-Isaac, the surface elevation change was calculated for each station for the date of the topographic survey, October 30, 2014. This elevation was compared to the RSET reading that was taken in October 2011, within the same time period of the 2011 topographic survey. At BA39-01, the calculated elevation change for 10/30/2014 and the measured elevation change on 10/07/2011 do not support an increase in elevation between surveys; however, BA39-02 and BA39-03 data suggest otherwise. At BA39-02, the calculated elevation change for 10/30/2014 was -1.14 cm and the measured elevation change on 10/07/2011 was -4.73 cm, amounting to an increase of 3.59 cm between surveys. At BA39-03, the calculated elevation change for 10/30/2014 was -3.87 cm and the measured elevation change on 10/20/2011 was -7.27 cm, representing an increase of 3.40 cm at the site. These results lend credibility to a slightly higher elevation in some areas of BA-0039 during the 2014 topographic survey.

Table 1. Surface elevation change, accretion and shallow subsidence values for the BA-0039 project area and CRMS4103, which represents conditions in the natural, neighboring marsh. The BA-0039 and CRMS4103 post-Isaac accretion rates for the plot sets established in April 2012 were calculated using only data collected post-Isaac to remove the influence of the storm. Accretion and RSET data collected on 09/13/12, just two weeks post-Isaac, were also removed from CRMS4103 analyses to remove the storm's immediate influence. When two establishment dates are provided, the reported rate is the average of the rates from the respective dates. n = the number of measurements used to calculate the rate.

Monitoring Time Frame	Surface Elevation Change			Accretion				Shallow Subsidence
Pre-Isaac (09/2010–04/2012)	**Rate (cm/yr)**	SE	n	**Plot Set Establishment Date**	**Rate (cm/yr)**	SE	n	**Rate (cm/yr)**
BA39-01	-5.59	0.87	12	09/21/2010	0.53	0.29	8	6.12
BA39-02	-3.16	0.58	12	09/21/2010	0.27	0.16	11	3.43
BA39-03	-7.60	0.44	12	09/21/2010	0.87	0.83	11	8.47
BA-0039 Project Area	**-5.55**	2.01	36	09/21/2010	**0.60**	0.53	30	**6.15**
CRMS4103 (04/2009–04/2012)	-0.49	2.73	24	04/21/2009 (n=12), 03/16/2010 (n=15)	0.95	0.11	2	1.44
Post-Isaac (04/2013–03/2016)								
BA39-01	-0.92	0.70	28	04/02/2012 (n=11), 04/15/2014 (n=15)	0.90	0.19	2	1.82
BA39-02	-0.45	0.69	28	04/02/2012 (n=11), 04/15/2014 (n=15)	0.72	0.63	2	1.17
BA39-03	0.19	2.46	28	04/23/2012 (n=12), 04/14/2014 (n=13)	1.84	0.25	2	1.65
BA-0039 Project Area	**-0.38**	4.05	84	04/2012 (n=34), 04/2014 (n=43)	**1.27**	0.17	2	**1.65**
CRMS4103 (04/2013–03/2016)	-0.10	2.93	28	04/19/2012 (n=11), 04/09/2014 (n=15)	0.77	0.82	2	0.87
Total (09/2010–03/2016)								
BA39-01	-0.74	1.34	40	09/21/2010	1.53	1.51	17	2.27
BA39-02	0.57	1.50	40	09/21/2010	1.71	2.24	20	1.14
BA39-03	0.61	2.90	40	09/21/2010	2.90	2.09	20	2.29
BA-0039 Project Area	**0.15**	3.83	120	09/21/2010	**2.04**	2.44	57	**1.89**
CRMS4103 (04/2009–03/2016)	1.21	4.20	56	04/21/2009 (n=17), 03/16/2010 (n=24)	1.90	0.23	2	0.69

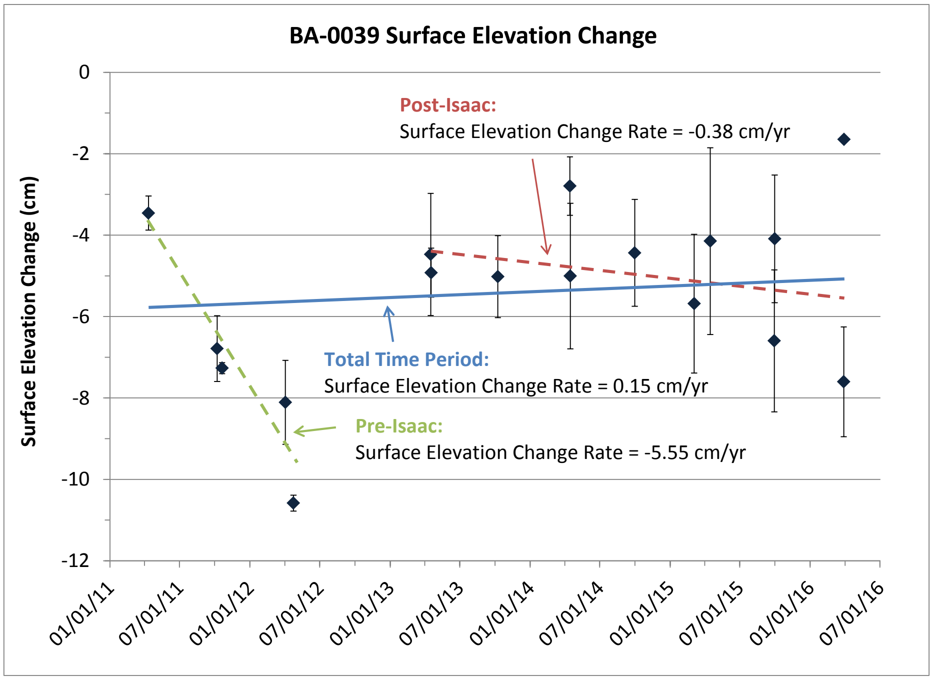


Figure 14. Mean surface elevation change (± SE) in the BA-0039 project area. Surface elevation change rates are calculated for the entire monitoring period, pre-Hurricane Isaac, and post-Hurricane Isaac. Graphs for each site are included in Appendix D.

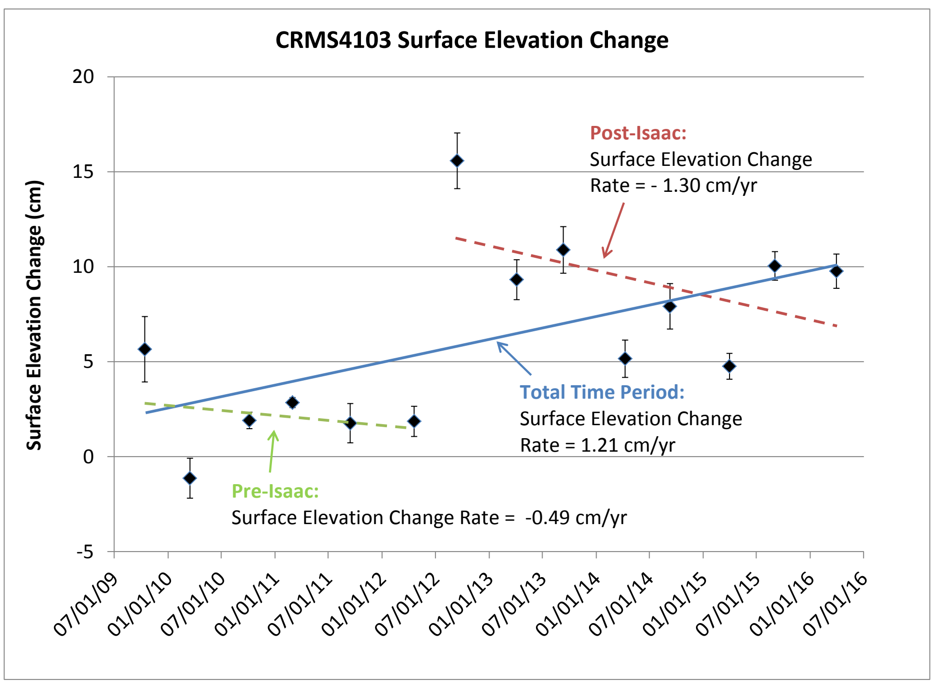


Figure 15. Surface elevation change (± SE) at CRMS4103. Surface elevation change rates are calculated for the entire monitoring period, pre-Hurricane Isaac, and post-Hurricane Isaac. The post-Isaac surface elevation change rate is -0.10 cm/yr if the data collected two weeks after the storm on 09/13/2012 are removed from the calculation.

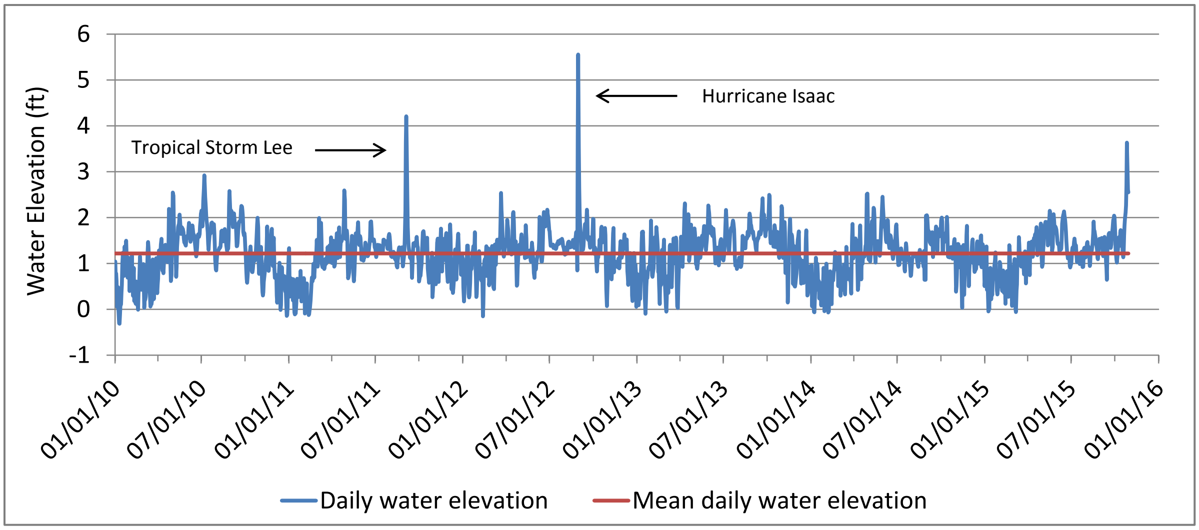


Figure 16. Daily water elevation and mean daily water elevation (NAVD88, Geoid99) recorded at CRMS4103 between 01/01/2010 and 10/30/2015.

Accretion

The rate of accretion is obtained by calculating a linear regression between measurements over time. CRMS protocol recommends the use of the full (long-term) record when calculating accretion rates due to the high variability inherent in short-term accretion monitoring. In instances when full-term records are not available for adequate comparison, the short-term rates (1.5–3.0 years of data collection) should be averaged to provide an approximation of the site's accretion rate.

Sediment accretion in the project area during the first two years after construction (pre-Hurricane Isaac) was low, occurring at a mean rate of 0.60 cm/yr ± 0.53 SE, with accretion being somewhat higher in the nearby natural marsh at CRMS4103 (0.95 cm/yr ± 0.11 SE) (Table 1, Figure 17). Field notes recorded during data collection in the project area most frequently described the marsh surface as dry (BA39-01, BA39-02) or wet (BA39-03), with no to few roots in the extracted core. The first BA-0039 accretion measurements that occurred after Hurricane Isaac in April 2013 indicated a mean sediment accretion of 7.18 cm ± 0.63 SE (Figure 17). Comments written during data collection described 5–7 cm of storm deposition above the sand layer. Sediment accretion appeared even greater at CRMS4103 (12.77 cm); however, this measurement was taken just two weeks after the storm, resulting in less time for sediment consolidation (Figure 18).

The mean rate of accretion in the project area since Hurricane Isaac has been 1.27 cm/yr ± 0.17 SE, an increase of 0.67 cm/yr over the pre-Isaac rate (Table 1, Figure 17). Since we are comparing short-term data sets, the difference may be due to inherent variability in data collection. But a higher accretion rate post-Isaac could be explained by an increase in root growth in the surface sediments, which has been documented on the accretion field data sheets. It could also be explained by soil expansion due to increasing water content (greater flooding). While field conditions at site BA39-01 and BA39-02 were noted as dry during the first two years of monitoring, after the storm, they were consistently recorded as wet or flooded, and since the 04/23/2012 sampling, BA39-03 has been noted as flooded with water depth ranging from 1–10 cm. Other explanations could be sediment deposition or differences in the soil properties pre- and post-Isaac. The mean rate of accretion at CRMS4103 since Hurricane Isaac has been 0.77 cm/yr ± 0.82 SE, less than in the BA-0039 project area and slightly less than the pre-Isaac CRMS4103 rate (Table 1, Figure 18).

The long-term accretion record for the BA-0039 project area indicates an increase of 2.04 cm/yr ± 2.44 SE, with the greatest accretion occurring at site BA39-03 (Table 1, Figure 17). The long-term accretion rate is greater than both the pre- and post-Isaac rates because it includes the effect of sediment deposition from Hurricane Isaac. The long-term accretion rate for CRMS4103 is similar to that for BA-0039, at 1.90 cm/yr ± 0.23 SE (Table 1, Figure 18).

By subtracting the rate of surface elevation change from the rate of accretion, we can determine the rate of shallow subsidence at each station (Table 1). Shallow subsidence occurs in the depth between the accretion feldspar marker horizon and the bottom of the rod that is driven into the ground to resistance when the RSET station is established. Sediment compaction, decomposition of organic matter, root development, and the amount of water in the sediment can all contribute to changing elevation within this zone (Cahoon et al. 2006). As previously mentioned, these processes can also affect the accretion rate, but their influence is typically greater in the zone of shallow subsidence, where the soil depth is significantly greater (e.g. several meters as compared to few centimeters).

During the BA-0039 pre-Isaac monitoring period, shallow subsidence was the driving influence in the rate of surface elevation change. The high mean shallow subsidence rate of 6.15 cm/yr was primarily driven by compaction of the newly-deposited river sediment (Table 1). Shallow subsidence was highest at site BA39-03 (8.47 cm/yr), which was differentiated from the other two sites pre-Isaac by being located in a lower-elevation area with wet or slightly flooded soils. In the neighboring natural marsh at CRMS4103, shallow subsidence was much lower, as expected, at 1.44 cm/yr. Since Hurricane Isaac, shallow subsidence in the project area has declined considerably to 1.65 cm/yr, but it is still occurring at a higher rate than at CRMS4103 (0.87 cm/yr). The long-term rate of shallow subsidence in the project area has been 1.89 cm/yr, as compared to 0.69 cm/yr at CRMS4103 (Table 1).

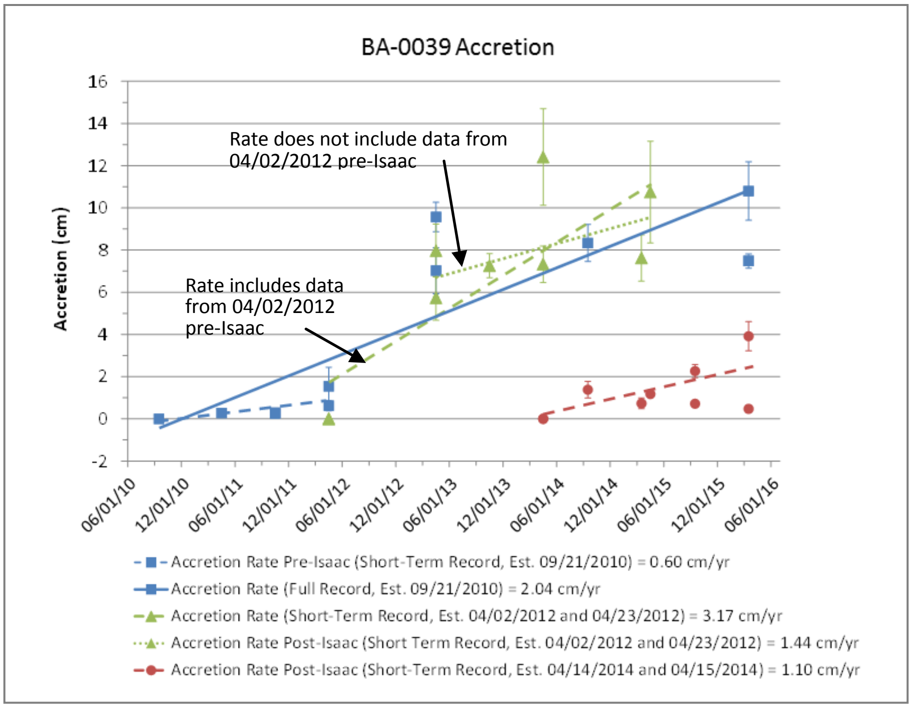


Figure 17. Mean accretion (± SE) in the BA-0039 project area. The accretion rate is graphed for monitoring periods pre- and post-Isaac, as well as for the full monitoring period. The two post-Isaac accretion rates are averaged in Table 1. Graphs for each site are included in Appendix D.

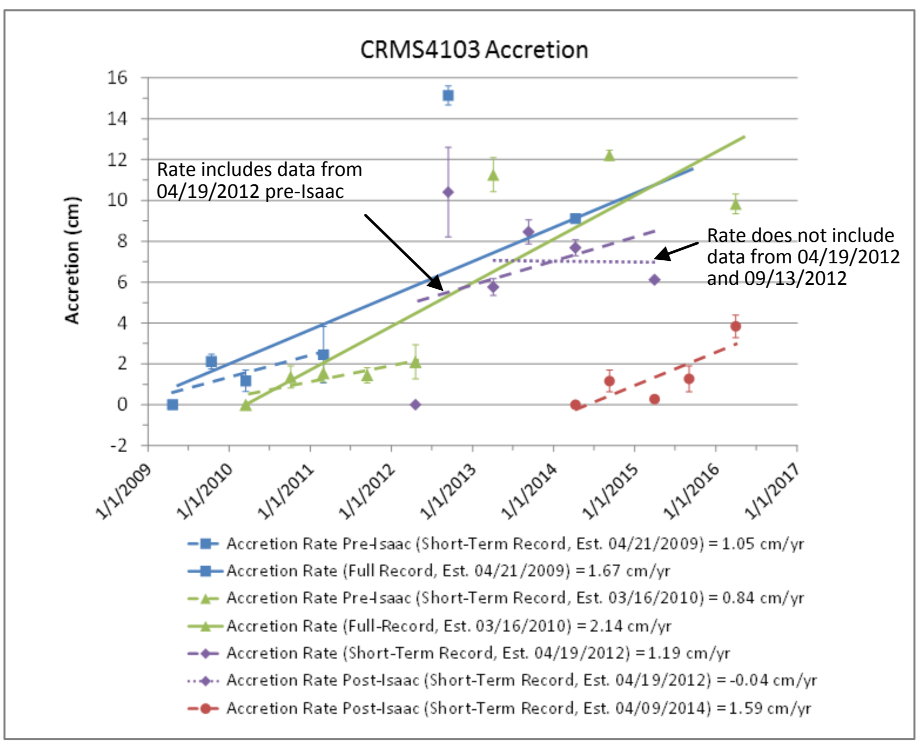


Figure 18. Accretion (± SE) at CRMS4103. The rate of accretion is graphed for monitoring periods pre- and post-Isaac, as well as for the full monitoring period. The two pre-, two post- and two full record accretion rates are averaged in Table 1.

iv. Vegetation

With any marsh creation project, it can take several years for the establishment of a vegetative community that resembles the community of the natural surrounding marsh. This is especially true when creating a marsh platform that is composed of a different sediment type and is built to an initial elevation that is different than that of the surrounding marsh. In addition to the sediment characteristics and the elevation of the platform, the developing marsh community will be influenced by the hydrology in the marsh, the extent of the plantings in the project area, and the availability and composition of a nearby seedbank. Vegetation monitoring for BA-0039 examines how the species cover and composition change over time and on how the vegetative community compares to that of the surrounding natural marsh.

Total Percent Cover

Total percent cover is a visual estimation of vegetative cover that is assessed at each station and ranges from 0% –100%. Mean total percent cover for vegetation in the BA-0039 project area was compared between years at each of the three monitoring sites and in the project area (sites assessed collectively) using ANOVA in Proc GLM, $\alpha = 0.05$, followed by a Tukey's post-hoc test (SAS Institute Inc., Cary, NC, version 9.4). Total cover was significantly different over years at all sites and in the project area, with sites BA39-01 and BA39-02 and the project area showing a continuing upward trend in vegetative cover (Figure 19). Total cover increased at all sites between 2010 and 2011, but the increase was significant only at BA39-03, where cover increased from 44% to 79%. The increase in cover was also significant in the project area, with an increase from 40% in 2010 to 64% in 2011. Between 2011 and 2014, a significant increase occurred at BA39-01, where cover nearly doubled from 45% to 86%. Conversely, cover at BA39-03 declined significantly between these years from 79% in 2011 to 41% in 2014. Site BA39-03 is located in an area of lower elevation where some of the stations experience frequent to continual flooding. Between the 2010 and 2014 surveys, a significant increase in vegetative cover occurred at BA39-01, BA39-02 and in the project area.

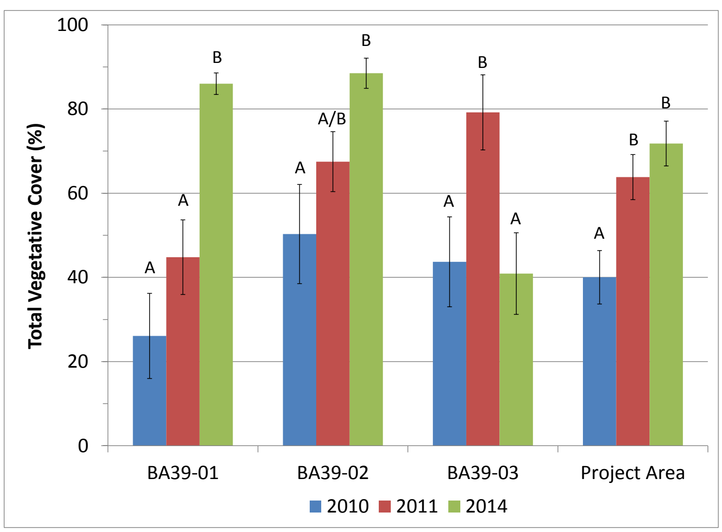


Figure 19. Mean total vegetative cover (± SE) at each BA-0039 monitoring site (10 stations/site) and in the project area in 2010, 2011, and 2014. Significant differences between years are indicated by different letters ($\alpha = 0.05$). BA39-01: $p < 0.0001$, $F_{2,27} = 15.05$; BA39-02: $p = 0.0104$, $F_{2,27} = 5.44$; BA39-03: $p = 0.0169$; $F_{2,27} = 4.76$; project area: $p = 0.0004$; $F_{2,87} = 8.44$.

Individual Species Percent Cover

Individual species percent cover is the visual estimation of the percent cover for each species of vegetation at a station. Because the covers for species can overlap due to different heights and growth forms, the sum of the individual species' covers at a station can exceed 100%. *Paspalum vaginatum* (seashore paspalum) had the highest mean percent cover in the BA-0039 project area in 2010 (13.4%), 2011 (19.3%) and 2014 (22.1%) (Figure 20). Other species showed greater variation in relative cover between years. *Bacopa monnieri* (herb of grace) had the second highest mean percent cover when averaged over years (9.3%) and also had the second highest percent cover in 2014 (14.4%), but its relative cover was lower in 2010 and 2011. *Typha latifolia* (broadleaf cattail) had the third highest mean percent cover in the project area when averaged over years (7.0%), but the cover of a different cattail species, *Typha domingensis* (southern cattail), was higher in 2014 (13.1%). Cattail species can be difficult to distinguish from one another and they commonly hybridize; therefore, some variation in species identification by the surveyors is possible.

The genus *Paspalum* was not identified to species for the 2014 survey; however, it is classified in this report as *P. vaginatum* because it is the only *Paspalum* species previously recorded in the project area, it was the dominant species in the 2010 and 2011 surveys, and it was planted in the project area. Five thousand plugs of this species were planted along sections of the project perimeter May 2010–June 2010 to stabilize soils and enhance the establishment of vegetation (Faust 2010). The 'Brazoria' cultivar that was chosen for this project grows well in a range of soils and is characterized by its ability to rapidly colonize and stabilize bare soils with salinity up to 10 ppt (Fine and Thomassie 2000a). Twenty-one thousand plugs of *Spartina alterniflora* (smooth cordgrass), Vermilion cultivar, were also planted along the southeastern shore of MCA 2 between May 2010 and June 2010 (Faust 2010). The 'Vermillion' cultivar is described as growing within a salinity range of 8−33 ppt and is identified as an effective species for stabilizing sediments in dredge fill projects. It grows best in mineral soils with water depths between 1 to 18 inches (Fine and Thomassie 2000b). Observations made during the 2016 annual inspection noted the continued success of this species along the shoreline (Appendix A, photo 8), despite local salinity being below the species' stated range (Figure 21).

While the cover of *P. vaginatum* increased at sites BA39-01 and BA39-02 between 2011 and 2014, it disappeared from site BA39-03 in 2014, despite being the dominant species recorded during the 2011 survey. The disappearance of *P. vaginatum* at BA39-03 is an indication of how elevation and hydrology are influencing the development of different vegetative communities. In 2014, the elevation at the BA39-01 and BA39-02 vegetation stations was 1.77 ft ± 0.03 SE and 1.70 ft ± 0.06 SE, respectively; whereas the elevation at BA39-03 was lower at 1.26 ft ± 0.14 SE (NAVD88, Geoid99). The lower elevation stations at BA39-03 are in areas that experience frequent to continuous flooding. This environment has facilitated a shift in the dominant species from *P. vaginatum*, which can tolerate only periodic flooding, to more flood-tolerant *T. latifolia*. *Typha latifolia* increased at BA39-03 from 0% cover in 2010 to 13.5% in 2014. *Typha latifolia* and cattails in general are aggressive colonizers that can tolerate continuous flooding and tend to form monotypic stands under favorable conditions (USDA NRCS 2006). *Typha* species are also abundant at sites BA39-01 and BA39-02, but they comprise a lower relative percentage of the vegetative cover. Not all stations at BA39-03 are dominated by *T. latifolia*. In 2014, the three highest elevation stations (1.7 ft–1.9 ft NAVD88, Geoid99) were dominated by *Spartina patens* (saltmeadow cordgrass), which at 13.4% mean cover was essentially a codominant species with *T. latifolia*. Based on the location of these stations, they are likely located in remnant *S. patens* marsh.

Floristic Quality Index

While the percent cover of individual species provides data on their abundance, it fails to provide an assessment of the quality of marsh habitat. The Floristic Quality Index (FQI) is useful in characterizing the quality and stability of the marsh. The calculation of the FQI was developed by Swink and Wilhelm (1979), but has been modified by Cretini et al. (2011) 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 lowest value (e.g. invasive species) and 10 being a species that is characteristic of a vigorous coastal wetland (e.g. *Spartina alterniflora*). A station with a high FQI score represents a community that has a low percentage of invasive and disturbance species and is dominated by species that are found in a stable marsh community.

The ideal FQI range for marshes in an inactive deltaic plain in Louisiana is > 80 (Cretini et al. 2011). The FQI score for BA-0039 was only 20.4 in 2010, but the survey was conducted just five months after project completion. The FQI score nearly doubled to 39.2 in 2011, and experienced a modest increase to 43.2 in 2014 (Figure 20). With the exception of *P. vaginatum* (CC = 7), the dominant species in the project area have low CC scores that are preventing a stronger positive response for the FQI. However, the cover of *S. patens* (CC = 9) has continued to increase at each of the project sites since 2010 and if this trend continues, this species could result in a higher FQI. The FQI scores in 2014 were similar for stations BA39-01 (FQI = 55.1) and BA39-02 (FQI = 49.6), and if viewed separately from BA39-03, indicate a stronger increase in the marsh quality and stability since 2011. However, due to the low vegetative cover at BA39-03 in 2014, the FQI is significantly lower at this site (FQI = 24.8), resulting in an overall lower FQI for BA-0039 for this year.

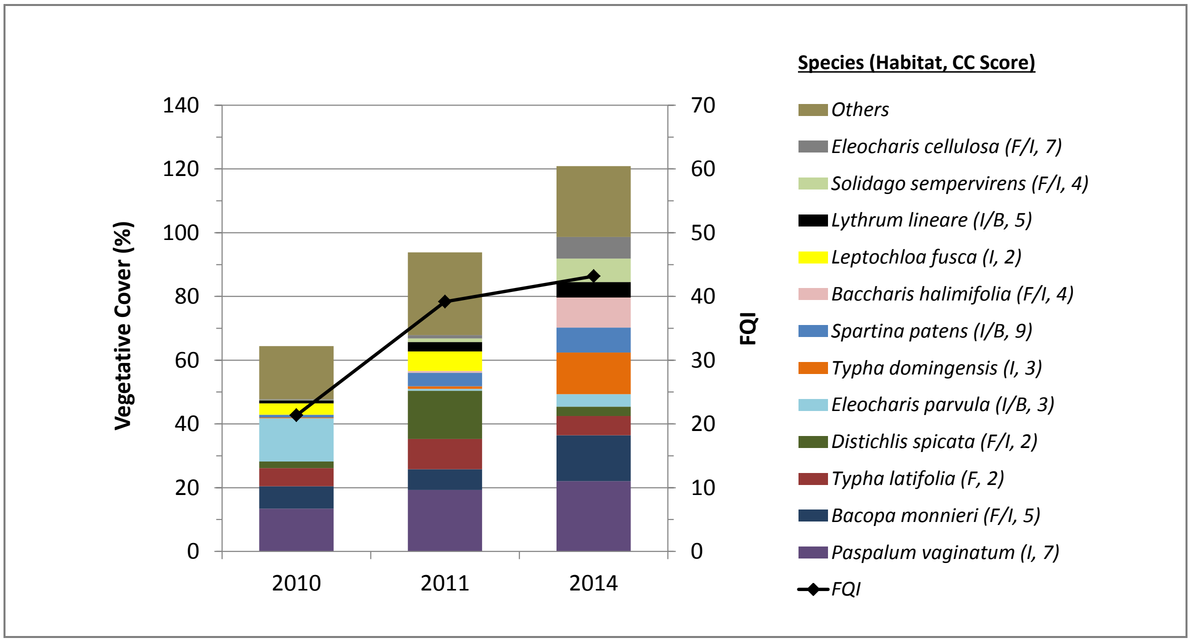


Figure 20. BA-0039 mean percent cover of vegetative species and FQI score. Species in the legend are ordered based on the highest mean percent cover over years, from bottom to top. The marsh habitat where the species typically grows and its CC score are listed after the species name. F: fresh, I: intermediate, B: brackish, S: salt.

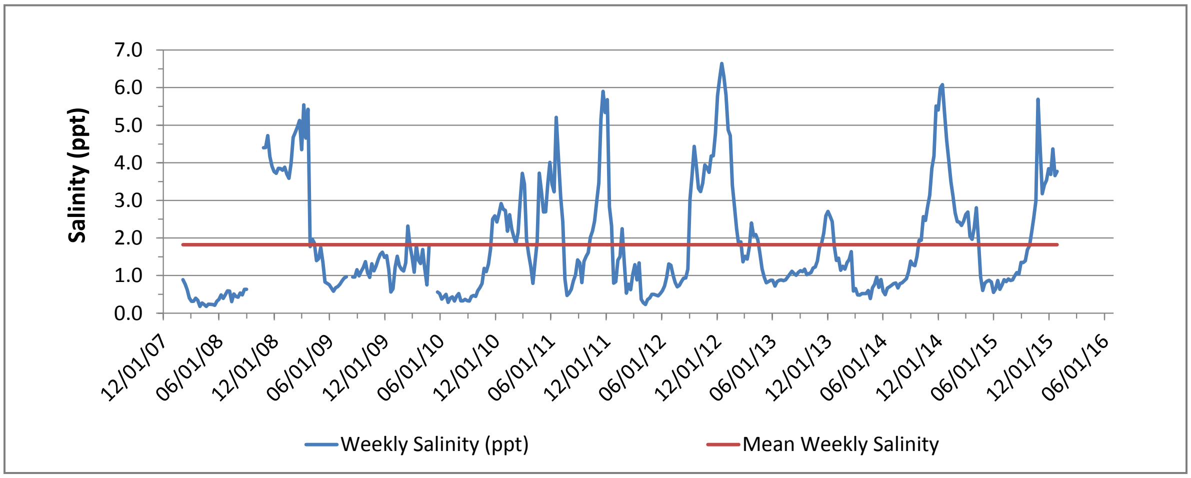


Figure 21. Weekly salinity at CRMS4103 between 02/01/2008 and 12/31/2015. Mean weekly salinity during the monitoring time frame was 1.82 ppt ± 0.07 SE, with weekly salinity ranging from 0.18 ppt – 6.64 ppt.

Species Distribution and Richness

By combining cover data with species distribution data, a more complete picture is generated of the vegetative community. Together, these data can help to determine if a species' distribution is patchy, or if it is occurring more widely throughout the project area. If averaged over years, *P. vaginatum* and *B. monnieri* not only had the highest covers, they also were the most widely-distributed species in the project area. *Paspalum vaginatum* was found at an average of 52% of stations, while *B. monnieri* was found at 47% (Table 2). Despite the disappearance of *P. vaginatum* from site BA39-03 in 2014, its mean distribution in the project area remained high due to an expansion of its range at BA39-01 and BA39-02.

Bacopa monnieri has continued to expand throughout the project area and was the most widely-distributed species in 2014, occurring at 67% of stations (Table 2). This species is a low growing, sprawling plant that grows well in fresh and intermediate marsh. *Eleocharis parvula* (dwarf spikerush) was the third most widely-distributed species over years, occurring at 32% of stations. This sedge occurred at 57% of sites in 2010, but has since become less widespread, occurring at only 13% of sites in 2011 and 27% of sites in 2014. *Eleocharis parvula* is also a low growing species that often forms a carpet layer of vegetation less than 10 cm tall. *Baccharis halimifolia* (eastern baccharis) was not present at sites during the 2010 survey, but was present at 37% of sites in 2014. This shrub is a species that is common in coastal scrub-shrub communities and grows in areas of higher elevation that are not frequently inundated. The mean percent cover of this species increased from 0% cover in 2010 to 9.4% cover in 2014, with the greatest cover occurring at BA39-02 in 2014 (21.7%).

The number of species recorded in the BA-0039 project area averaged 34 species over years, with a high of 40 species in 2011 and a low of 30 species in 2010 (Table 2). Site BA39-01 was the only site that saw a continuing increase in the number of recorded species for 2014. The site increased from 20 species in 2011, to 23 species in 2014, with *B. halimifolia*, *Lythrum lineare* (wand lythrum), *S. patens* and *Solidago sempervirens* (seaside goldenrod) all noted for the first time at this site during the 2014 survey. Site BA39-02 decreased from 28 species in 2011 to 22 species in 2014, but the most significant change in species richness occurred at BA39-03, where the number of species declined from 23 in 2011 to 10 in 2014. The decline in the number of species at this site is likely due to the increased depth and duration of flooding at many of the stations.

Table 2. Percent of BA-0039 vegetation stations (n = 30) where each species occurred for each survey. *Habitat* is the marsh habitat where the species is most commonly found. F = fresh, I = intermediate, B = brackish, S = salt.

Scientific Name	Common Name	2010		2011		2014		Habitat
		Cover (%)	Stations (%)	Cover (%)	Stations (%)	Cover (%)	Stations (%)	
Alternanthera philoxeroides	alligatorweed	0.2	3	0.9	10	0.5	13	F/I
Amaranthus australis	southern amaranth	2.7	30	1.5	47	1.0	10	I/B
Ammannia latifolia	pink redstem	0.2	7	0.5	27	0.2	10	F/I
Baccharis halimifolia	eastern baccharis	.	.	0.6	10	9.4	37	F/I
Bacopa monnieri	herb of grace	7.1	27	6.5	47	14.4	67	F/I
Batis maritima	turtleweed	.	.	< 0.1	3	.	.	S
Bidens laevis	smooth beggartick	.	.	.	.	0.5	7	F
Cynodon dactylon	Bermudagrass	.	.	3.0	7	1.2	3	F
Cyperus filicinus	fern flatsedge	.	.	0.1	7	0.4	7	F/I
Cyperus haspan	haspan flatsedge	0.3	3	.	.	.	.	F
Cyperus odoratus	fragrant flatsedge	5.0	43	.	.	2.1	17	I
Distichlis spicata	saltgrass	2.1	20	15.2	43	3.0	23	F/I/B/S
Echinochloa sp.	cockspur grass	.	.	< 0.1	3	.	.	F/I
Echinochloa walteri	coast cockspur grass	2.4	30	1.2	17	0.2	3	I
Eleocharis albida	white spikerush	.	.	4.5	27	.	.	I/B
Eleocharis baldwinii	Baldwin's spikerush	0.7	3	2.4	10	.	.	F
Eleocharis cellulosa	Gulf Coast spikerush	0.3	10	1.0	13	6.8	30	F/I
Eleocharis macrostachya	pale spikerush	0.5	7	2.2	13	0.2	3	I
Eleocharis parvula	dwarf spikerush	13.6	57	0.6	13	3.9	27	I/B
Hydrocotyle ranunculoides	floating marshpennywort	.	.	.	.	1.6	10	F
Ipomoea sagittata	saltmarsh morning-glory	0.2	7	< 0.1	3	1.0	23	F/I
Iva annua	annual marsh elder	.	.	< 0.1	3	.	.	F
Iva frutescens	Jesuit's bark	0.1	3	0.5	10	1.8	7	I
Kosteletzkya virginica	Virginia saltmarsh mallow	.	.	.	.	0.3	3	F/I
Leptochloa fusca	Malabar sprangletop	3.6	33	6.1	37	.	.	I
Lythrum lineare	wand lythrum	0.9	17	3.0	27	4.8	43	I/B
Mollugo verticillata	green carpetweed	0.2	3	0.3	10	.	.	F
Panicum dichotomiflorum	fall panicgrass	.	.	1.7	17	.	.	F/I
Paspalum vaginatum	seashore paspalum	13.4	50	19.3	57	22.1	50	I
Pluchea odorata	sweetscent	1.4	13	2.2	30	.	.	I/B
Polygonum lapathifolium	curlytop knotweed	0.6	13	0.1	3	.	.	F
Polygonum punctatum	dotted smartweed	0.2	3	0.1	3	0.7	10	F/I
Portulaca oleracea	little hogweed	0.1	3	.	.	.	.	F
Sabatia calycina	coastal rose gentian	.	.	.	.	0.6	7	F
Sagittaria lancifolia	bulltongue arrowhead	.	.	0.1	7	1.7	10	F/I
Schoenoplectus americanus	chairmaker's bulrush	.	.	0.3	3	5.2	17	I/B
Schoenoplectus californicus	California bulrush	> 0.1	3	.	.	.	.	I
Schoenoplectus pungens	common threesquare	.	.	.	.	1.8	3	F
Schoenoplectus tabernaemontani	softstem bulrush	0.7	3	0.1	3	.	.	I/B
Sesbania drummondii	poisonbean	.	.	0.1	3	.	.	F
Sesbania herbacea	bigpod sesbania	.	.	0.1	3	.	.	I
Solidago sempervirens	seaside goldenrod	0.1	3	1.1	23	7.4	40	F/I
Spartina alterniflora	smooth cordgrass	.	.	1.5	3	0.2	10	S
Spartina patens	saltmeadow cordgrass	0.8	3	4.2	23	7.8	37	I/B
Symphyotrichum divaricatum	southern annual saltmarsh aster	.	.	1.9	40	.	.	F
Symphyotrichum sp.	aster	.	.	0.5	13	0.4	13	F
Symphyotrichum tenuifolium	perennial saltmarsh aster	0.1	3	.	.	.	.	I/B
Typha domingensis	southern cattail	.	.	0.8	7	13.1	40	I
Typha latifolia	broadleaf cattail	5.7	10	9.5	27	6.0	23	F
Typha sp.	cattail	0.2	3	.	.	.	.	F/I
Vigna luteola	hairypod cowpea	1.2	10	0.1	7	0.6	20	I
Total Number of Species		**30**		**40**			**32**	

Comparison to Natural, Local Marsh

The BA-0039 project area and the surrounding natural marsh are both categorized as intermediate marsh based on the species composition, with the marsh transitioning to brackish just south of the project area. The closest CRMS station is CRMS4103, which is located in intermediate marsh approximately 1.5 miles northwest of BA-0039. Vegetation data have been collected annually from this site since 2008, following the same vegetation station design and monitoring protocol as employed at BA-0039. The marsh community at CRMS4103 has been dominated by *S. patens*, which averaged 25.7% cover between years and ranged from a high of 69% mean cover in 2008, to a low of 8.2% mean cover in 2014. This species has shown an overall decline in relative abundance in recent years, with 2011 being the last year when it was the dominant species at the site. The vines *Ipomoea sagittata* (saltmarsh morning glory) and *Vigna luteola* (hairypod cowpea) have also been consistent components of the marsh community, averaging 14.7% and 14.0% cover between years, respectively (Figure 22).

Ten additional vegetation stations are located within an approximate two-mile radius of BA-0039 (Figure 3). These stations are associated with the Naomi Outfall Management (BA-0003c) project. The most recent vegetation survey for BA-0003c was conducted in 2009, with similar surveys done on a three-year interval since 1997. The species with the highest mean cover over years were the same as at CRMS4103: *S. patens* (50%), *I. sagittata* (7%) and *V. luteola* (7%) (Figure 23). One BA-0003c vegetation station (BA03c-48) was located within the BA-0039 project area and was surveyed a final time in 2006 prior to BA-0039 construction. The dominant species each year at this station was *S. patens*, with an average 70% cover between years, ranging from a high of 90% cover in 1997, to a low of 35% cover in 2003.

The BA-0039 created marsh shares most of the same species as those that are found in the surrounding natural marsh; however, the dominant species are noticeably different. As previously noted, *P. vaginatum* was planted in the BA-0039 project area and has been the dominant species recorded during each survey. While *P. vaginatum* is a naturally-occurring common species at CRMS sites in the Calcasieu/Sabine and Mermentau basins, it is less common at CRMS sites in the Barataria basin. *Spartina patens* has historically been the dominant species occurring in the surrounding natural marsh. This species is increasing in cover and range in the BA-0039 project area, which may indicate a transition towards a more stable vegetative community. In 2014, the cover for this species was nearly the same in the BA-0039 project area (7.8%) as at CRMS4103 (8.2%), with the cover at individual BA-0039 sites ranging from 3.0% to 13.4%.

A 2014 comparison of the FQI between the created marsh at BA-0039 and the natural marsh at CRMS4103 reveals that the FQI for the BA-0039 project area (43.2) is nearly identical to that for CRMS4103 (43.5). Sites BA39-01 and BA39-02 actually had higher FQIs than CRMS4103, at 55.1 and 49.6, respectively. The FQI for CRMS4103 has been somewhat variable over years, ranging from a high of 67.4 in 2008, to a low of 43.5 in 2014 (Figure 22). The years with higher FQI scores benefitted from a high sum of species covers, as well as a larger contribution to the total cover from high CC score species such as *S. patens* (CC = 9) and *I. sagittata* (CC = 8). The mean FQI for the ten BA-0003c stations surrounding the project area was higher than that at BA-0039 and was relatively stable between 1997 and 2009, ranging from 60.1 to 67.3, despite large fluctuations between years in the sum of the species covers (Figure 23). The percent cover of *S. patens* has played a strong role in the FQI value for these stations, as it did for CRMS4103.

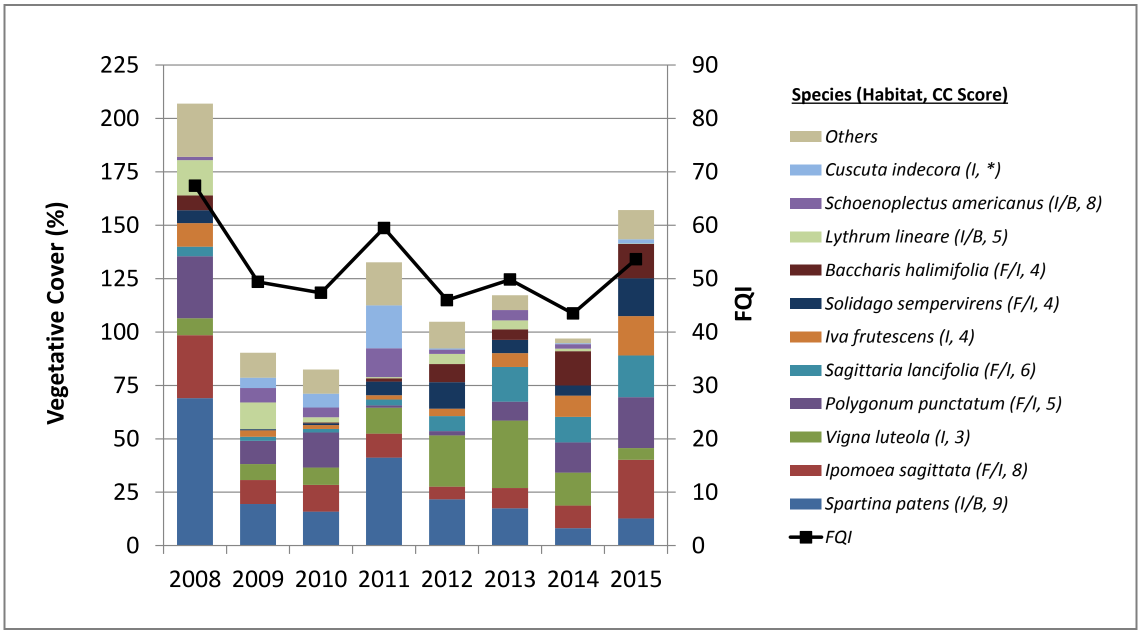


Figure 22. Mean cover (%) of species and FQI score for CRMS4103. The species in the legend are ordered based on the highest mean cover (%) over years, from bottom (*S. patens*–highest) to top (*C. indecora*–lowest). The marsh habitat where the species typically grows and its CC score are listed after the species name. F = fresh, I = intermediate, B = brackish, S = salt. * *C. indecora* (bigseed alfalfa dodder) is a non-rooted parasitic plant and is not included in the FQI calculation.

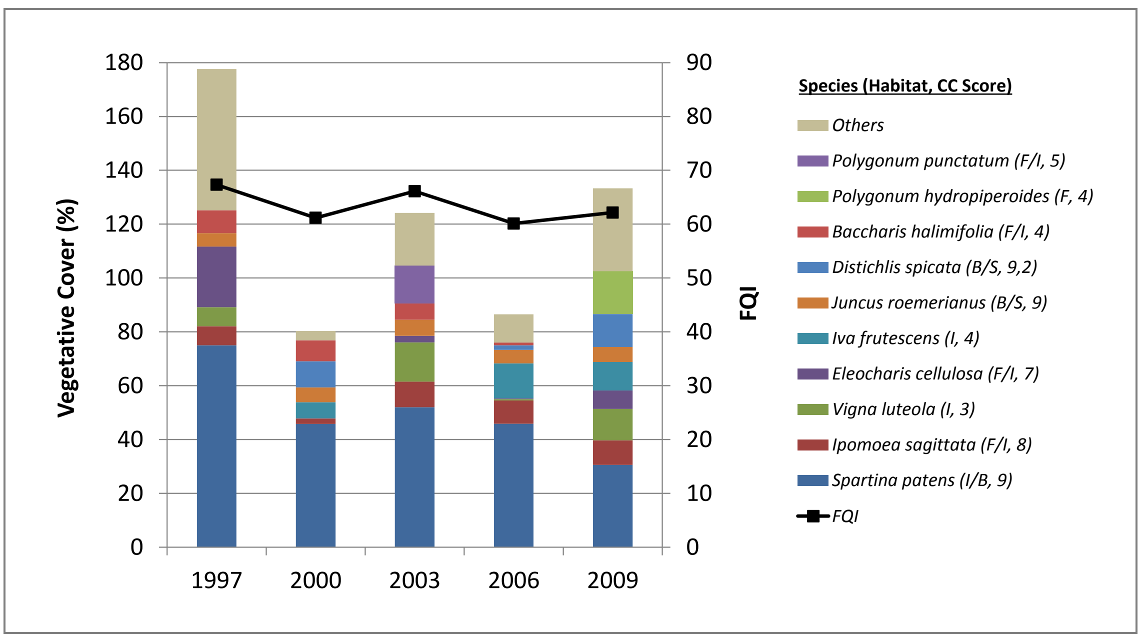


Figure 23. Mean cover (%) of species and FQI score for BA-0003c vegetation stations (n=10) located within 2 miles of the BA-0039 project area. The species in the legend are ordered based on the highest mean cover (%) over years, from bottom (*S. patens*–highest) to top (*P. punctatum*–lowest). The marsh habitat where the species typically grows and its CC score are listed after the species name. F = fresh, I = intermediate, B = brackish, S = salt.

v. Soil Properties

Soil cores were collected in September 2010, October 2013 and September 2015 from the three BA-0039 monitoring sites. The 2013 cores were collected as part of an independent CPRA-funded study. However, the data collection and analyses followed the same CRMS protocols used for the 2010 and 2015 surveys, and the 2013 data are therefore included with the analyses in this report. Soil properties were compared between sites and depths using ANOVA in Proc GLM, $\alpha = 0.05$, followed by a Tukey's post-hoc test (SAS Institute Inc., Cary, NC, version 9.4).

The soil that was dredged from the Mississippi River to create the marsh platform for BA-0039 was sandy with very low organic content. The mean percent organic matter of the cores analyzed in 2010 was only 1.62% ± 0.42% SE and was not significantly different between depths (Figure 24). These results are not surprising, considering organic material accumulates in soil largely due to the growth and subsequent death and decomposition of vegetation. The expectation was that the organic content of the soil would increase slowly throughout the life of the project, as was seen with Bayou LaBranche Marsh Creation (PO-0017) — a CWPPRA marsh creation project that was constructed with soil dredged from Lake Pontchartrain. The organic content of the PO-0017 soil increased over 17 years from 5.55% ± 0.25 SE in 1996, to 12.65% ± 1.42 SE in 2013 (Richardi 2014). Soil cores in this project were collected down to only 10 cm depth, within the zone where the greatest increase in organic matter would likely occur.

Between the 2010, 2013, and 2015 surveys, the percent organic content was significantly different in the top 8 cm of soil in the BA-0039 project area, with a surprisingly high increase between 2010 and 2013. The mean percent organic matter between 2010 and 2013 increased significantly from 1.60% ± 0.80 SE to 26.69% ± 5.30 SE in the upper 4 cm of soil, and from 1.03% ± 0.45 SE to 17.80% ± 5.04 SE between 4 cm and 8 cm of depth (Figure 24). At greater depths, there was no significant change in the percent organic matter between years. Soil cores that were collected and analyzed from BA-0039 in 2015 showed no significant change from the 2013 data, although there was a noticeable decline in organic matter between 4 cm and 8 cm.

Sandy sediment with low organic content, such as that used to construct BA-0039, tends to have less pore space between grains and as a result, has a higher bulk density (USDA NRCS 2008). The mean bulk density of the BA-0039 soil in 2010 was indeed high, at 1.28 g/cm^3 ± 0.04 SE, and was not significantly different between depths. While the organic content of soils can be expected to slowly increase over years in created marsh, bulk density can be expected to slowly decline. Again referencing the PO-0017 marsh creation project, over 17 years the bulk density of the soil decreased from 1.16 g/cm^3 ± 0.02 SE in 1996 to 0.58 g/cm^3 ± 0.06 SE in 2013, although it appeared to stabilize by 2005 (Richardi 2014).

As with percent organic content, the bulk density of the BA-0039 soil cores was compared within each soil depth layer to detect changes over time. Significant differences were seen in the top 12 cm of sediment, with a marked decrease in the bulk density between 2010 and 2013 (Figure 25). This decline was most pronounced in the upper 4 cm of sediment, where bulk density decreased from 1.18 g/cm^3 ± 0.09 SE in 2010 to 0.30 g/cm^3 ± 0.10 SE in 2013.

Soil cores collected from BA-0039 in 2015 showed no significant change in bulk density from 2013 between 0 cm and 8 cm depth; however, there was a significant increase between 8 cm and 12 cm (Figure 25). This increase may be explained by compaction of the sediment, which resulted in the sampling of the original marsh creation sediment, rather than the sediment deposited from Hurricane Isaac, or sampling in an area where there was less sediment deposition (discussed below). There has been no significant change in bulk density since 2010 at depths greater than 12 cm.

The significant changes in the percent organic content and bulk density of the soils in the BA-0039 project area are due to sediment deposition that resulted from Hurricane Isaac, which came ashore in southeast Louisiana on August 29, 2012. A post-hurricane assessment of the project, conducted by CPRA personnel on September 27, 2012, noted a considerable amount of wrack and a new thin layer of sediment deposition in the project area. Additionally, field notes from the first sediment sampling post-Isaac (October 2013) indicated 6–10 cm of sediment deposition on top of the sandy marsh surface. These observations, along with accretion and surface elevation change data collected at the BA-0039 stations after the hurricane, support that the pronounced changes in soil properties are due to new sediment deposition, rather than changes within the pre-existing marsh creation soils.

Mean percent organic matter and bulk density were compared between soil cores collected from BA-0039 and surrounding CRMS sites to compare soil characteristics of the created marsh to that of the nearby natural marsh. The 2013 BA-0039 data were not included in the analyses since the only significant difference between the 2013 and 2015 data was bulk density at 8–12 cm depth. Additionally, soil cores were collected from the CRMS sites between 2007 and 2008 and do not exhibit the effects of sediment deposition from Hurricane Isaac. The organic matter of soil cores collected from CRMS sites varied considerably based on location and marsh habitat, with CRMS0287 (fresh marsh) having the highest mean percent organic matter (84.50% ± 1.24 SE) and CRMS0248 (brackish marsh) having the lowest (28.67% ± 1.61 SE) (Figure 26). The percent organic matter of soil cores collected from BA-0039 in 2010 was significantly lower at all depths as compared to the surrounding CRMS sites ($p < 0.0001$). But by 2015, the percent organic matter in the upper 4 cm of the sediment column had greatly increased and was similar to that at sites CRMS0248 and CRMS0276 at the same depth. At greater depth, the mean percent organic matter for BA-0039 was still significantly lower than that measured at the four CRMS sites ($p < 0.05$).

The bulk density of the BA-0039 soil cores collected in 2010 was significantly higher at all depths than the bulk density of cores collected at the surrounding CRMS sites ($p < 0.0001$). Similar to percent organic matter, the bulk density of the soil collected from the CRMS sites varied considerably based on the site location and marsh habitat. CRMS0287 had the lowest mean bulk density (0.06 g/cm^3 ± 0.00 SE) and CRMS0248 had the highest (0.26 g/cm^3 ± 0.03 SE) (Figure 27). The analysis of the BA-0039 cores collected in 2015 showed a significant decrease in bulk density in the upper sediment layers to a level approaching that of the CRMS sites. Between 0 cm and 4 cm depth, the bulk density of the BA-0039 sediment was similar to that at all four CRMS sites, and between 4 cm and 8 cm depth, it was similar to that at CRMS0248. At greater depth, the mean percent organic matter for BA-0039 was significantly higher than that measured at the four CRMS sites ($p < 0.05$).

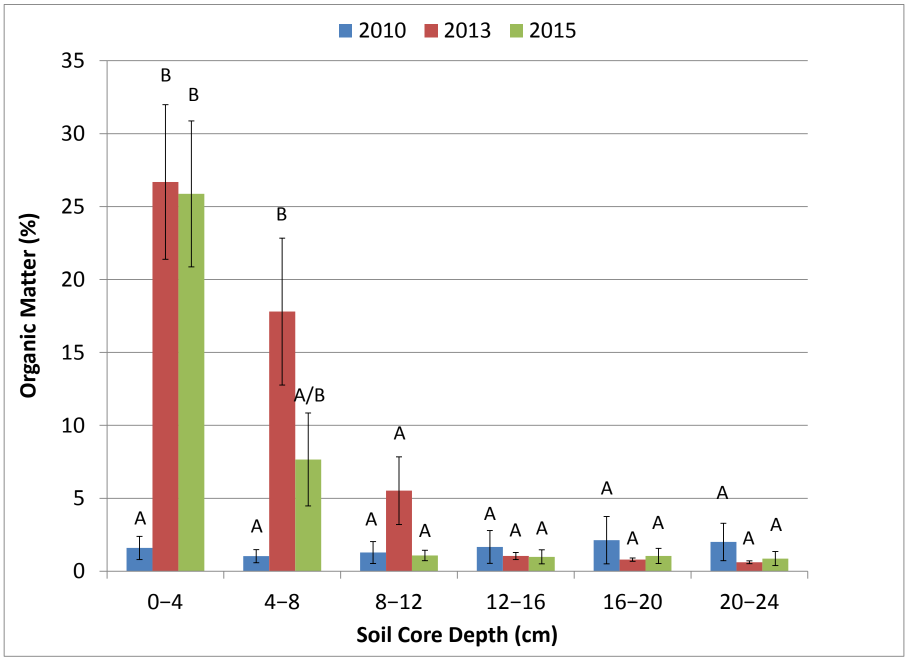


Figure 24. Mean organic matter (± SE) of soil cores collected in the BA-0039 project area. Significant differences between years at each depth are indicated by different letters (α = 0.05, n = 9; 0 cm – 4 cm: $p = 0.0003$, $F_{2,24} = 11.35$; 4 cm – 8 cm: $p = 0.0078$, $F_{2,24} = 5.99$).

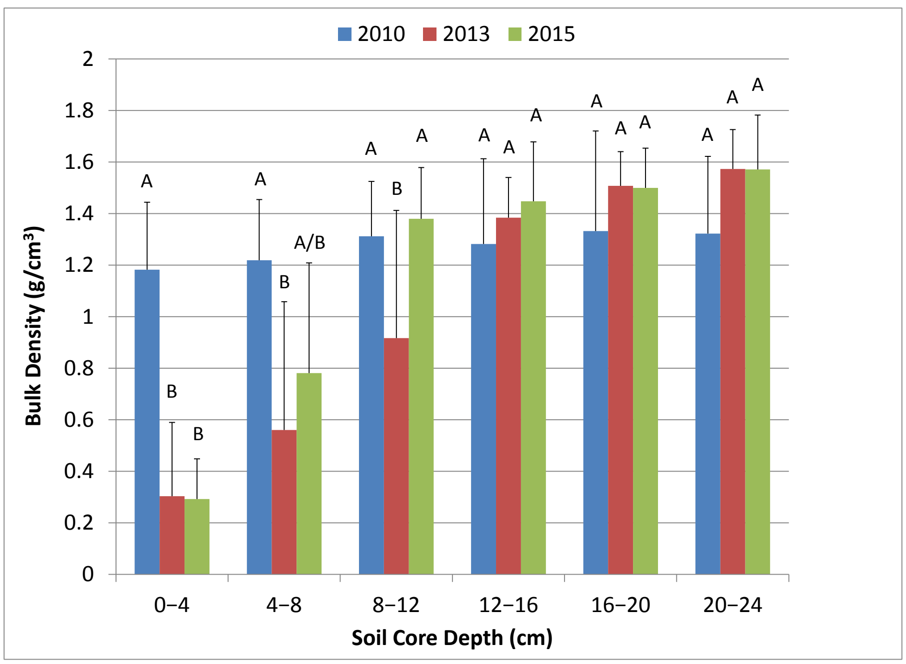


Figure 25. Mean bulk density (± SE) of soil cores collected in the BA-0039 project area Significant differences between years at each depth are indicated by different letters (α = 0.05, n = 9; 0 cm – 4 cm: $p < 0.0001$, $F_{2,24} = 40.33$; 4 cm – 8 cm: $p = 0.0065$, $F_{2,24} = 6.25$; 8 cm – 12 cm: $p = 0.0141$, $F_{2,24} = 5.12$).

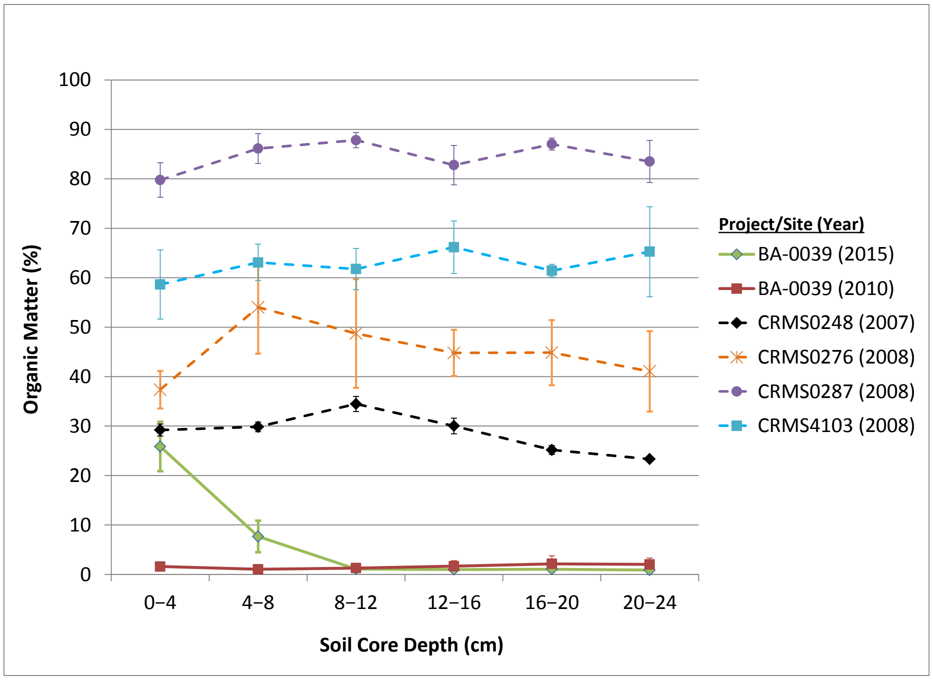


Figure 26. Mean percent organic matter (± SE) of soil cores collected from the BA-0039 project area and from surrounding CRMS sites. The year after the project/site name in the legend refers to the year of sample collection.

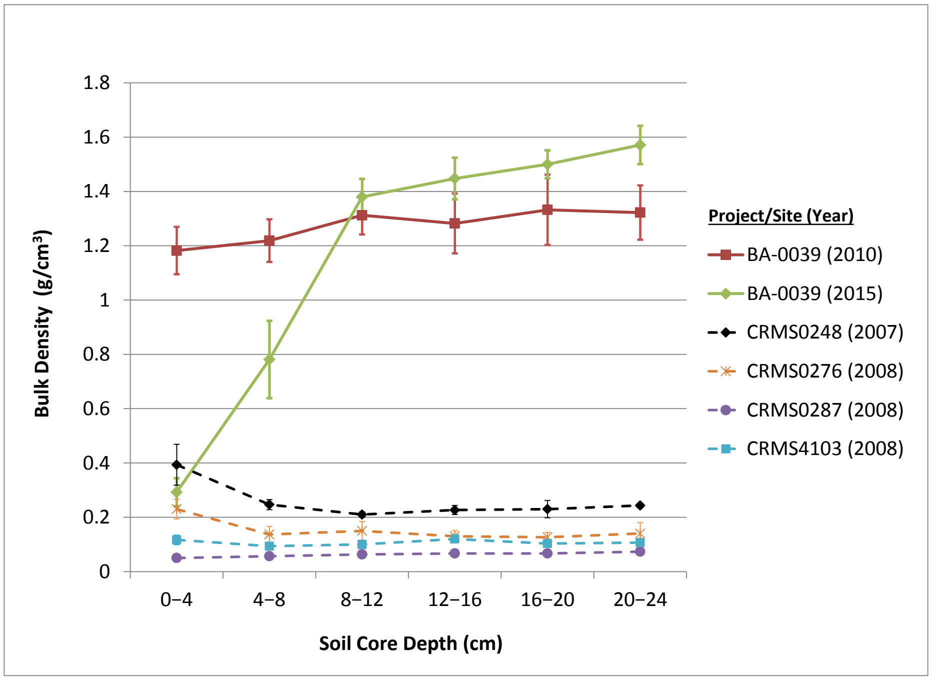


Figure 27. Mean bulk density (± SE) of soil cores collected from the BA-0039 project area and from surrounding CRMS sites. The year after the project/site name in the legend refers to the year of sample collection.

V. Conclusions

a. Project Effectiveness

The goals of BA-0039 are to restore/create approximately 372 acres and nourish approximately 99 acres of emergent marsh (total 471 acres) in an area that was mostly open water (USEPA, LDNR 2007). The land-water analysis classified 458 acres as land and 37 acres as water (495 total acres). While the acres of classified land are inflated due to an additional 24 project acres being incorporated into the land-water analysis, the analysis clearly indicates that the project has successfully used river sediment to create a viable marsh platform with a rapidly developing emergent marsh community. The 37 acres of water are largely due to the shallow ponding area that exists in the lower elevation region of Marsh Creation Area 2. It is possible that this area will prevent the attainment of 471 acres of emergent marsh, but flood tolerant species such as cattails do appear to be expanding in the region, as less flood-tolerant species are excluded.

Vegetation surveys have shown that the marsh platform has increased in emergent marsh vegetative cover between years, with the exception of areas that are experiencing prolonged to constant flooding. The plantings of *Paspalum vaginatum* and *Spartina alterniflora* were both effective at quickly establishing vegetation on and bordering the newly dredged sediment. *Paspalum vaginatum*, in particular, has done exceptionally well in the project area as a pioneer species and has remained the dominant species throughout survey years. This species is recommended for future marsh creation projects that utilize river sediment and are constructed in coastal areas with similar environmental conditions. The project's targeted elevation of +1.3 ft NAVD88 (Geoid99) at year 10 was based on the elevation of local, natural *Spartina patens* marsh. The BA-0039 project is still young, < 5 years old at the time of the 2014 vegetation survey; however, the cover and range of *S. patens* has been expanding at all monitoring sites and is likely indicative of a stabilizing and maturing marsh community.

b. Recommended Improvements

1) The as-built elevation survey is used to determine whether the marsh platform has been built to the permitted constructed elevation, which for BA-0039 was +2.0 ft ± 0.3 ft NAVD88 (Geoid99). Based on the elevations taken along the survey transects, the majority of the project area was constructed to an elevation ≥ +2.0 feet. Survey transects were established following a grid pattern and were spaced every 500 ft apart, with elevations taken every 50 ft along each transect line. When the transects are overlaid on aerial photography, it appears that due to their spacing, they failed to fully identify the extent of the lower elevation area in Marsh Creation Area 2 where ponding has occurred.

   It is recommended that as-built surveys are conducted in a way that improves the characterization of the surface of the project area. Decreasing the space between transects is one option; however, other methods may be better suited to capture the elevation of the area within the grid formed by the survey transects. It is recognized that increasing the number of transects increases the cost of the survey, but not all of the transects would need to be resurveyed in future years. Drones could also be used during construction to provide aerial imagery for the detection of potentially low elevation areas or other conditions outside of the permitted construction specifications. Suspect elevations within the project area could then be further explored and addressed prior to demobilization.

2) The design elevation for BA-0039 was +2.0 ft with a ± 0.3 ft tolerance for constructed fill height (NAVD88, Geoid99). It may be advisable to provide only a positive tolerance range, or at least decrease the negative tolerance limit, to encourage the attainment of the design elevation.

3) It is recommended that monitoring be extended from 12 years to 20 years, in accordance with the standard CWPPRA time frame for monitoring. A final land-water analysis, elevation survey, vegetation survey and soil analysis near year 20, as well as a project close-out report, would allow for an important longer-term assessment of the sustainability of this marsh creation project. Mississippi River Sediment Delivery System−Bayou Dupont was the first project constructed using Mississippi River sediment. As such, monitoring results are particularly important to gauge project performance and inform future marsh creation projects that also utilize river sediment. Twelve years of monitoring may not be enough time to gauge the success of this project and chronicle its transition towards a mature emergent marsh community.

c. Lessons Learned

1) The high percent cover for *Paspalum vaginatum* 'Brazoria' in the project area indicates that this species was a wise choice for planting. It is a recommended species for marsh creation plantings with similar environmental conditions due to its ability to rapidly colonize bare ground.

2) Ponding in the lower elevation area of Marsh Creation Area 2 may hinder the full attainment of project goals. A more robust as-built survey is advisable for future marsh creation projects, as it could identify areas that require additional fill prior to demobilization.

3) LiDAR surveys are well-suited for dry, unvegetated or lightly-vegetated project areas where accuracy of less than 10 cm is not required. These conditions were not met for the BA-0039 project. Questionable elevations required an additional survey using RTK to target areas where interference with the LiDAR data collection was suspected. Future elevation surveys for this project should be conducted using RTK surveying procedures, despite the likely higher cost.

4) Hurricane Isaac had a profound, measurable impact on the BA-0039 project area. The deposition of sediment from the storm surge increased surface elevation and served to temporarily offset subsidence. The deposited sediment also provided the project area with a layer of highly-organic sediment with low bulk density that could otherwise have taken decades to attain.

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Appendix A

2016 Inspection Photographs for Mississippi River Sediment Delivery System–Bayou Dupont (BA-0039)

Photo 1. A gap in the spoil bank on the eastern boundary of Marsh Creation Area 1 enhances hydrologic exchange within the project area.

Photo 2. A gap in the spoil bank on the southern boundary of Marsh Creation Area 1 enhances hydrologic exchange within the project area.

Photo 3. A gap was created in the southern containment dike of Marsh Creation Area 2 to enhance hydrologic exchange.

Photo 4. BA-0039 Marsh Creation Area 1, looking south from the BA-0043-EB sediment pipeline corridor. The pipeline is visible along the bottom of the photograph.

Photo 5. BA-0039 Marsh Creation Area 1, looking northwest from the BA-0043-EB sediment pipeline corridor.

Photo 6. BA-0039 Marsh Creation Area 2, looking west from atop the Plaquemines Parish flood protection levee.

Photo 7. BA-0039 Marsh Creation Area 2, looking south from atop the Plaquemines Parish flood protection levee.

Photo 8. *Spartina alterniflora* planted along the southwestern edge of BA-0039 Marsh Creation Area 2 in 2010 continues to thrive.

Appendix B

Mississippi River Sediment Delivery System–Bayou Dupont (BA-0039) OM&M Budget

with 3-Year Budget Projection

Mississippi River Sediment Delivery System - Bayou Dupont BA-0039																				
Federal Sponsor: USEPA																				
Construction Completed : 2010																				
PPL 12																				
Budget in federal fiscal years (October 1-September 30)																				
Current Approved OM&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
	FY11	FY12	FY13	FY14	FY15	FY16	FY17	FY18	FY19	FY20	FY21	FY22	FY23	FY24	FY25	FY26	FY27	FY28	FY29	FY30
State O&M (inspections)	$6,809	$3,197	$5,612	$3,326	$5,267	$3,726	$3,529	$3,600	$4,442	$3,900	$3,777	$4,152	$3,930	$4,008	$4,089	$4,170	$4,254	$4,339	$4,426	$4,514
Corps Admin	$785	$801	$817	$834	$850	$867	$885	$902	$921	$939	$958	$977	$996	$1,016	$1,037	$1,057	$1,079	$1,100	$1,122	$1,145
Federal S&A	$6,809	$3,197	$5,612	$3,326	$5,267	$3,726	$3,529	$3,600	$4,442	$3,900	$3,777	$4,152	$3,930	$4,008	$4,089	$4,170	$4,254	$4,339	$4,426	$4,514
Total O&M	$14,403	$7,195	$12,041	$7,486	$11,384	$8,319	$7,943	$8,102	$9,805	$8,739	$8,512	$9,281	$8,856	$9,032	$9,215	$9,397	$9,587	$9,778	$9,974	$10,173
Monitoring																				
Aerial Photography			$14,167						$15,957											
Survey - Project Area and Settlement Plates	$52,325		$54,495		$56,638															
Survey - Borrow Area	$41,860																			
Geotechncial Instrumentation for Monitoring Hydraulically Dredged Fill Material	$37,608																			
Monitoring Site Installation, Construction, and Survey O&M	$36,628																			
Vegetation	$7,849		$8,174			$8,674			$9,205			$9,769								
Soil Samples	$4,252				$4,602					$5,086										
RSET	$1,125	$1,149	$1,172	$1,195	$1,219	$1,243	$1,268	$1,294	$1,319	$1,346										
Total Annual Monitoring	$181,647	$1,149	$78,008	$1,195	$62,459	$9,917	$1,268	$1,294	$26,481	$6,432	$0	$9,769	$0	$0	$0	$0	$0	$0	$0	$0
Total Annual OM&M	$196,050	$8,344	$90,049	$8,681	$73,843	$18,236	$9,211	$9,396	$36,286	$15,171	$8,512	$19,050	$8,856	$9,032	$9,215	$9,397	$9,587	$9,778	$9,974	$10,173
Total Budget Amount	**$568,841**																			

Current Approved OM&M Budget (Revised Schedule)	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
	FY11	FY12	FY13	FY14	FY15	FY16	FY17	FY18	FY19	FY20	FY21	FY22	FY23	FY24	FY25	FY26	FY27	FY28	FY29	FY30
State O&M (inspections)	$6,809	$3,197	$5,612	$3,326	$5,267	$3,726	$3,529	$3,600	$4,442	$3,900	$3,777	$4,152	$3,930	$4,008	$4,089	$4,170	$4,254	$4,339	$4,426	$4,514
Corps Admin	$785	$801	$817	$834	$850	$867	$885	$902	$921	$939	$958	$977	$996	$1,016	$1,037	$1,057	$1,079	$1,100	$1,122	$1,145
Federal S&A	$6,809	$3,197	$5,612	$3,326	$5,267	$3,726	$3,529	$3,600	$4,442	$3,900	$3,777	$4,152	$3,930	$4,008	$4,089	$4,170	$4,254	$4,339	$4,426	$4,514
Total O&M	$14,403	$7,195	$12,041	$7,486	$11,384	$8,319	$7,943	$8,102	$9,805	$8,739	$8,512	$9,281	$8,856	$9,032	$9,215	$9,397	$9,587	$9,778	$9,974	$10,173
Monitoring																				
Aerial Photography			$14,167									$15,957								
Survey - Project Area and Settlement Plates		$52,325			$54,495						$56,638									
Survey - Borrow Area	$41,860																			
Geotechncial Instrumentation for Monitoring Hydraulically Dredged Fill Material	$37,608																			
Monitoring Site Installation, Construction, and Survey O&M	$36,628																			
Vegetation	$7,849	$8,174			$8,674			$9,205				$9,769								
Soil Samples	$4,252					$4,602						$5,086								
RSET	$1,125	$1,149	$1,172	$1,195	$1,219	$1,243	$1,268	$1,294	$1,319	$1,346										
Total Annual OM&M	$129,322	$61,648	$15,339	$1,195	$64,388	$5,845	$1,268	$10,499	$1,319	$1,346	$56,638	$30,812	$0	$0	$0	$0	$0	$0	$0	$0
Total Annual OM&M	$143,725	$68,843	$27,380	$8,681	$75,772	$14,164	$9,211	$18,601	$11,124	$10,085	$65,150	$40,093	$8,856	$9,032	$9,215	$9,397	$9,587	$9,778	$9,974	$10,173
Total Budget Amount	**$568,841**																			

The Current Approved OM&M Budget (Revised Schedule) represents the modified monitoring schedule based on monitoring that has already occurred and the revised projected years for monitoring events. Note: the year for each monitoring event corresponds to the expected year the charges will be applied to the budget. See section IV. Monitoring Activity, b. Monitoring Elements (p. 5) for the actual years the monitoring events occur. The highlighted years (FY17–FY19) represent the current 3-year budget projection.

Appendix C

Field Inspection Notes for Mississippi River Sediment Delivery System–Bayou Dupont

(BA-0039)

MAINTENANCE INSPECTION REPORT CHECK SHEET

Project No. / Name: **BA-0039 Mississippi River Sediment Delivery System - Bayou Dupont**

Date of Inspection: 05/25/2016 Time: 9:30 am

Structure No. N/A

Inspector(s): Hopkins, Richardi, Crawford

Structure Description: N/A

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

Type of Inspection: Annual

Weather Conditions: Partly Cloudy, Light Wind

Item	Condition	Pysical Damage	Corrosion	Photo #	Observations and Remarks
Containment dikes	Good	None	N/A	Appendix A, photos 1–3	
Marsh Creation Areas	Good	None	N/A	Appendix A, photos 4–8	
Highway Casing					Casing is not visible. It is in use by the current contractor for conveying sediment to the next project.
Railroad Casing					Casing is not visible. It is in use by the current contractor for conveying sediment to the next project.

Notes: No signs of vandalism in the project area.

Appendix D

Station Surface Elevation Change and Accretion Graphs for Mississippi River Sediment Delivery System–Bayou Dupont

(BA-0039)

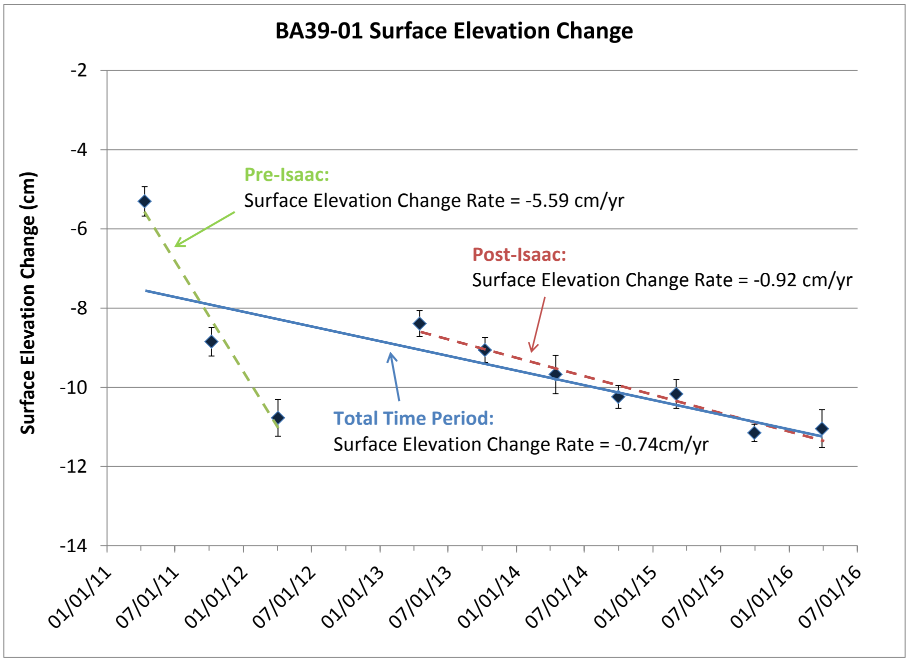

Figure 1. Surface elevation change (± SE) at RSET station BA39-01SO1. Surface elevation change rates are calculated for the entire monitoring period, pre-Hurricane Isaac, and post-Hurricane Isaac.

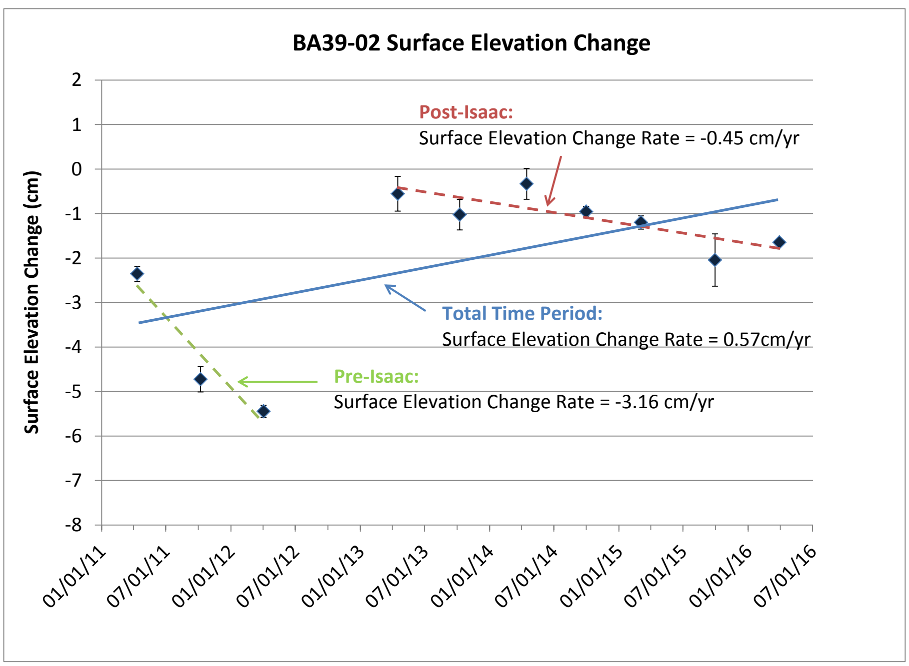

Figure 2. Surface elevation change (± SE) at RSET station BA39-02SO1. Surface elevation change rates are calculated for the entire monitoring period, pre-Hurricane Isaac, and post-Hurricane Isaac.

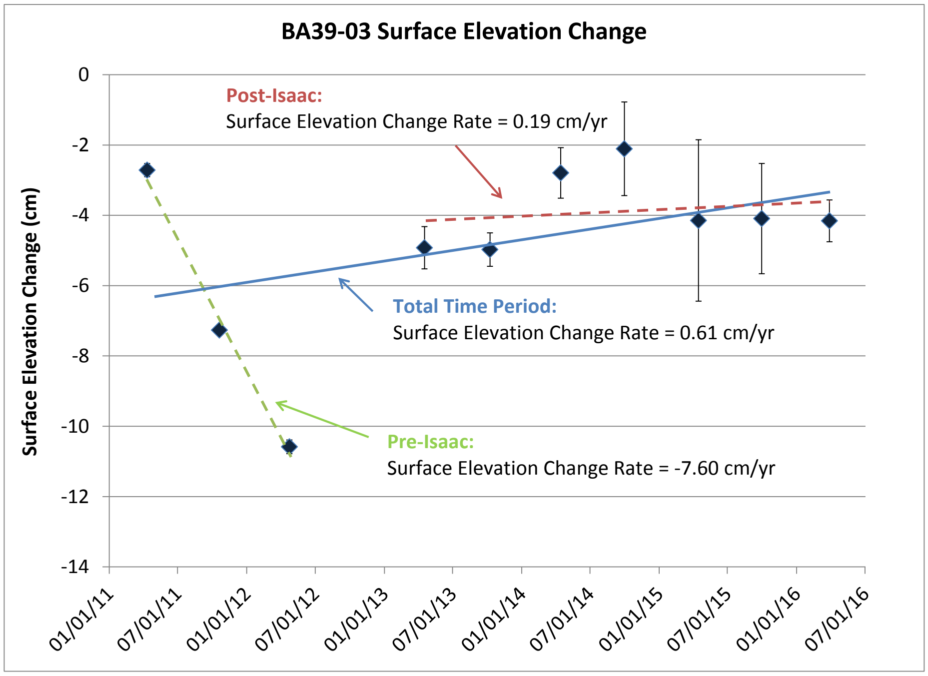

Figure 3. Surface elevation change (± SE) at RSET station BA39-03SO1. Surface elevation change rates are calculated for the entire monitoring period, pre-Hurricane Isaac, and post-Hurricane Isaac.

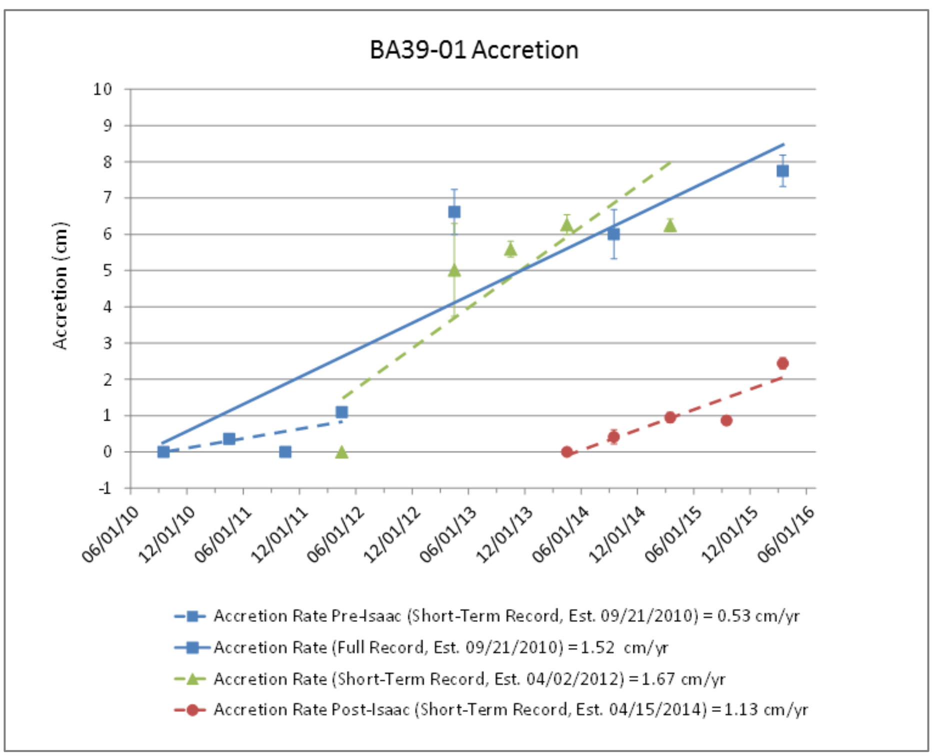

Figure 4. Accretion (± SE) at BA39-01. Accretion rates are calculated for the entire monitoring period, pre-Hurricane Isaac, and post-Hurricane Isaac.

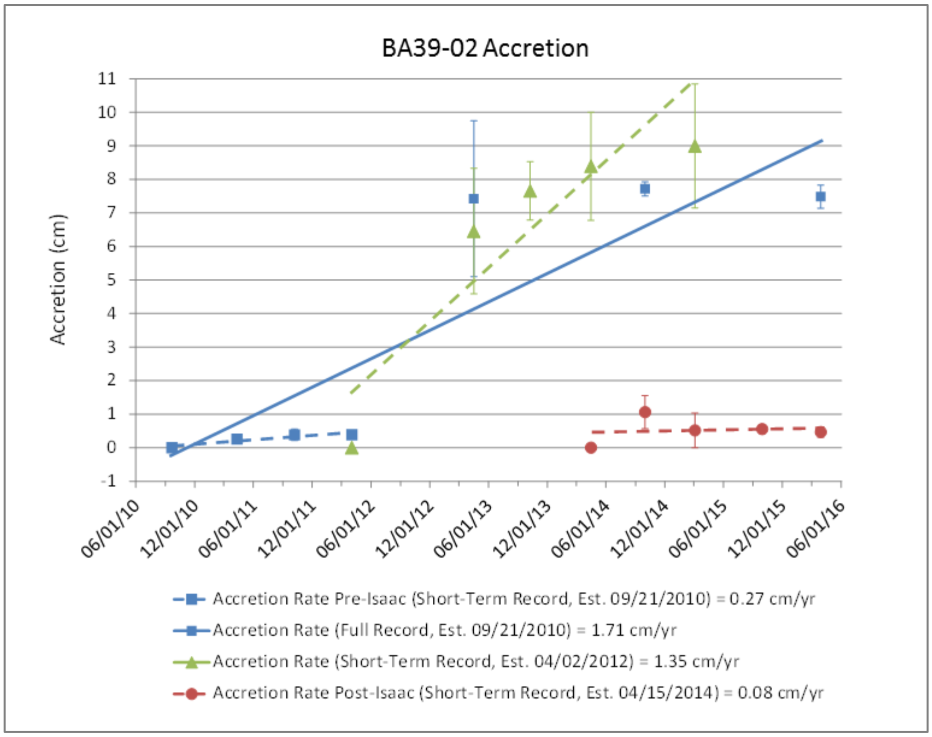

Figure 5. Accretion (± SE) at BA39-02. Accretion rates are calculated for the entire monitoring period, pre-Hurricane Isaac, and post-Hurricane Isaac.

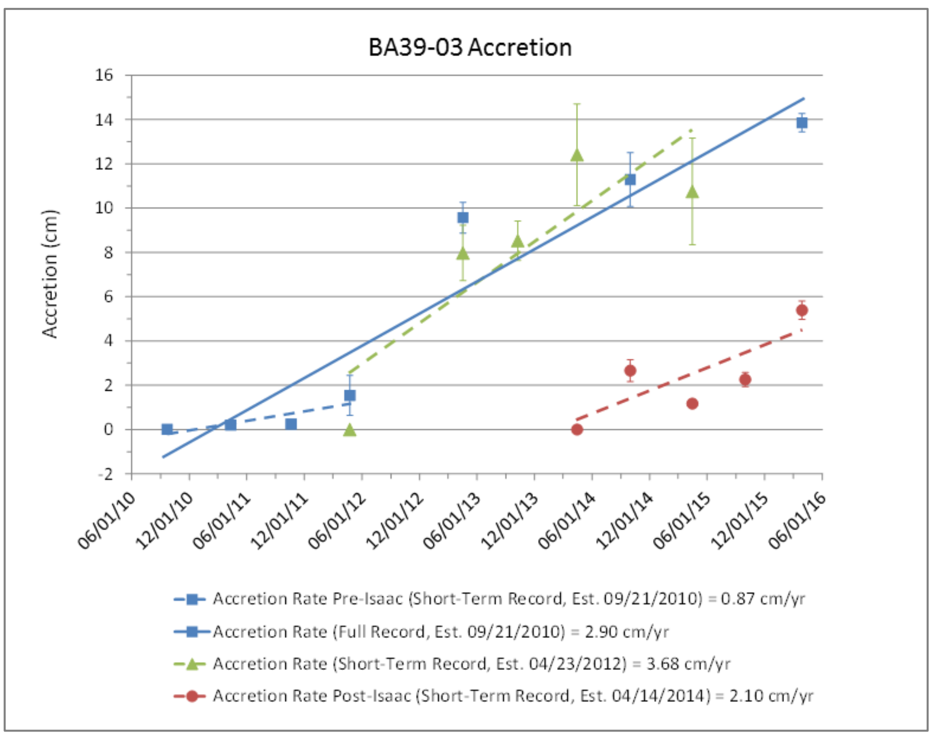

Figure 6. Accretion (± SE) at BA39-03. Accretion rates are calculated for the entire monitoring period, pre-Hurricane Isaac, and post-Hurricane Isaac.