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

2012 Operations, Maintenance, and Monitoring Report

for

Little Lake Shoreline Protection/Dedicated Dredging Near Round Lake (BA-37)

State Project Number BA-37
Priority Project List 11

June 2012
Lafourche Parish

Prepared by:
Glen P. Curole
and
Adam M. Ledet

Operations Division
Thibodaux Field Office
1440 Tiger Drive, Suite B
Thibodaux, LA 70301

Suggested Citation:

Curole, G. P. and A. M. Ledet. 2012. *2012 Operations, Maintenance, and Monitoring Report for Little Lake Shoreline Protection/Dedicated Dredging Near Round Lake (BA-37), Coastal Protection and Restoration Authority of Louisiana, Thibodaux, Louisiana. 47 pp.*

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For
Little Lake Shoreline Protection/Dedicated Dredging Near Round Lake
(BA-37)

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Preface

This report includes monitoring data collected through February 2012, and annual Maintenance Inspections through May 2012.

The 2012 report is the 2nd report in a series of OM&M reports. For additional information on lessons learned, recommendations and project effectiveness please refer to the 2010 Operations, Maintenance, and Monitoring Report on the CPRA web site.

I. Introduction

The Little Lake Shoreline Protection/Dedicated Dredging Near Round Lake (BA-37) project is a shoreline protection, marsh creation, and marsh nourishment restoration project located in the southwestern portion of the Barataria Basin in Lafourche Parish, LA (figure 1). The project area consists of 556 ha (1,374 acres) of intermediate marsh and open water habitat found along the southern lake rim of Little and Round Lakes. The project was federally sponsored by the National Marine Fisheries Service (NMFS) and locally sponsored by the Coastal Protection and Restoration Authority of Louisiana (CPRA) under the Coastal Wetlands Planning, Protection, and Restoration Act (CWPPRA). The BA-37 project was part of the 11th CWPPRA priority project list (PPL 11). The shoreline protection phase of this restoration project extends for 7,917 m (25,976 ft) from the eastern bank of the Breton Canal to the western bank of John the Fool Bayou along the southern shoreline of Little and Round Lakes (figure 2). The marsh creation and nourishment phase of the BA-37 project forms its eastern border with the western bank of John the Fool Bayou, its western border with the eastern bank of the Tennessee Gas Pipeline Canal, and its northern border with the southern Round Lake shoreline (figure 2). The Bayou L'Ours Ridge lies directly south of the project, and the Louisiana Offshore Oil Port's (LOOP) oil storage caverns and brine retention pond are situated southwest of the project (figure 2).

The Bayou L'Ours subdelta was formed during the Lafourche deltaic lobe period (Gagliano and Wicker 1989). During this time, Bayou Lafourche and its network of distributaries comprised the main channel of the Mississippi River. Nutrient rich sediments were deposited along the banks of these distributaries primarily through overbank flooding (Sasser and Evers 1995). As a result, a ridge network (natural levees) was established along these channels creating enclosed basins encircled by elevated ridges (Gagliano and Wicker 1989).

In the years since the creation of the Lafourche delta, the sediment and freshwater supply to the Bayou L'Ours subdelta has decreased considerably. The Mississippi River changed its course to form the Plaquemine and Balize deltaic lobes, a dam was placed at the junction of the Mississippi River and Bayou Lafourche in 1904, and the Mississippi River was

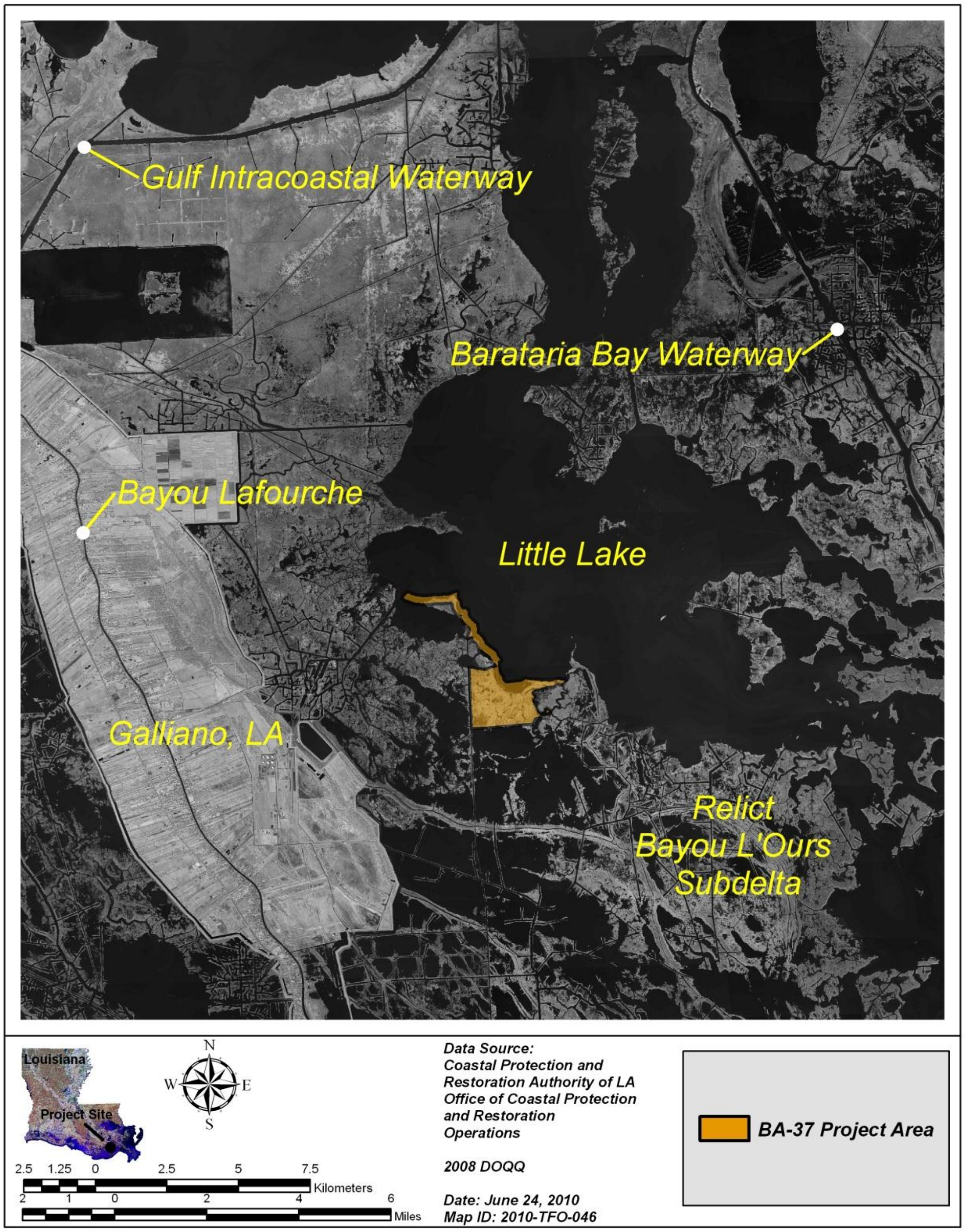


Figure 1. Location and vicinity of the Little Lake Shoreline Protection/Dedicated Dredging Near Round Lake (BA-37) project.

Figure 2. Location of the Little Lake Shoreline Protection/Dedicated Dredging Near Round Lake (BA-37) project area.

channelized by the construction of artificial levees along its banks. In addition, Bayou L'Ours has become a relict distributary of Bayou Lafourche (Sasser and Evers 1995). Therefore, the hydrology of the Barataria Basin as well as the Bayou L'Ours subdelta has been altered by natural and anthropogenic changes in freshwater and sediment distributions.

The reduced freshwater and sediment supply has been a major influence in the formation of highly organic freshwater and intermediate marshes surrounded by slowly subsiding ridges and lake rims composed of mineral sediment deposits (Gagliano and Wicker 1989; Sasser and Evers 1995). These impounded organic marshes formed a floating marsh mat (flotant) overlying a layer of peat and organic muck (Gagliano and Wicker 1989; Sasser and Evers 1995). Sediment-poor organic soils accrete vertically predominately through slow oxidation of decaying plant matter and vegetative growth (root elongation) (Nyman et al. 1993; Delaune et al. 1993).

The soils found in the BA-37 project area are composed of a Lafitte-Clovelly association. These organic soils are generally found in very poorly drained brackish marshes (USDA 1984). Chabreck and Linscombe classified the project area as intermediate marsh in 1997, brackish to intermediate marsh in 1988, and brackish marsh in 1978. The area was also classified as brackish marsh by Chabreck et al. in 1968 and as floating three corner grass marsh by O'Neil in 1949. This area has been mapped as *Spartina patens* (saltmeadow cordgrass) and *Schoenoplectus americanus* (chairmaker's bulrush) brackish marsh (Sasser and Evers 1995; USDA 1984). *Eleocharis parvula* (dwarf spikerush), *Bacopa monnieri* (herb of grace), and *Ipomoea sagittata* (saltmarsh morning-glory) have also been found to inhabit Lafitte-Clovelly association soils (USDA 1984).

There was very little marsh degradation in the Bayou L'Ours basin until the advent of canal dredging for pipeline construction and oil field access in the 1940's (Gagliano and Wicker 1989). During the 1950's and 1960's, several rather deep access canals were allowed to breach the Bayou L'Ours ridge creating large gaps in the ridge which significantly altered the hydrology in the semi enclosed basin (Gagliano and Wicker 1989; Sasser and Evers 1995). These canals decreased the marsh surface elevations of the highly organic marsh mats, and introduced saltwater into a fresh and intermediate marsh environment. Tidal scouring of organic sediments, vegetation die-back, and subsidence resulted in extensive interior wetland loss (Gagliano and Wicker 1989; Sasser and Evers 1995). Land loss data indicate that wetland area in the Bayou L'Ours basin decreased by 6,085 acres (2,434 ha) and total open water increased by 6,197 acres (2,509 ha) during the period from 1945 to 1989 (Sasser and Evers 1995). Specifically, the marshes between the Bayou L'Ours ridge and the Little and Round Lake rims showed considerable interior wetland loss from 1956 to 1978 (Sasser and Evers 1995). The marsh creation and nourishment area continued to experience large scale inland wetland loss from 1978 to 1990 (figure 3) (Barras et al. 1994). These marshes are reportedly subsiding at a rate of 0.006-0.011 m/yr (0.021-0.035 ft/yr) (Sweeney 2001). The

Little and Round Lake rims have continually transgressed from 1956 to1990 and are reportedly eroding at a rate of 6-12 m/yr (20-40 ft/yr) (Sweeney 2001).

The Little Lake Shoreline Protection/Dedicated Dredging Near Round Lake (BA-37) project consist of two major features, a shoreline protection structure and marsh creation and nourishment area. A 7,917 m (25,976 ft) foreshore rock dike was constructed along the -0.6 m (-2 ft) NAVD 88 contour of Little and Round Lakes (figure 3). The rock dike was constructed by placing rocks on top of a geotextile foundation. The dike was constructed using three lifts. All segments of the 7,917 m (25,976 ft) dike received the first two rock lifts, and 5,804 m (19,041 ft) of the dike was recapped during the third lift (figure 3). Approximately, 145,528 tons of 250 lbs class rocks were used to construct the first two lifts and 29,762 tons of R650 class rocks were used to construct the third lift. The two lift segments of the dike were built to an elevation of 0.8 m (2.5 ft) NAVD 88 while the third lift segments were built to elevations of 1.1 m (3.5 ft) NAVD 88 and 1.2 m (4.0 ft) NAVD 88. Fish dips (breaches in the rock structure) were installed in the foreshore rock dike every 305 to 457 m (1,000 to 1,500 ft) for fisheries access. Construction of the BA-37 foreshore rock dike began on March 21, 2006 and was completed by February 11, 2007.

The marsh creation and nourishment phase of this project consisted of three project features: containment dikes, marsh creation in open water areas, and marsh nourishment over existing marsh. Several earthen containment dikes were placed along the border of the marsh creation and nourishment area (figure 3). These structures were built to an elevation of 1.1 m (3.5 ft) NAVD 88. The sediments dredged from Little Lake were pumped into the marsh creation and nourishment disposal area (figure 3). Approximately, 372 ha (920 acres) of marsh platform were created and nourished during construction. These constructed marshes were raised to a 0.72 m (2.36 ft) NAVD 88 elevation. After sediment consolidation, the containment dike was gapped in several locations. Construction of the BA-37 marsh creation and nourishment area began on November 26, 2005 and ended on August 14, 2006.

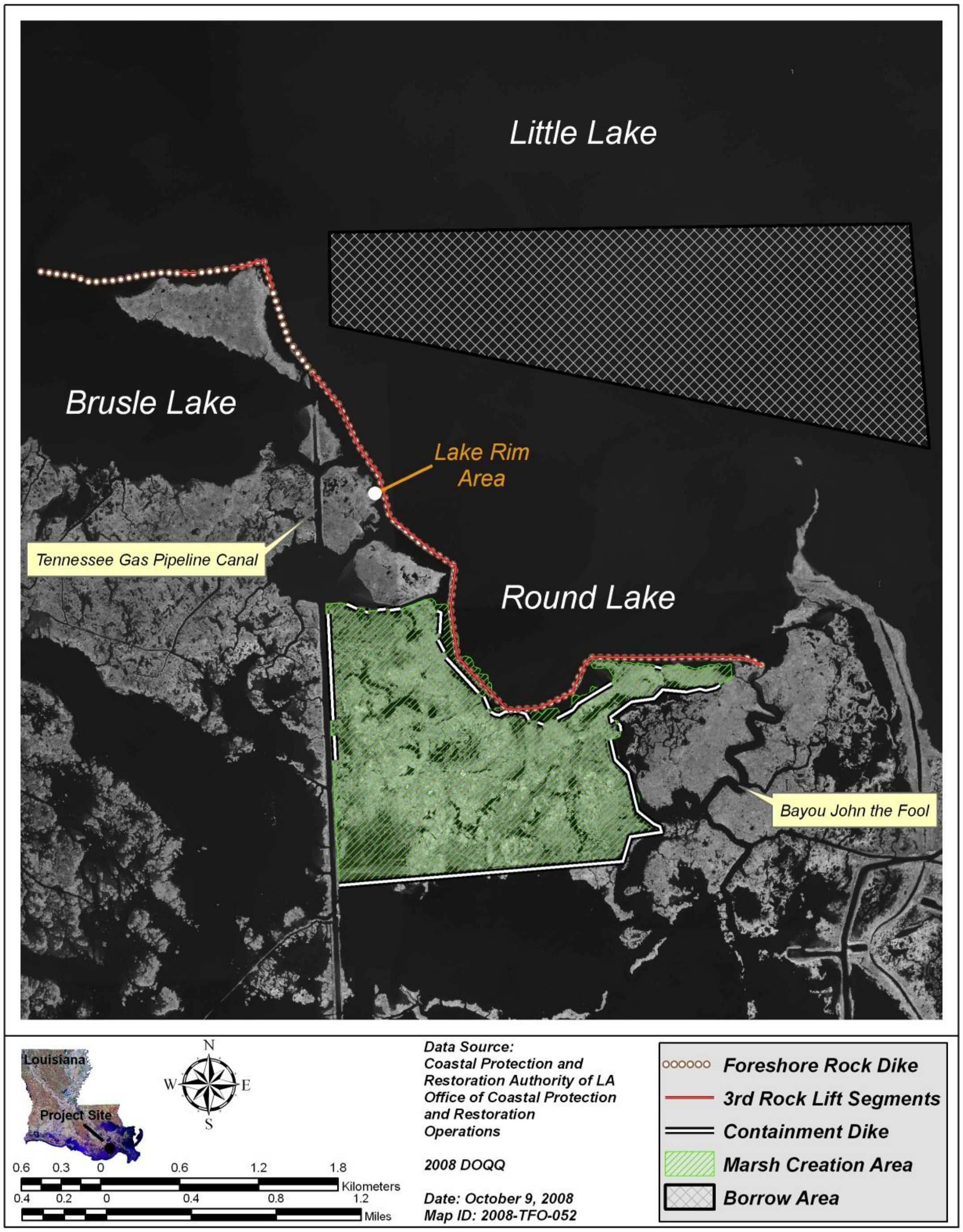


Figure 3. Location of the Little Lake Shoreline Protection/Dedicated Dredging Near Round Lake (BA-37) project features.

II. Maintenance Activity

a. Project Feature Inspection Procedures

The purpose of the annual inspection of the Little Lake Shoreline Protection / Dedicated Dredging near Round Lake Project (BA-37) is to evaluate the constructed project features in order to identify any deficiencies. The inspection results are used to prepare a report detailing the condition of the project features and recommending any corrective actions considered necessary. Should it be determined that corrective actions are needed, the OCPR shall provide, in the report, a detailed cost estimate for engineering, design, supervision, inspection, construction, and contingencies and an assessment of the urgency of such repairs (O&M Plan, 2008). The annual inspection report also contains a summary of maintenance projects which were completed since completion of constructed project features and an estimated projected budget for the upcoming three (3) years for operation, maintenance, and rehabilitation. In addition to the three (3) year budget, a spreadsheet has been included showing the baseline O&M funding and current approved O&M funding levels. The three (3) year projections for operation and maintenance are shown in Appendix C. A summary of past operation and maintenance projects completed since construction of the Little Lake Shoreline Protection / Dedicated Dredging Near Round Lake Project is outlined in Section IV.

The annual inspection of the Little Lake Shoreline Protection / Dedicated Dredging Near Round Lake Project (BA-37) took place on May 29th, 2012. In attendance were Adam Ledet, Shane Triche, and Glen Curole of CPRA; John Foret with NMFS; and Randy Moertle representing the landowner. The attendees met at the Clovelly Canal Boat Launch and traveled to the project area by boat. The annual inspection began at approximately 11:00am at the west end of the rock shoreline protection at Segment 1 in Bay L'Ours and ended at the southeast end of the rock dike at John the Fool Bayou. The field trip included a visual inspection of the 24 rock dike segments of the shoreline protection, all warning signs, and the outer edges of the marsh creation area. The marsh creation area was viewed from the northern boundary along the south shoreline of Round Lake and the southwest corner of the area. The inspection ended at approximately 1:20pm with a water level reading of 0.6' NAVD88 at station BA-02-57. Photographs from the inspection are located in Appendix A.

b. Inspection Results

<u>Rock Segments 1 – 24 (Photos 1 – 22, 29 – 36, Appendix A)</u>

All rock segments were visually inspected by boat. As expected, it appears all rock segments have experienced some amount of rock settlement. Some segments have portions that are below EL 2.5 FT including those that did not receive a third lift during construction (1-5, 8, 9). There are no recommendations for corrective action at this time; however the segments should continue to be monitored for further settlement.

The elevation of the settlement plates were initially surveyed after construction in 2007 and then again every year until 2011. Comparing the final construction survey elevations of the settlement plates (February 2007) to the latest settlement plate survey (September 2011) shows an average settlement of 0.42 feet across the 24 segments, with the most extreme settlement being 0.70 feet. The survey conducted in 2011 (year 4) was the latest of the five surveys done since construction. The surveys will continue in years 10 and 15 of the project life to determine additional settlement of the rock dike and if a maintenance lift of the rock dike is needed.

Spoil that was placed behind the rock segments has fully vegetated. Also, it appears that the SAV (submerged aquatic vegetation) behind the rock segments continues to increase from past inspections. This can be seen in the inspection photos located in Appendix A.

Currently, Rock Segments 1 and 2 have no marsh or vegetation along their southern edge, only open water. The fringe mash that once separated Brusle Lake and Bay L'Ours, located along Rock Segments 1 and 2, has been eroded below the water level by Hurricane Katrina. This land loss occurred during construction of the project and the rock segments were put in place as designed and contracted. There are no recommendations for maintenance at this time; however this site will continue to be monitored to determine if the rock segments have become a hazard, and corrective actions will be conducted as needed.

<u>Marsh Creation Area (Photos 22 – 24, Appendix A)</u>

The fill material in the marsh creation area has fully vegetated. As mentioned above, marsh creation area grid point "O&M" surveys were performed in May 2008, June 2009, July 2010, and September 2011 as well as "as-built" and 9-month post-placement (May 2007) surveys. Figure 5 through Figure 10 displays the change in marsh creation elevation from the time of construction to the time of the latest available data (September 2011).

The 2011 rock dike and marsh survey will serve as the fifth of year 1-5 surveys. It was completed in September 2011 and its marsh creation elevations can be seen in Figure 10. There will also be "O&M" surveys of the marsh creation area in Years 10 and 15 as per the O&M Plan.

c. Maintenance Recommendations

i. **Immediate/ Emergency Repairs**
None

ii. **Programmatic/ Routine Repairs**
Install a staff gage.

d. Maintenance History

Below is a summary of completed maintenance projects and operation tasks performed since completion of the Little Lake Shoreline Protection / Dedicated Dredging Near Round Lake Project (BA-37).

May 2008 – Survey of marsh creation area was performed by Shaw Coastal, Inc. The marsh elevations at the grid points within the marsh creation area as well as top elevations of the 24 rock dike settlement plates were collected. This survey represents the first of the scheduled O&M surveys to be performed but is actually the second post-construction survey. The first post-construction survey was performed by Shaw Coastal, Inc. in May 2007 with remaining construction funds immediately following acceptance of the project. The actual surveying consultant costs associated with the 2008 survey was $36,007.28.

July 2009 – Survey of marsh creation area was performed by Shaw Coastal, Inc. The marsh elevations at the grid points within the marsh creation area as well as top elevations of the 24 rock dike settlement plates were collected. This survey represents the second of the scheduled O&M surveys to be performed but is actually the third post-construction survey. The actual surveying consultant costs associated with the 2009 survey was $42,590.40.

July 2010 – Survey of marsh creation area was performed by Morris Hebert, Inc. The marsh elevations and the grid points within the marsh creation area as well as the tops elevations of the rock dike settlement plates were collected. This survey represents the third of the scheduled O&M surveys to be performed but is actually the forth post-construction survey. The actual surveying consultant costs associated with the 2010 survey is $23,500.

September 2011 – Survey of the marsh creation area, rock dike, and settlement plates was performed by Morris Hebert, Inc. The marsh elevations and the grid points within the marsh creation area, the profile of the rock dike sections, as well as the tops elevations of the rock dike settlement plates were collected. This survey represents the last of the scheduled O&M surveys to be performed post-construction. The actual surveying consultant cost associated with the 2011 survey was $60,013.23.

III. Operations Activity

No operation activities are required for the BA-37 project.

IV. Monitoring Activity

Pursuant to a CWPPRA Task Force decision on August 14, 2003 to adopt the Coastwide Reference Monitoring System-*Wetlands* (CRMS-*Wetlands*) for CWPPRA, updates were made to the BA-37 Monitoring Plan to merge it with CRMS-*Wetlands* and provide more useful information for modeling efforts and future project planning while maintaining the monitoring mandates of the Breaux Act. There is one CRMS site located in the project area, CRMS6303. This site was added to the marsh creation and nourishment area after construction on October 24, 2008.

a. Monitoring Goals

The specific project strategies of the Little Lake Shoreline Protection/Dedicated Dredging Near Round Lake (BA-37) project are (1) to construct a foreshore rock dike along the Little and Round Lake shorelines to reduce the marsh edge erosion rate, (2) to place dredged sediments in confined open water disposal areas to create intermediate or brackish marsh, (3) to plant *Spartina alterniflora* (smooth cordgrass) plugs to stabilize marsh creation disposal areas and increase emergent marsh vegetation cover, and (4) to place dredged sediments above the marsh surface to nourish existing marsh. The construction of a foreshore rock dike will slow erosion along the southwestern Little Lake shoreline by damping wind-induced wave energy. The placement of dredged material and subsequent establishment of vegetation is expected to result in the direct creation and nourishment of marsh habitat at an elevation of 1.0 ft (0. 3 m) NAVD 88 by the 5th year of the post-construction period (Belhadjali and Cowan 2003).

The specific measurable goals established to evaluate the effectiveness of the project are:

1. Reduce the marsh edge erosion rate along the Little and Round Lake shorelines.
2. Create approximately 551 acres (223 ha) of marsh at suitable elevations for growth and establishment of intermediate or brackish emergent vegetation.
3. Nourish approximately 406 acres (164 ha) of existing marsh to enhance the growth and establishment of intermediate or brackish emergent vegetation.
4. Maintain 799 acres (323 ha) of emergent marsh at the end of the 20 year project life.

b. Monitoring Elements

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

Elevation

Topographic surveys were employed to document elevation and volume changes inside the Little Lake Shoreline Protection/Dedicated Dredging Near Round Lake (BA-37) project area. Pre-construction (December 2005), and as-built (August 2006) elevation data were collected in the marsh creation area using cross sectional (500 ft intervals) and real time kinematic (RTK) survey methods. Subsequent post-construction topographic surveys were performed in June 2007, May 2008, August 2009, August 2010, and October 2011. In addition, twenty-four (24) settlement plates were surveyed using RTK methods to estimate foreshore rock dike subsidence. The settlement plates were surveyed during installation (March to November 2006), during the second rock lift (August 2006 to January 2007), during the as-built survey (February 2007), and during the post-construction period in May 2008, August 2009, July 2010, and September 2011. All survey data were established using or adjusted to tie in with the Louisiana Coastal Zone (LCZ) GPS Network.

Survey data were re-projected horizontally and vertically to the UTM NAD83 coordinate system and the NAVD 88 vertical datum in meters using Corpscon® software. The re-projected data were imported into ArcView® GIS software for surface interpolation. Triangulated irregular network models (TIN) were produced from the point data sets. Next, the TIN models were converted to grid models (2.0 m^2 cell size), and the spatial distribution of elevations were mapped. The grid models were clipped to the BA-37 marsh creation area and settlement plate polygons to estimate elevation and volume changes.

Elevation changes from December 2005-August 2006, August 2006-June 2007, August 2006-May 2008, August 2006-August 2009, August 2006-August 2010, and August 2006-October 2011 in the marsh creation area were calculated by subtracting the corresponding grid models using the LIDAR Data Handler extension of ArcView® GIS. Settlement plate elevation changes were calculated using the aforementioned procedures in November 2006-January 2007, November 2006-Feburary 2007, November 2006-May 2008, November 2006-August 2009, November 2006-July 2010, and November 2006-September 2011. After the elevation change grid models were generated, the spatial distribution of elevation changes in the BA-37 marsh creation area and on the settlement plates were mapped in quarter meter elevation classes. Lastly, volume changes in the marsh creation area were calculated in cubic meters (m^3) using the Cut/Fill Calculator function of the LIDAR Data Handler extension of ArcView® GIS. Volumes changes were not calculated for the settlement plates because foreshore rock dike subsidence was the parameter investigated. Note, these elevation and volume calculations are valid only for the extent of the survey area.

Shoreline Change

Shoreline position data were analyzed to estimate shoreline changes inside the BA-37 project area using the Digital Shoreline Analysis System (DSAS version 2.1.1) extension of ArcView® GIS (Thieler et al). Pre- and post-construction change rates were calculated for the marsh creation area and the lake rim area (project shoreline outside of marsh creation area) (figures 2 and 3) independently. Shoreline positions were determined by digitizing aerial photographs at a 1:800 scale as per the Steyer et al. (1995) method, which defines shoreline position as the edge of the live emergent vegetation. The resulting polylines established the shoreline positions in UTM NAD 83 coordinates. Pre-construction and post-construction aerial photographs were acquired over an eleven year period to discern the foreshore rock dike's effect on shoreline erosion rates. Pre-construction aerial photographs were collected on February 4, 1998; April 15, 2003; January 25, 2004; and November 1, 2005 while post-construction aerial photographs were captured on September 20, 2007 (6 months post-construction) October 29, 2008 (1.5 years post-construction), and July 12, 2010 (3.5 years post-construction). All images were georectified using UTM NAD 83 horizontal datum.

The February 1998, April 2003, January 2004 and November 2005 shorelines were created in ArcView® GIS software to establish pre-construction shoreline change rates, and the September 2007, October 2008, and July 2010 shorelines were created to establish post-construction shoreline change rates. Secondly, an offshore baseline was generated from an offset of the February 1998 shoreline. Thirdly, the DSAS attribute editor was populated by identifying shorelines and the baseline and dating shorelines. Next, 1000 m (3280 ft) simple transects were cast from the baseline at 50 m (164 ft) intervals producing shoreline change, intersect, and transect shapefiles. Then, these shapefiles were edited by eliminating transects that intersect the shorelines at irregular angles. Finally, shoreline change data were imported into Excel® to calculate average and annual erosion rates for each period. Shoreline change rates were assessed and mapped for the ensuing periods February 1998-April 2003, April 2003-January 2004, January 2004-November 2005, February 1998-November 2005, September 2007-October 2008, and October 2008-July 2010 for the area behind the 7,925 m (26,000 ft) BA-37 foreshore rock dike.

Lake Rim Area

Pre-construction (February 1998, April 2003, January 2004 and November 2005) and post-construction (September 2007, October 2008, and July 2010) aerial photographs were utilized to delineate the area of lake rim portion (figures 2 and 3) of the BA-37 project over time. The areal extent of the lake rim area was estimated by drawing polygons around the subaerial land within the lake rim area at a 1:5000 scale. Once drawn the area inside the polygons were calculated using the Calculate Area function of ArcGIS®.

CRMS Supplemental

Additional data collected at CRMS-*Wetlands* stations is being used as supporting or contextual information for the BA-37 project. Data types collected at CRMS sites include hydrologic, emergent vegetation, physical soil characteristics, discrete porewater salinity, marsh surface elevation change, vertical accretion, and land/water analysis of 0.4 mi^2 (1.0 km^2) area encompassing the station (Folse et al. 2012). For this report, land/water analysis, vegetation data, and hydrologic data from one site situated within the project area (CRMS6303) will be used to characterize the structure of the project area marshes (figures 2 and 4). In the future, data collected from the CRMS network over a sufficient amount of time to develop valid trends will be used to develop integrated data indices at different spatial scales (local, basin, coastal) to which we can compare project performance.

Land/Water Classification CRMS6303

Land/water analysis was performed on a 1.0 km^2 (0.4 mi^2) portion of the marsh creation area at the CRMS6303 site (figures 2 and 4). The U.S. Geological Survey's National Wetlands Research Center (USGS/NWRC) obtained 1.0 m (3.3 ft) resolution color infrared (CIR) aerial photography to delineate land and water habitats over time. A pre-construction aerial image was captured on November 1, 2005 and a post-construction image was captured on October 29, 2008. These images were analyzed, interpreted, processed, and verified for quality and accuracy using protocols established in Folse et al. (2012). Specifically, habitats in the 1 km^2 (0.4 mi^2) were condensed to a land or water classification. Land was considered to be a combination of emergent marsh, scrub-shrub, wetland forested, and upland habitats. The open water, beach/bar/flat, and submerged aquatics (SAV) habitat classes were considered water. Once grouped into these two classes, the acreages of land and water were calculated. After the analysis was complete, the classification data and the photomosaic were mapped to spatially view the data. The percentages of land and water and the land to water ratios were also determined to summarize the data.

Vegetation CRMS6303

Vegetation data was collected in the BA-37 marsh creation area at the CRMS6303 site (figures 2 and 4) to document species composition and percent cover over time. Ten (10) plots were placed inside the 200 m^2 (239 yd^2) square, which is nested within the 1.0 km^2 (0.4 mi^2) square, as per Folse et al. (2012) (figure 7). Vegetation data were collected in October 2008 (2 year post-construction), July 2009 (3 years post-construction), June 2010 (4 years post-construction), and July 2011 (5 years post-construction) via the semi-quantitative Braun-Blanquet method (Mueller-Dombois and Ellenberg 1974; Sawyer and Keeler-Wolf 1995; Barbour et al. 1999). Plant species inside each 4m^2 plot were identified, and cover values were ocularly estimated. After sampling the plot, the residuals within a 5 m (16 ft) radius were inventoried. Mean percent cover was calculated to summarize the vegetation data and was grouped by year. Floristic quality index (FQI) was also estimated using the Cretini and Steyer (2011) protocol. Site FQI assessments were derived using mean percent cover values and coefficient of conservatism (CC) scores.

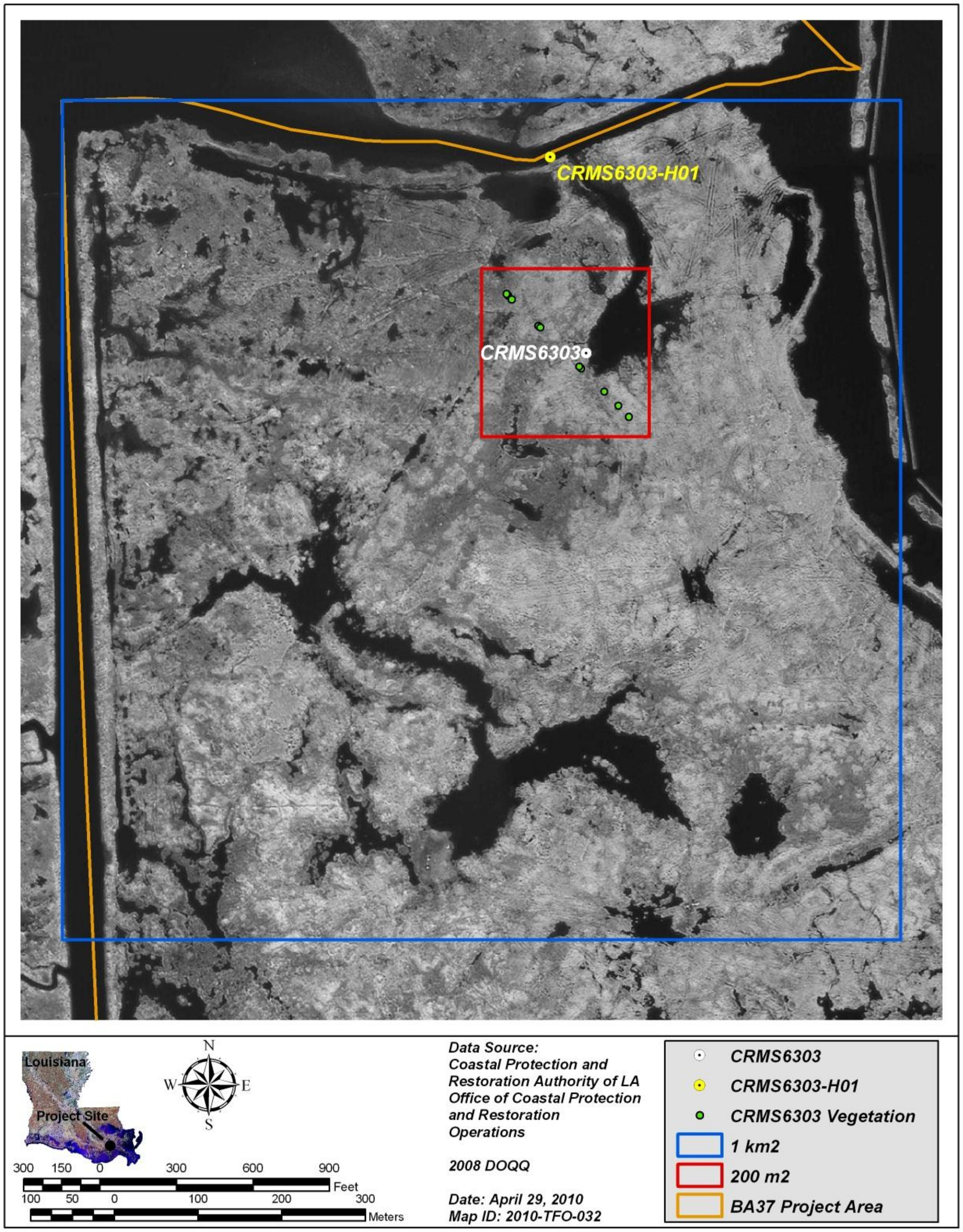


Figure 4. Location of CRMS6303 inside the Little Lake Shoreline Protection/Dedicated Dredging Near Round Lake (BA-37) project.

Hydrologic Data CRMS6303

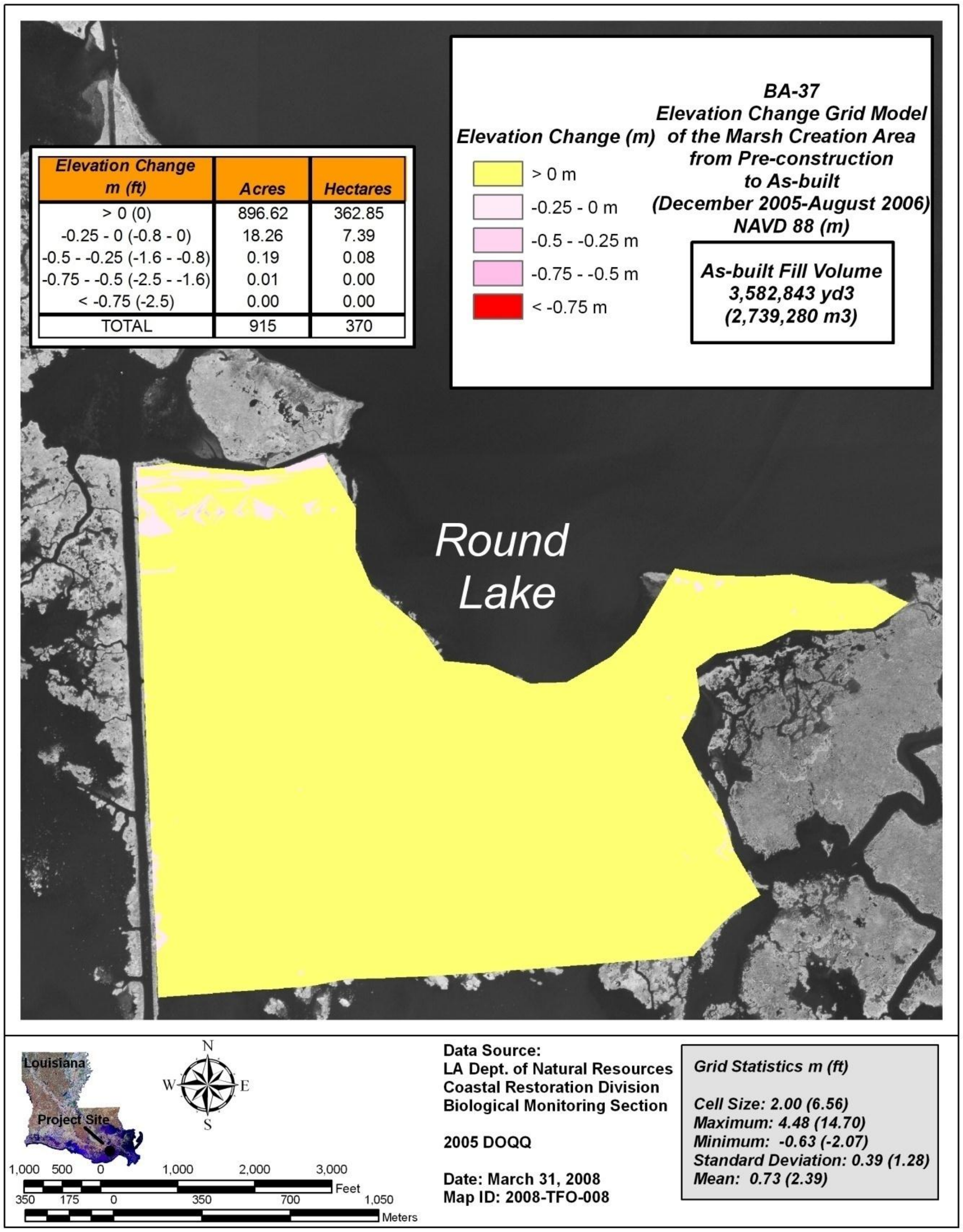
Hydrologic data is being collected at CRMS6303 in the BA-37 marsh creation area (figures 2 and 4). One (1) continuous recorder station was installed in the BA-37 project area to collect temperature (°C), specific conductance (μS/cm), salinity (ppt), and water level (ft) data on an hourly interval. The station was deployed and serviced, and the data was processed and verified for quality and accuracy in accordance with the Folse et al. (2012) protocol. The continuous recorder station was established on October 24, 2008 and has been under constant operation since that time. Daily mean water level and salinity data were calculated to summarize the data collected from this hydrologic monitoring station during the period from October 2008 to February 2012. In addition, annual hydrologic indexes (HI) were calculated for this site using mean salinity, percent time flooded, and the intermediate marsh classification. The HI scores are computed for a given water year, which begins October 1 and ends the following September 30.

c. Preliminary Monitoring Results and Discussion

Elevation

The Little Lake Shoreline Protection/Dedicated Dredging Near Round Lake (BA-37) marsh creation and nourishment area experienced volume reductions since construction was completed in 2006. Elevation change and volume distributions for the BA-37 marsh creation area are shown in figure 5 (Dec 2005-Aug 2006), figure 6 (Aug 2006-Jun 2007), figure 7 (Aug 2006-May 2008), figure 8 (Aug 2006-Aug 2009), figure 9 (Aug 2006-Aug 2010), and figure 10 (Aug 2006-Oct 2011). Elevation grid models for the Dec 2005, Aug 2006, Jun 2007, May 2008, Aug 2009, Aug 2010, and Oct 2011 surveys are also provided in appendix C. The volume and mean elevation changes inside the BA-37 constructed marsh are also plotted in figure 11. Approximately, 2,739,280 m^3 (3,582,843 yd^3) of sediment were deposited during construction in the marsh creation area (figures 5 and 11). In the post-construction period, sediment volume decreased by 29% from Aug 2006 to Jun 2007 (figures 6 and 11), by 35% from Aug 2006 to May 2008 (figures 7 and 11), by 44% from Aug 2006 to Aug 2009 (figures 8 and 11), by 41% from Aug 2006 to Aug 2010 (figures 9 and 11), and by 44% from Aug 2006 to Oct 2011 (figures 10 and 11). The total sediment volume loss in the marsh creation area from Aug 2006 to Oct 2011 was approximately 1,200,220 m^3 (1,569,828 yd^3). While the volume has declined by 44% since construction, a substantial volume of sediments remain in place [1,529,110 m3 (2,013,015 yd3)], and the rate of volume loss has been relatively flat since 2009 (figure 11). The corresponding post-construction mean elevation change inside the marsh creation area is graphically shown in figures 11 and 12 and the grid models in appendix C. Comparing the measured mean elevation changes to estimated values derived from consolidation curves (Eustis 2003) for fill elevations of 0.55 m (1.80 ft), 0.64 m (2.10 ft), 0.72 m (2.36 ft) and 0.91 m (3.00 ft), reveal that marsh creation area is settling and subsiding in agreement with its fill elevation consolidation curve, 0.72 m (2.36 ft) (figure 12). These preliminary results provide evidence suggesting that marsh creation area is condensing at a sustainable rate. Therefore, the goals to create marsh at suitable elevations and nourish existing marsh were achieved, and the goal to maintain emergent marsh at the end of the 20 year project life is still attainable.

The BA-37 foreshore rock dike has incurred minor settlement since construction was completed in 2007. Elevation changes for the foreshore rock dike are delineated in figure 13 (Mar 2006-Feb 2007), figure 14 (Mar 2006-May 2008), figure 15 (Mar 2006-Aug 2009), figure 16 (Mar 2006-Jul 2010), and figure 17 (Mar 2006-Sep 2011). The rock dike settled 0.61 m (2.00 ft) during construction. This primary settlement of the dike occurred from settlement plate installation to the as-built survey (Mar 2006-Feb 2007) (figure 13). Post-construction secondary settlement of the foreshore rock dike has shown settlement of 0.06 m (0.23 ft) from Feb 2007 to May 2008 (figure 14), 0.09 m (0.30 ft) from Feb 2007 to Aug 2009 (figure 15), 0.09 m (0.30 ft) from Feb 2007 to Jul 2010 (figure 16), and 0.13 m (0.44 ft) from Feb 2007 to Sep 2011 (figure 17). The



Elevation Change m (ft)	Acres	Hectares
> 0 (0)	896.62	362.85
-0.25 - 0 (-0.8 - 0)	18.26	7.39
-0.5 - -0.25 (-1.6 - -0.8)	0.19	0.08
-0.75 - -0.5 (-2.5 - -1.6)	0.01	0.00
< -0.75 (-2.5)	0.00	0.00
TOTAL	915	370

Figure 5. Elevation and volume change grid model from pre-construction (Dec 2005) to as-built (Aug 2006) at the Little Lake Shoreline Protection/Dedicated Dredging Near Round Lake (BA-37) project.

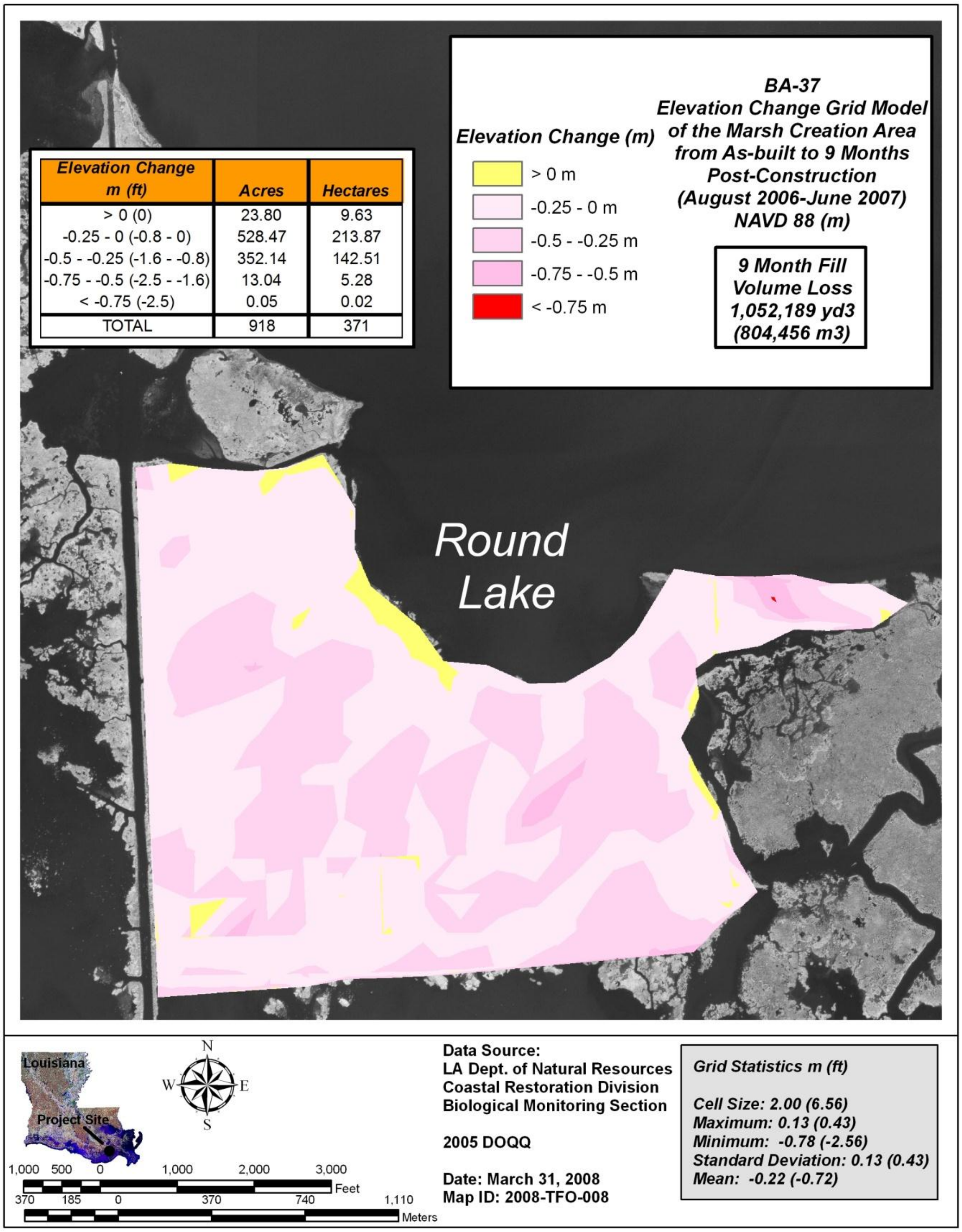


Figure 6. Elevation and volume change grid model from as-built (Aug 2006) to post-construction (Jun 2007) at the Little Lake Shoreline Protection/Dedicated Dredging Near Round Lake (BA-37) project.

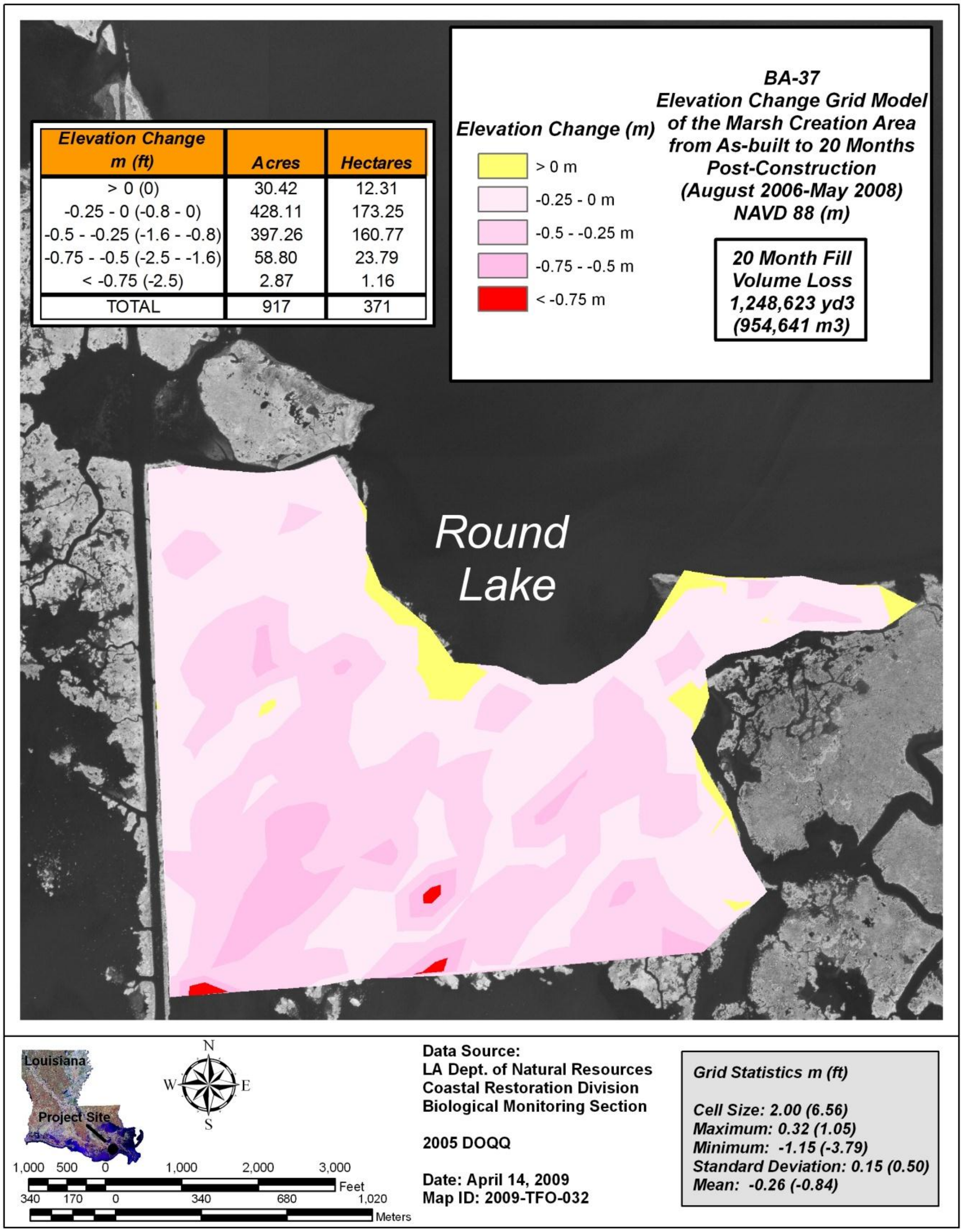


Figure 7. Elevation and volume change grid model from as-built (Aug 2006) to post-construction (May 2008) at the Little Lake Shoreline Protection/Dedicated Dredging Near Round Lake (BA-37) project.

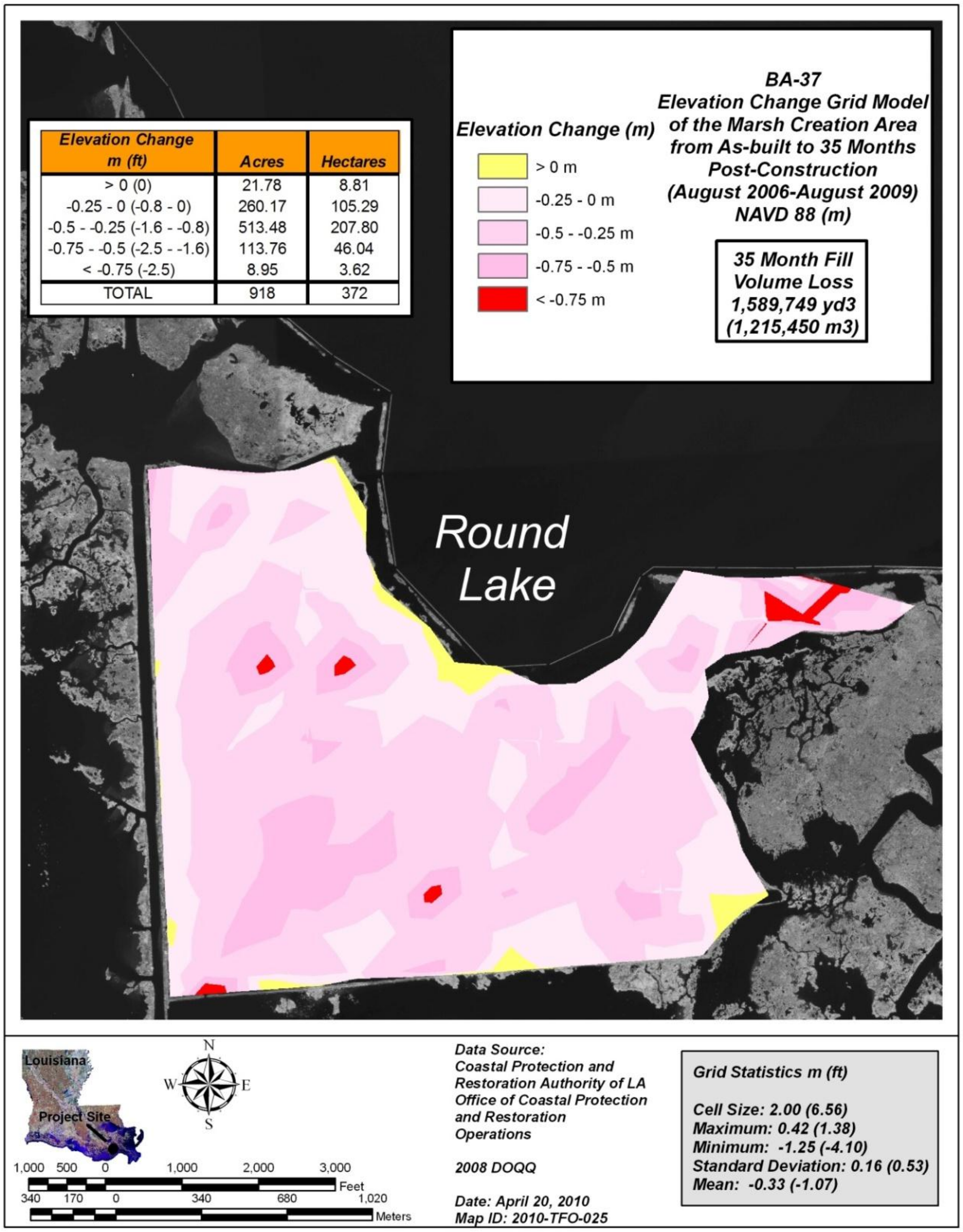


Figure 8. Elevation and volume change grid model from as-built (Aug 2006) to post-construction (Aug 2009) at the Little Lake Shoreline Protection/Dedicated Dredging Near Round Lake (BA-37) project.

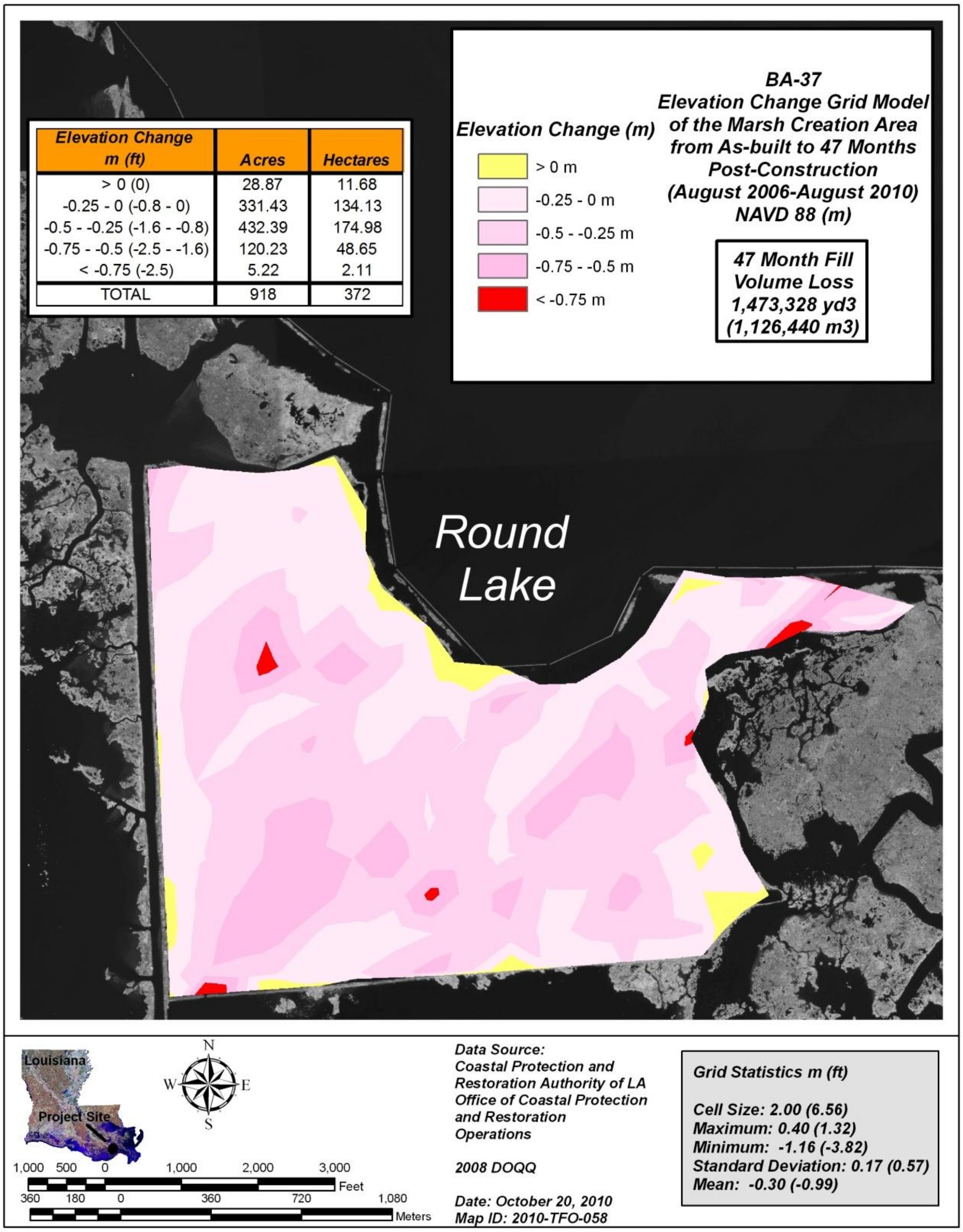


Figure 9. Elevation and volume change grid model from as-built (Aug 2006) to post-construction (Aug 2010) at the Little Lake Shoreline Protection/Dedicated Dredging Near Round Lake (BA-37) project.

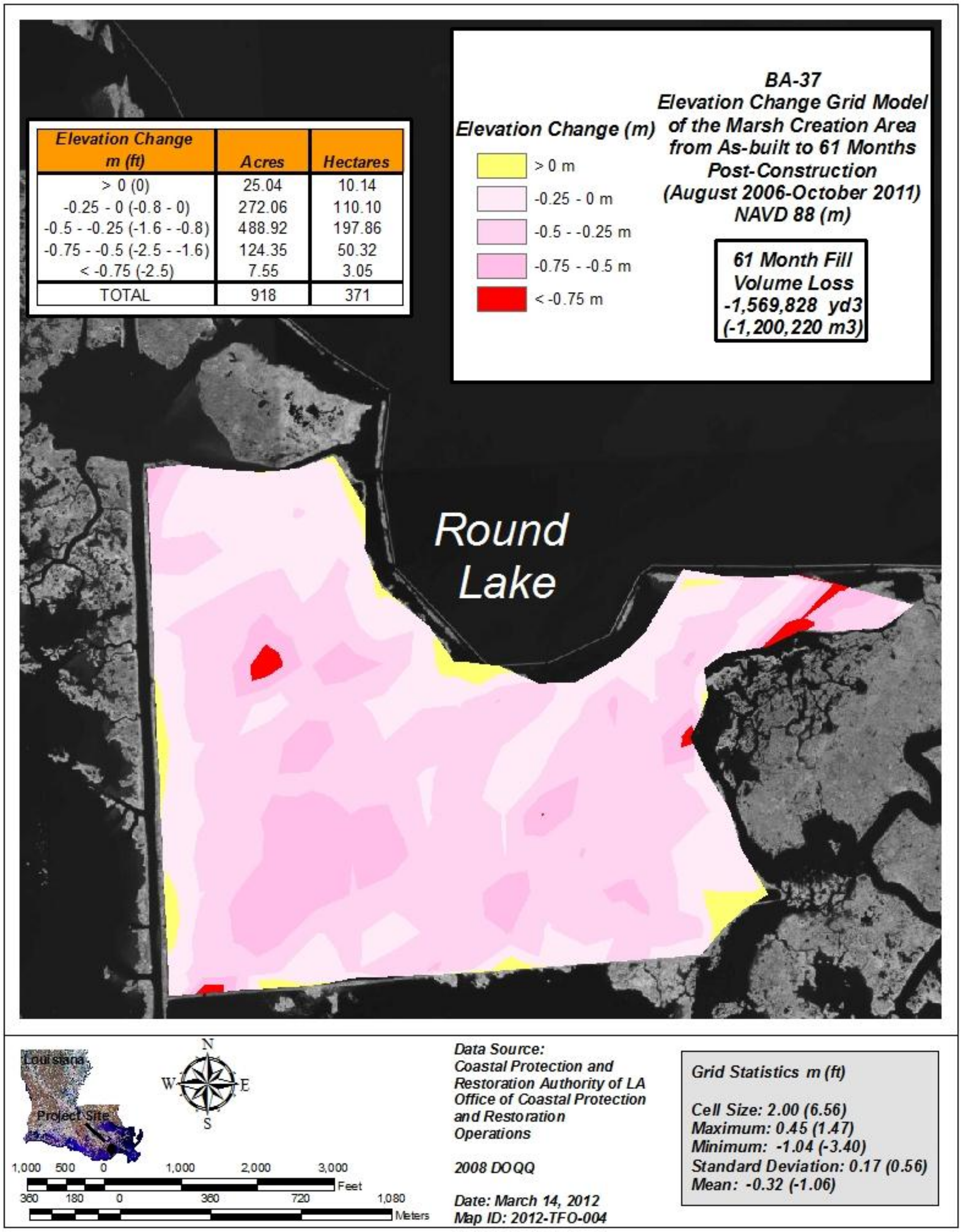


Figure 10. Elevation and volume change grid model from as-built (Aug 2006) to post-construction (Oct 2011) at the Little Lake Shoreline Protection/Dedicated Dredging Near Round Lake (BA-37) project.

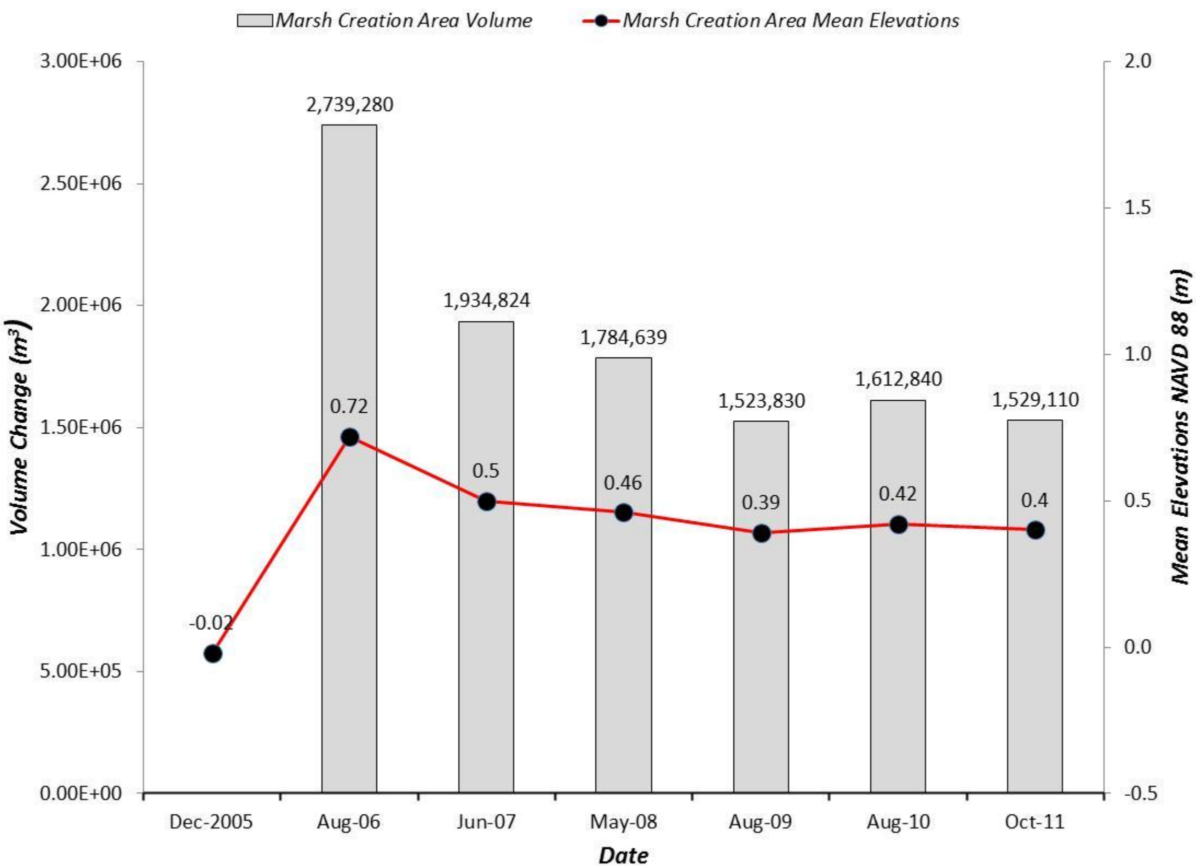


Figure 11. **Sediment volumes and mean elevations over time inside the Little Lake Shoreline Protection/Dedicated Dredging Near Round Lake (BA-37) marsh creation and nourishment area.**

rate of secondary settlement does not fit the predicted rock dike settlement curve established by Eustis (2003) during pre-construction. The measured value of secondary settlement is moderately larger than the estimated value (figure 18). However, the measured rate of secondary settlement has decreased from May 2008 to Sep 2011 (figures 15, 16, 17, and 18). The most probable reason for the rock dike's deviation from the settlement curve is the addition of 28,762 tons of rock to 19,041 ft (73%) of the dike. This third rock lift was necessitated by primary settlement of the dike during construction and added a load of 1.56 tons/ft to the sections of the rock dike that were recapped. The total overburden on the underlying soils below the third lift portions of the dike is 7.16 tons/ft while the dike segments only receiving two lifts have an overburden of 5.60 tons/ft. Future settlement plate surveys will monitor the post-construction settlement rate of the foreshore rock dike.

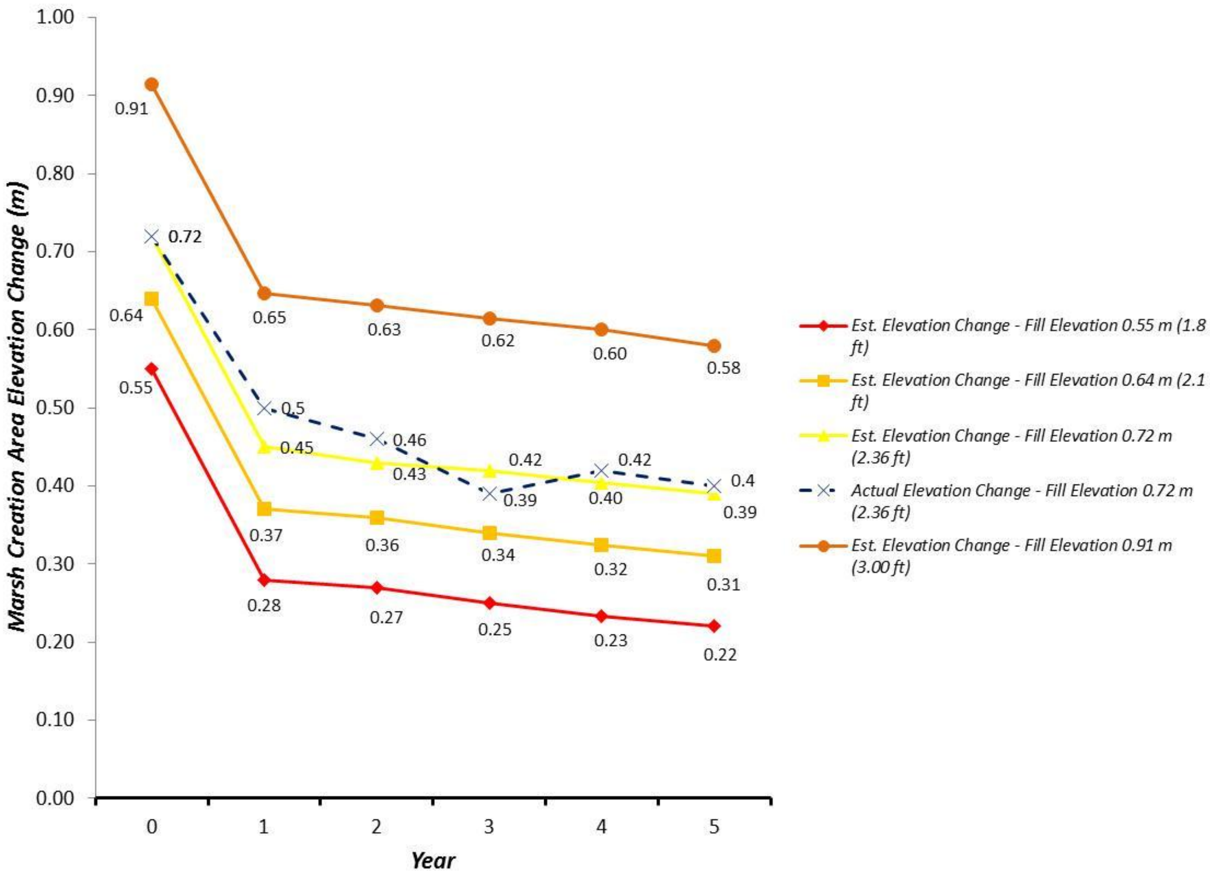


Figure 12. Estimated and actual sediment consolidation inside the Little Lake Shoreline Protection/Dedicated Dredging Near Round Lake (BA-37) marsh creation and nourishment area.

Shoreline Change

Preliminary pre and post-construction shoreline position data indicate that the foreshore rock dike has reduced shoreline erosion rates in the Little Lake Shoreline Protection/Dedicated Dredging Near Round Lake (BA-37) project area since construction was completed in Mar 2007. Pre-construction shoreline erosion rates averaged -3 m/yr (-11 ft/yr) in the marsh creation area and -18 m/yr (-59 ft/yr) in the lake rim area from Jan 1998 to Nov 2005 (8 years) (appendix D). Post-construction results for the period from Sep 2007 (6 months post-construction) to July 2010 (3.5 years post-construction) show average erosion rates of -1 m/yr (-2 ft/yr) (marsh creation area) and -4 m/yr (-14 ft/yr) (lake rim area) behind the foreshore rock dike (appendix D). Although the pre-construction erosion rate in the lake rim area is considerably larger than the post-construction rate, the lake rim shoreline transgressed at a high rate from 2007 to 2008 [-10 m/yr (-33 ft/yr)] (figure 19) primarily due to the effects of tropical storm activity on the shoreline.

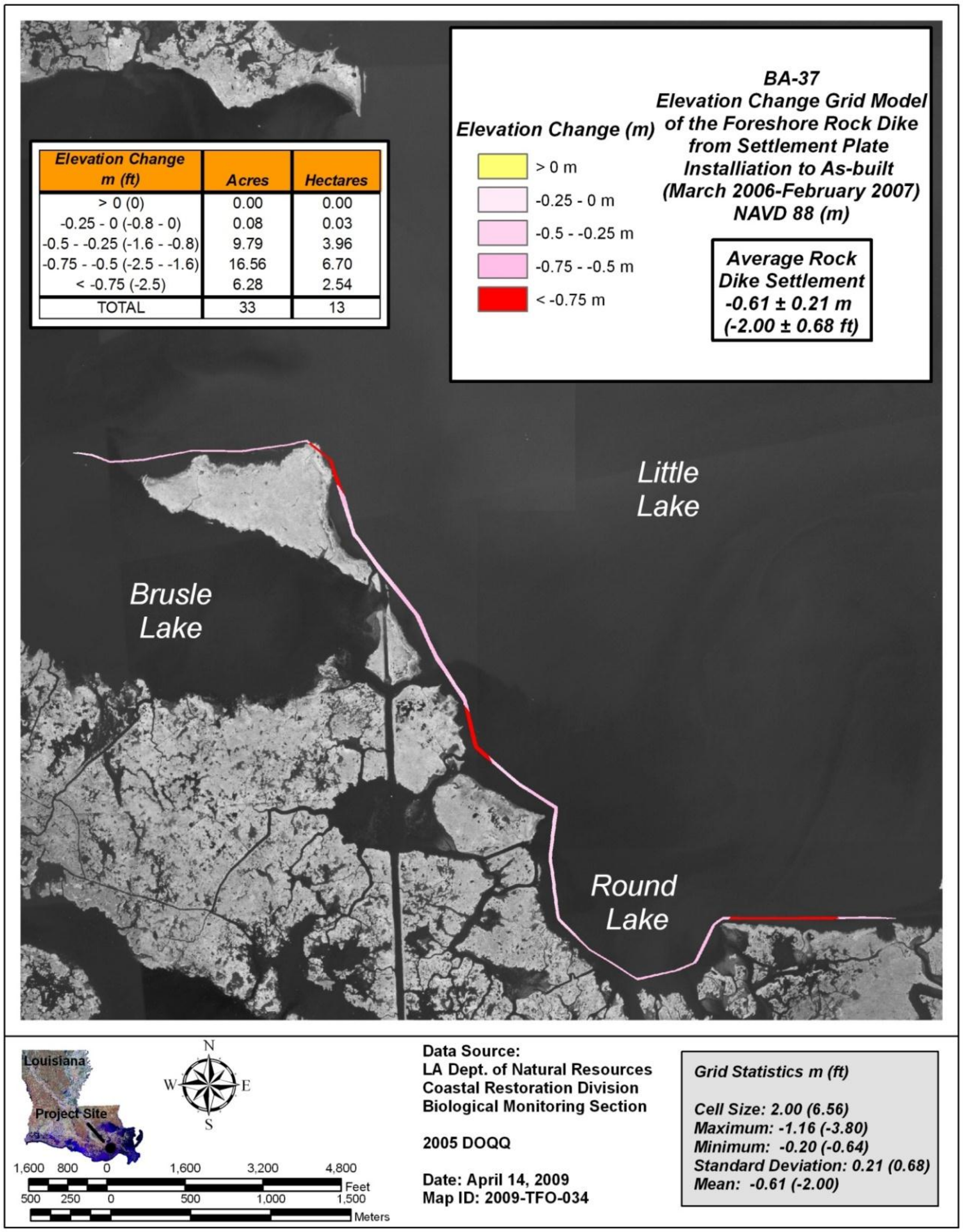


Figure 13. Elevation change grid model of the foreshore rock dike from settlement plate installation (Mar 2006) to as-built (Feb 2007) at the Little Lake Shoreline Protection/Dedicated Dredging Near Round Lake (BA-37) project.

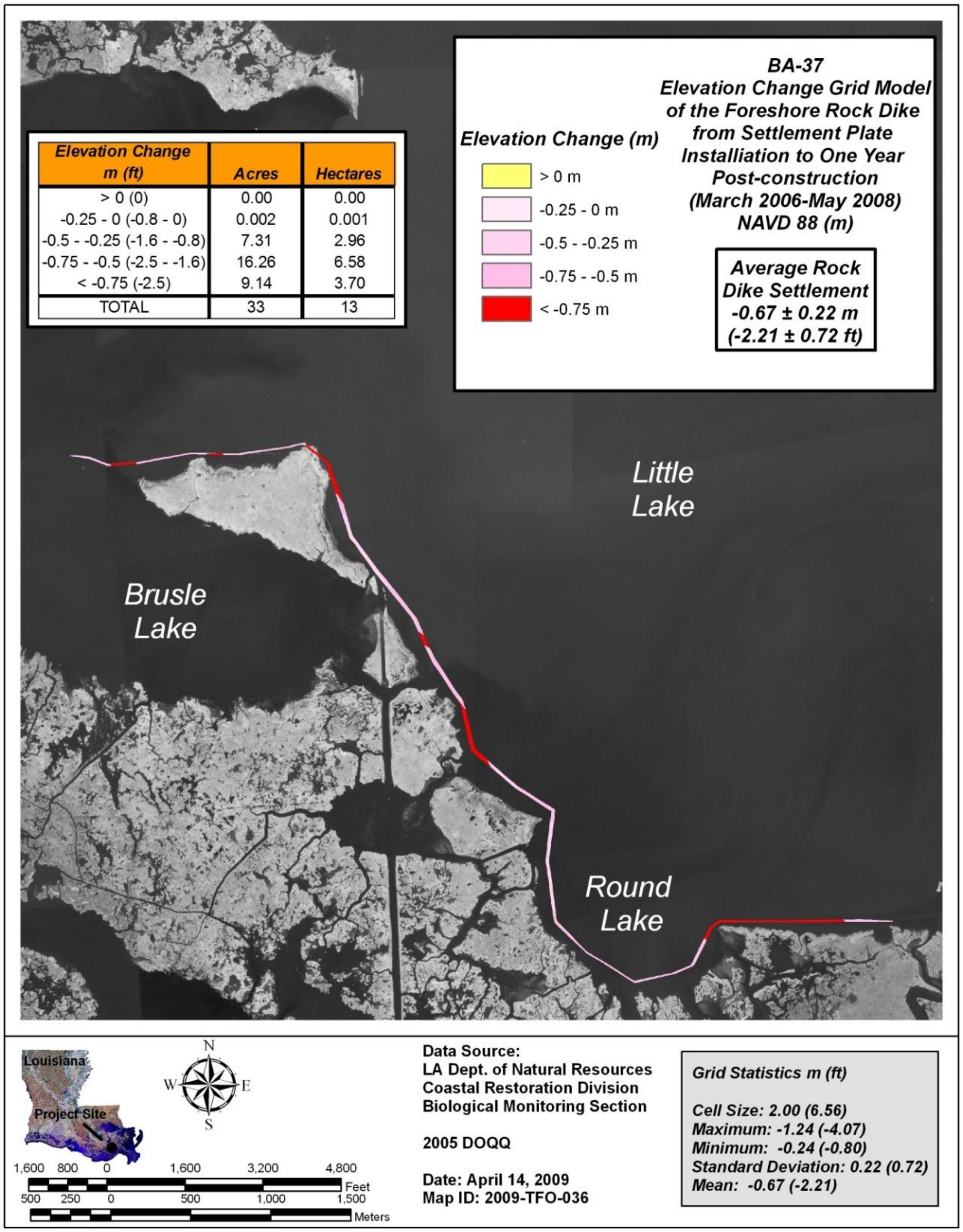


Figure 14. Elevation change grid model of the foreshore rock dike from settlement plate installation (Mar 2006) to post-construction (May 2008) at the Little Lake Shoreline Protection/Dedicated Dredging Near Round Lake (BA-37) project.

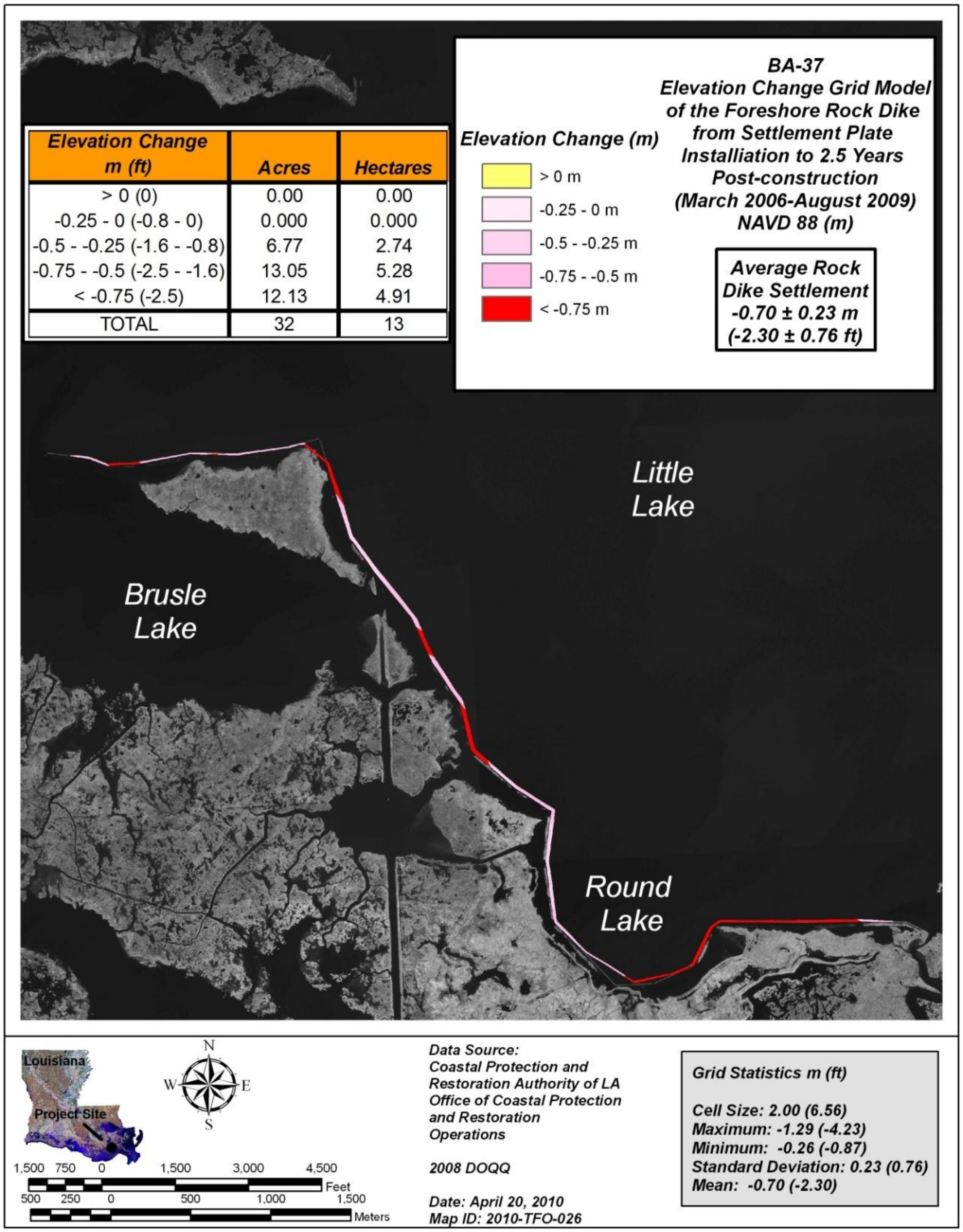


Figure 15. Elevation change grid model of the foreshore rock dike from settlement plate installation (Mar 2006) to post-construction (Aug 2009) at the Little Lake Shoreline Protection/Dedicated Dredging Near Round Lake (BA-37) project.

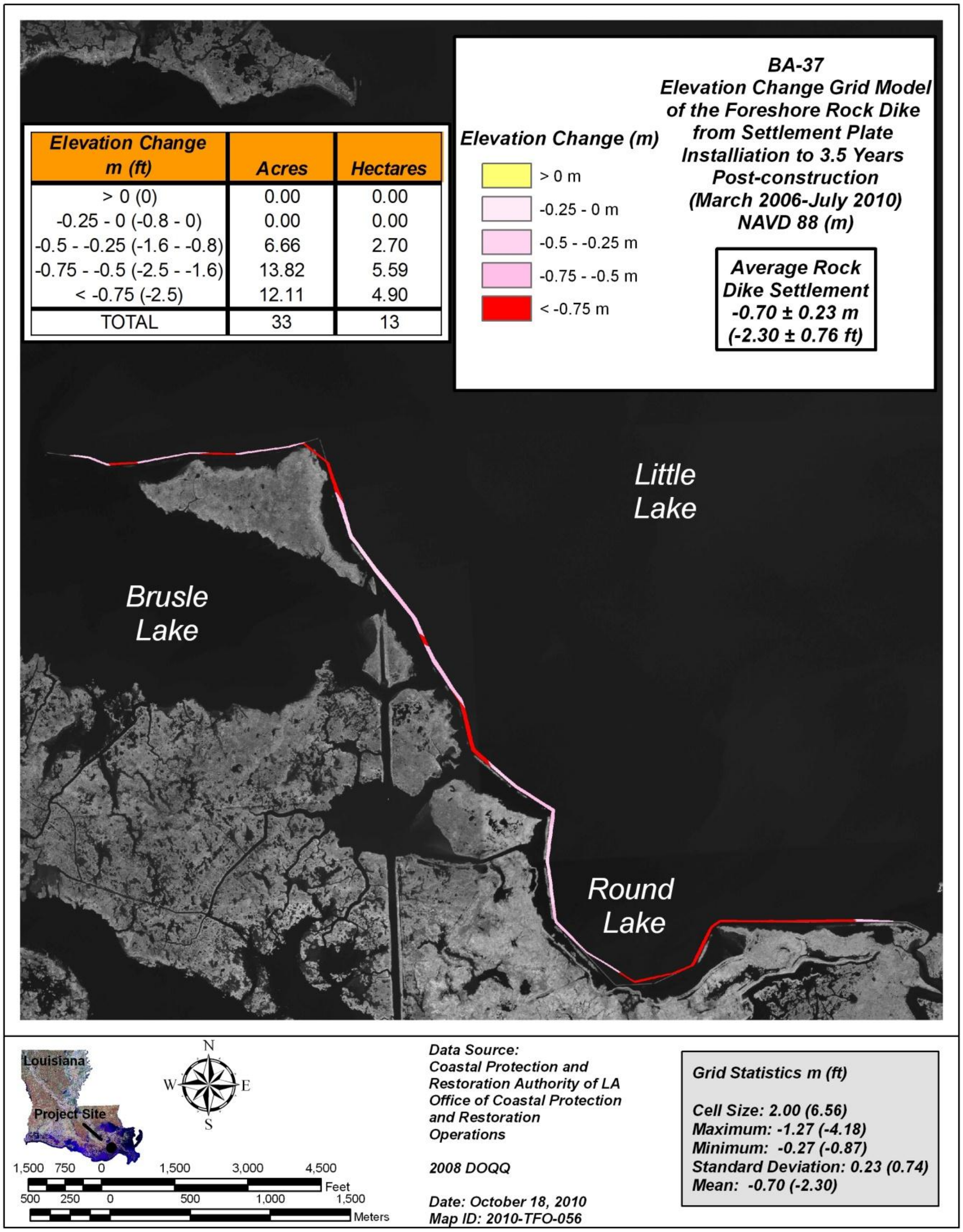


Figure 16. Elevation change grid model of the foreshore rock dike from settlement plate installation (Mar 2006) to post-construction (Jul 2010) at the Little Lake Shoreline Protection/Dedicated Dredging Near Round Lake (BA-37) project.

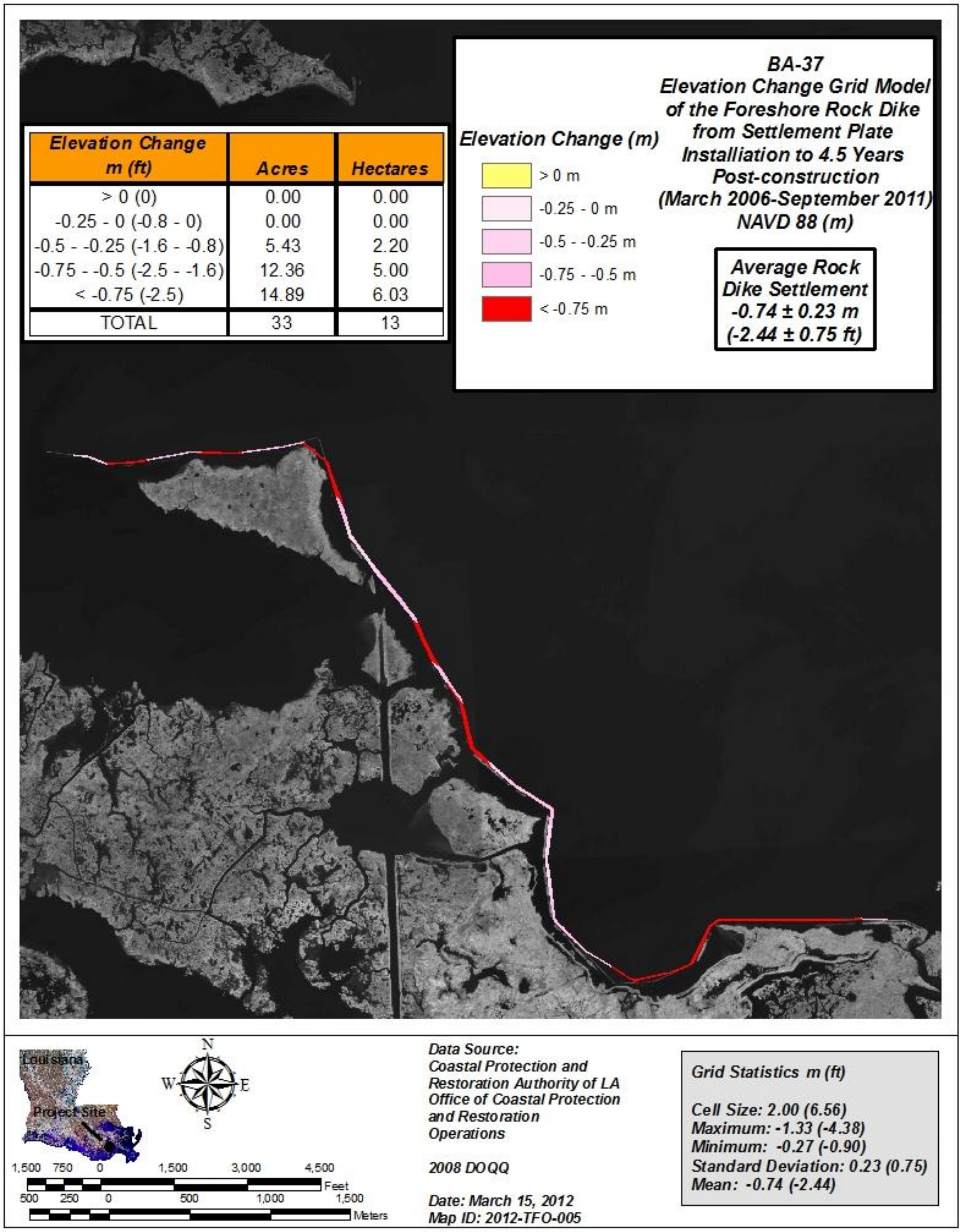


Figure 17. Elevation change grid model of the foreshore rock dike from settlement plate installation (Mar 2006) to post-construction (Sep 2011) at the Little Lake Shoreline Protection/Dedicated Dredging Near Round Lake (BA-37) project.

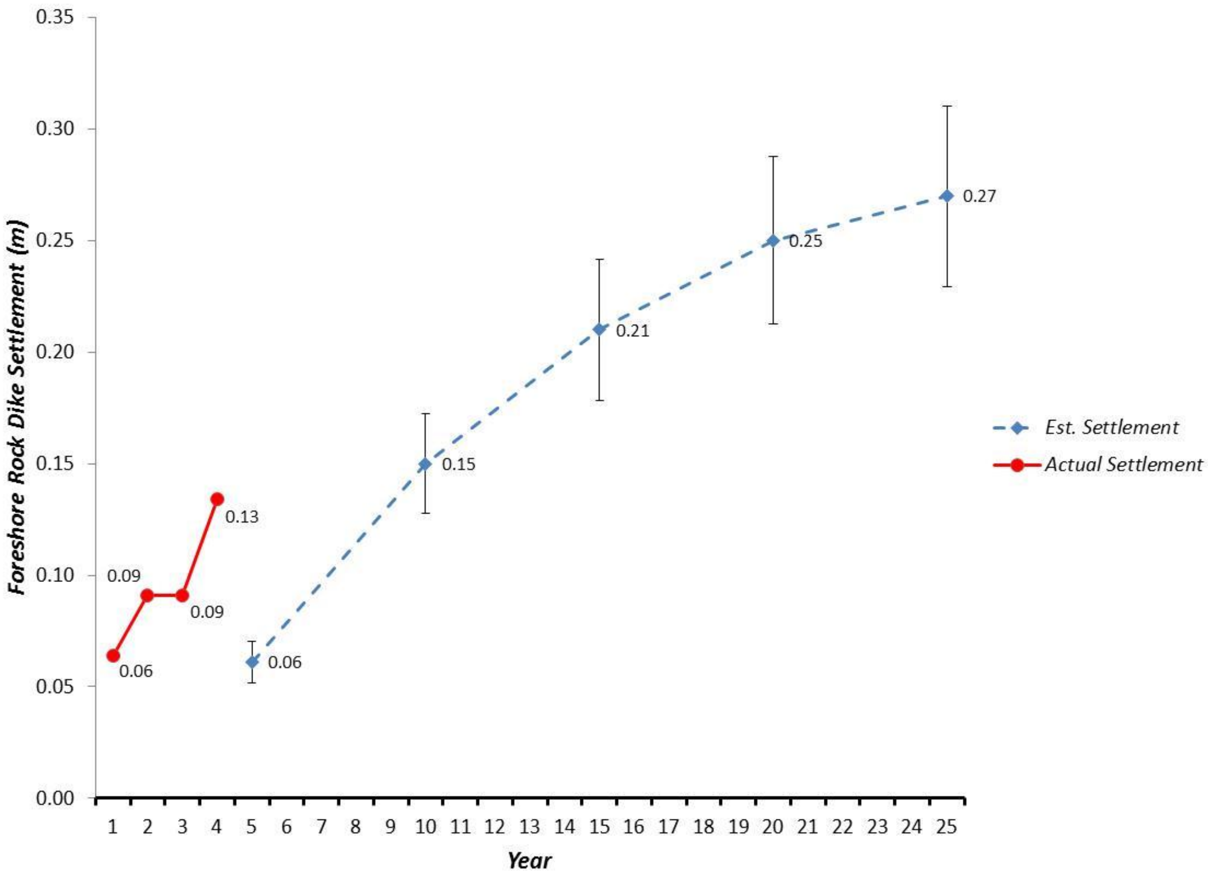


Figure 18. **Estimated and actual secondary settlement of the foreshore rock dike at the Little Lake Shoreline Protection/Dedicated Dredging Near Round Lake (BA-37) project.**

Pre-construction data reveals that the BA-37 shoreline was transgressing at a rapid rate. The marsh creation area shoreline eroded at rates of -2 m/yr (-7 ft/yr) from 1998 to 2003, -6 m/yr (-19 ft/yr) from 2003 to 2004, -6 m/yr (-21 ft/yr) from 2004 to 2005 (figure 19), and -3 m/yr (-11 ft/yr) from 1998 to 2005 (appendix D). The lake rim shoreline eroded at rates of -11 m/yr (-36 ft/yr) from 1998 to 2003, -7 m/yr (-24 ft/yr) from 2003 to 2004, -42 m/yr (-138 ft/yr) from 2004 to 2005 (figure 22), and -18 m/yr (-59 ft/yr) from 1998 to 2005 (appendix D). During the 8 year pre-construction interval, the project area shoreline receded -103 m (-339 ft). It is apparent from the shoreline erosion data that the 2005 hurricane season significantly altered and reshaped the project area shorelines (figure 19). The passage in quick succession of Hurricane Cindy (Jul 2005), Hurricane Katrina (Aug 2005) and Rita (Sep 2005) in close proximately to the project area (figure 20) probably eroded large sections of shoreline and aided in the removal of 640 m (2,100 ft) of shoreline from the western extent of the project (appendix D). Therefore, the 2005 hurricanes hastened the shoreline retreat in the pre-construction project area and intensified the land loss along the Little Lake and Round Lake rims.

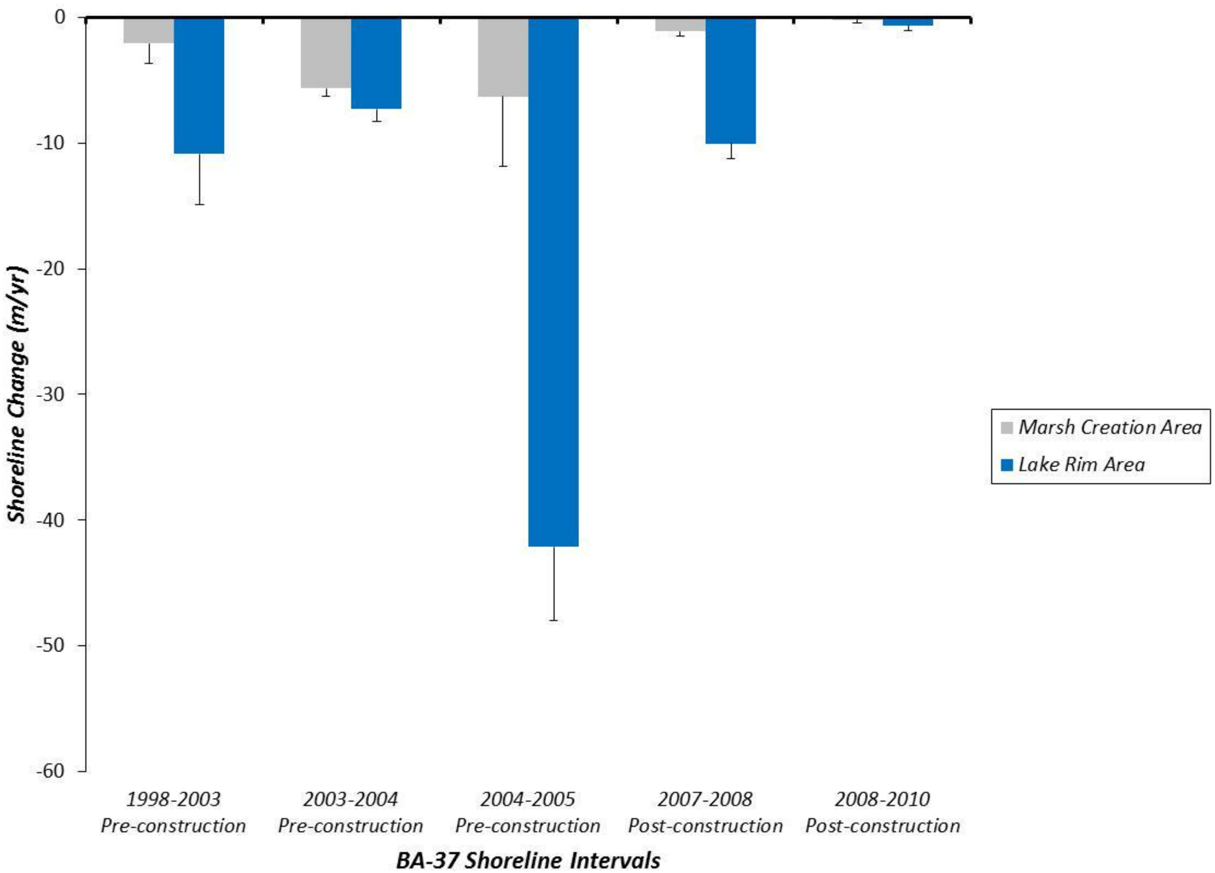


Figure 19. Pre (1998-2005) and post-construction (2007-2010) shoreline change at the Little Lake Shoreline Protection/Dedicated Dredging Near Round Lake (BA-37) project. Note the considerable erosion induced during the 2005 hurricane season.

Since construction of the foreshore rock dike, the marsh edge erosion rate has declined in the project area. However, the initial post-construction shoreline analysis suggests that the lake rim shoreline was transgressing at the pre 2005 rate. The average shoreline erosion rate behind the rock dike was -10 m/yr (-33 ft/yr) from Sep 2007 to Oct 2008 (figure 19) practically equivalent to the 1998-2003 (figure 19) and 1998-2004 (appendix D) erosion rates. The shoreline fronting the marsh creation area (figures 2 and 3) incurred minimal shoreline erosion [-1 m/yr (-4 ft/yr)] during the initial post-construction analysis (figure 19). Subsequent post-construction shoreline analysis show that the erosion rates in the marsh creation and lake rim areas have been considerably reduced since 2008. The marsh creation area transgressed at a rate of -0.2 m/yr (-1 ft/yr) from 2008 to 2010 and the lake rim area transgressed at 0.6 m/yr (-2 ft/yr) for the same interval (figure 19). The disparities between the marsh creation and lake rim erosion rates are probably related to differences in fetch and sediment additions to the marsh creation area shoreline. The lake rim area has a larger fetch [88 ± 4 m (288 ± 14 ft)] than the marsh creation area [57 ± 10 m (186 ± 32 ft)], and the input of mineral sediments has strengthened the marsh creation area shoreline.

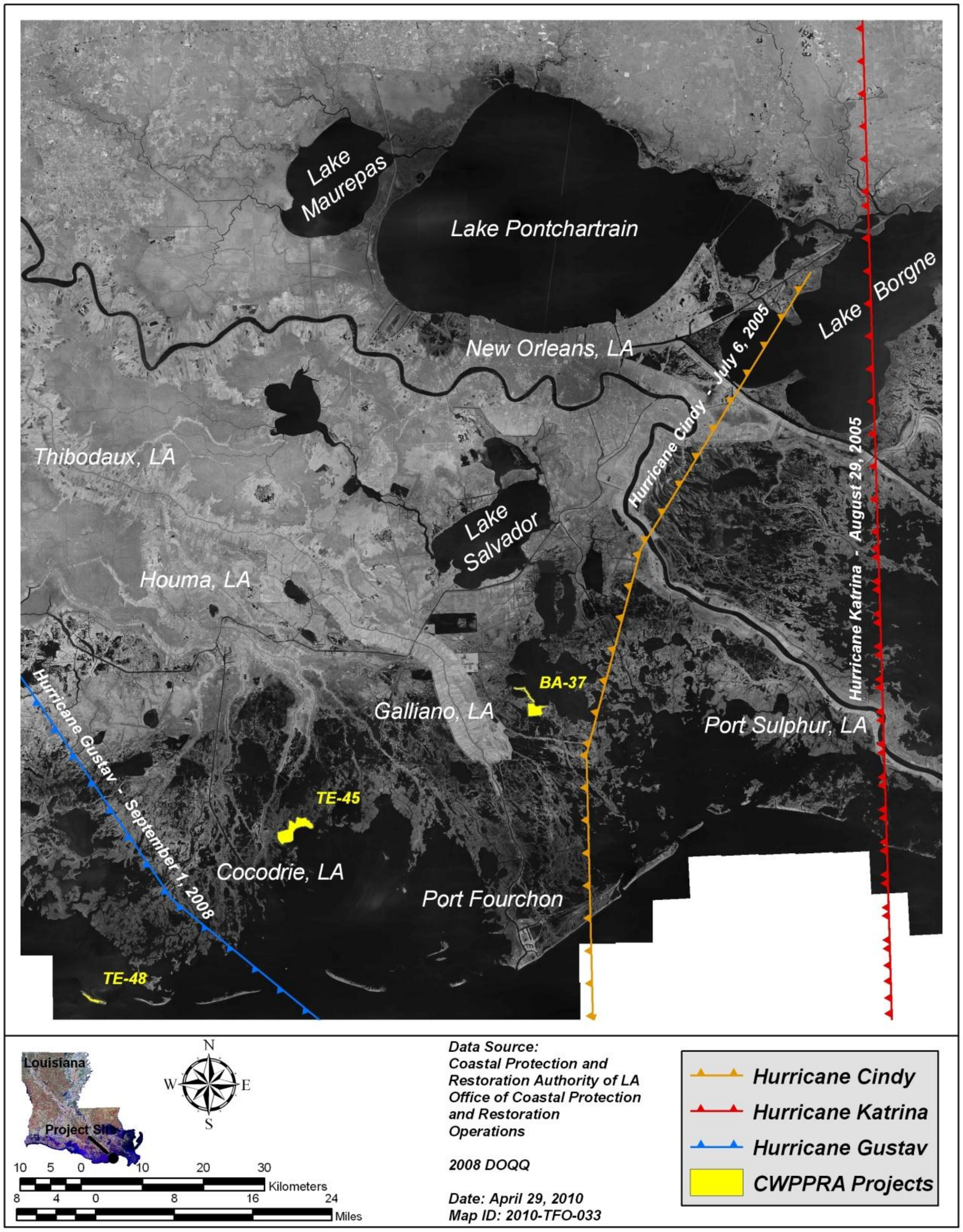


Figure 20. Pre-construction (2005) and post-construction (2008) hurricanes impacting the Little Lake Shoreline Protection/Dedicated Dredging Near Round Lake (BA-37) project area shoreline. Hurricanes Ivan (2004), Rita (2005), Ike (2008), and Tropical Storm Lee (2011) are not shown because the eye wall of these storms traveled further to the south (off the map).

The large fetch behind the lake rim reach of the rock dike also likely contributed to the high erosion rate behind this rock structure because waves have been shown to regenerate during high velocity winds when a large fetch lies between a coastal structure and a shoreline (Stone et al. 1999). Conversely, the marsh creation area shoreline fetch was substantially smaller. The increased erosion in the lake rim area could have been initiated by the massive erosion that incurred during the 2005 hurricane season (figure 19) because remaining fragments of the historical mineral lake rim (Gagliano and Wicker 1989) possibly eroded leaving organic soils exposed. Moreover, the input of mineral sediments has strengthened the marsh creation area shoreline facilitating a stable and perhaps sustainable shoreline position. Although hurricanes have been found to erode coastal marshes (Guntenspergen et al. 1995; Stone et al. 1997; Watzke 2004), cold fronts (Watzke 2004) and wind generated waves (Stone et al. 1999; Curole et al. 2002; Watzke 2004) have also been shown to cause marsh edge erosion. The underlying cause of the high post-construction erosion rate in the lake rim area appears to be Hurricane Gustav (Sep 2008) (figure 20) because the passage of this storm seems to have induced substantial shoreline transgressions during the 2007-2008 period (figure 19). In the absence of large scale tropical storms, the lake rim shoreline seems to incur low erosion rates. Future shoreline position data should clarify if the erosion rates behind the structure were induced solely by hurricane activity. Currently, the goal to reduce the marsh edge erosion rate is being attained because the marsh creation and lake rim shorelines seem to be maintaining their positions.

Lake Rim Area

The area of the Little Lake Shoreline Protection/Dedicated Dredging Near Round Lake (BA-37) lake rim (figures 2 and 3) has declined over time. The vast majority of these acreage decreases transpired prior to construction of the BA-37 project. During the eight year period before construction (1998-2005), the lake rim area acreage decreased by 64 ha (157 acres). Approximately, half of this pre-construction land loss occurred during the 2004-2005 interval and was probably induced by the 2005 hurricanes (table 1). In the post-construction period, the areal extent of the lake rim area was reduced by only 6 ha (15 acres) (table 1). Therefore, it is apparent that the foreshore rock dike has influenced the land loss rates in the lake rim area. The lake rim area analysis also confirms that pre-construction land-loss rates were intensified during periods of heightened hurricane activity.

Table 1 **Mean area of the Little Lake Shoreline Protection/Dedicated Dredging Near Round Lake (BA-37) lake rim area over time.**

Year	*Lake Rim Area Hectare (Acres)*	*Change Interval*	*Lake Rim Area Change Hectare (Acres)*
1998	160 (397)	*1998-2003*	-30 (-74)
2003	131 (323)	*2003-2004*	-3 (-8)
2004	127 (315)	*2004-2005*	-30 (-75)
2005	97 (240)	*2005-2007*	-1 (-3)
2007	96 (237)	*2007-2008*	-3 (8)
2008	93 (229)	*2008-2010*	-2 (-4)
2010	91 (225)	*1998-2010*	-70 (-172)

CRMS Supplemental

Land/Water Classification CRMS6303

The Land/Water classification of CRMS6303 showed that a 1.0 km^2 (0.4 mi^2) square portion of the BA-37 project increased in land area since construction. In Nov 2005 the marsh creation area consisted of nearly equal parts land and water. This analysis revealed that the 1.0 km^2 (0.4 mi^2) square enclosed 131 acres (53 ha) of land habitats and 117 acres (47 ha) of water habitats (appendix E). The percentage of land in the 1.0 km^2 (0.4 mi^2) square was 53% during this time (figure 21). This percentage corresponds to a land to water ratio of 1:1. After construction (Oct 2008) of the BA-37 marsh creation area, the land acreage inside the 1.0 km^2 (0.4 mi^2) square increased by 23 ha (57 acres) for a 23% increase in land area (figure 21). Therefore, two years post-construction the 6303 1.0 km^2 (0.4 mi^2) square consisted of 76 ha (188 acres) of land habitats (appendix E), which corresponds to a land to water ratio of 3:1.

Vegetation CRMS6303

The CRMS6303 vegetation data confirms the classification of Little Lake Shoreline Protection/Dedicated Dredging Near Round Lake (BA-37) marsh creation area as intermediate or brackish marsh. The dominant species found were *Spartina patens* (saltmeadow cordgrass), *Paspalum vaginatum* (seashore paspalum), *Schoenoplectus americanus* (chairmaker's bulrush), and *Spartina alterniflora* (smooth cordgrass) (figure22). *S. patens* (saltmeadow cordgrass), *Paspalum vaginatum* (seashore paspalum), *Schoenoplectus americanus* (chairmaker's bulrush), and *Spartina alterniflora* (smooth cordgrass) (figure 22). *S. patens*, *P. vaginatum*, and *S. americanus* are common inhabitants and indicator species for intermediate or brackish marsh. While *S. alterniflora* is ubiquitous in salt marsh communities, this species is also known to populate brackish and intermediate communities (Chabreck and Condrey 1979). The cover disparities between the 2008 sampling and later sampling events are probably due to seasonal variations in species growth. The 2008 vegetation

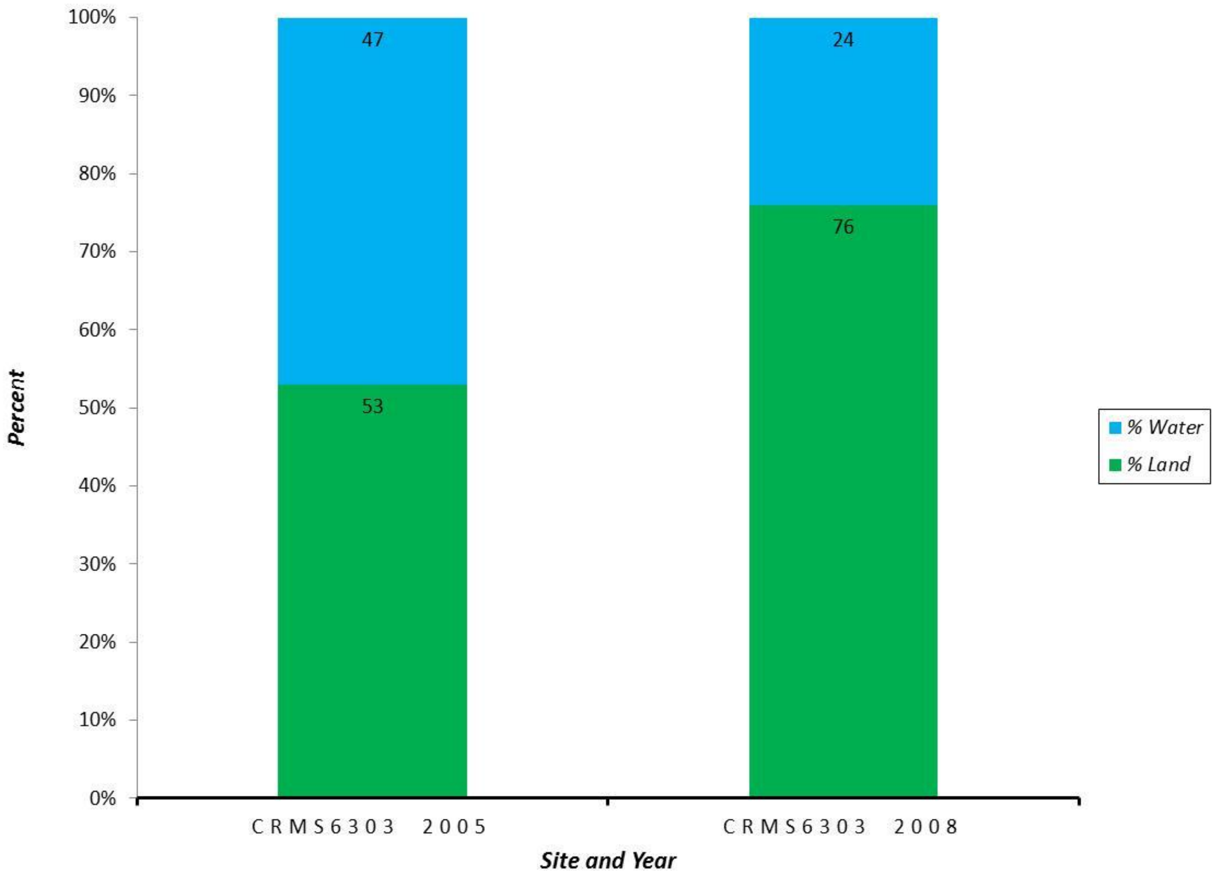


Figure 21. **Percentage of land and water inside the CRMS6303 1.0 km2 (0.4 mi2) square in 2005 (pre-construction) and 2008 (post-construction).**

sampling occurred in October and the 2009, 2010, and 2011 data were collected in June and July (figure 22). Some *Spartina* species have been shown to have seasonal standing crops (Kirby and Grosselink 1976). As a result, their cover values are also cyclic and vary by season. The relatively large FQI and mean cover values consistently measured at CRMS6303 (figure 22, 23, and 24) signify that this CRMS site is structurally intermediate or brackish marsh habitats. Therefore, it is highly likely that a considerable portion of the marsh creation area is composed of intermediate or brackish marshes. Note that the site FQI score decreased when the site was reclassified as intermediate marsh (figure 23). The site FQI scores were comparable to the Barataria Basin (figure 25) and higher than the coastwide averages (figure 26). In closing, the CRMS6303 vegetation data support the assumption that the BA-37 marsh creation and nourishment goals are being attained.

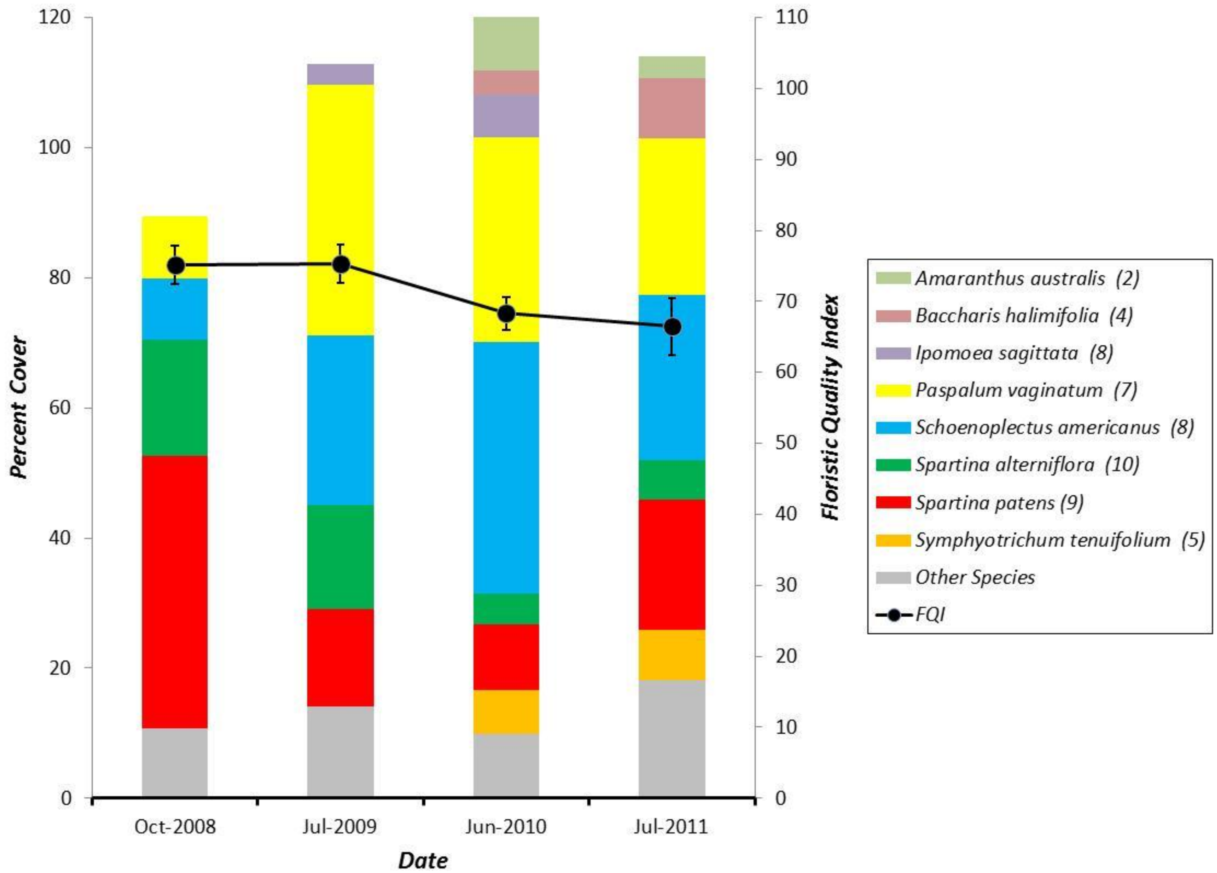


Figure 22. Mean percent cover and floristic quality index (FQI) for vegetation species populating the CRMS6303 200 m2 (239 yd2) square in 2008, 2009, 2010, and 2011.

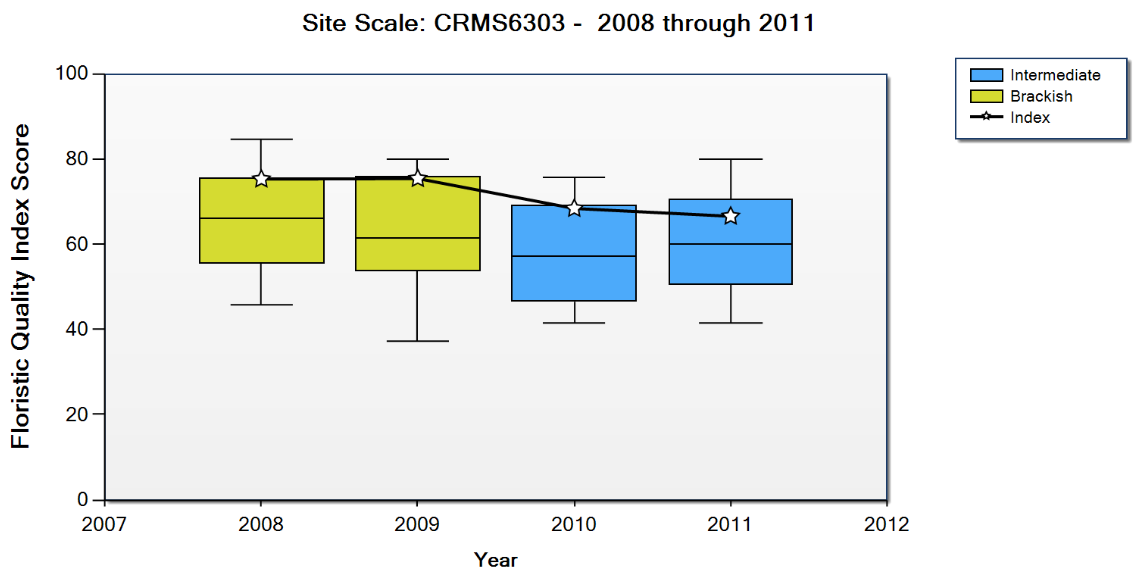


Figure 23. **Floristic quality index (FQI) for the CRMS6303 site over time. Note that this site is currently being classified as intermediate marsh, but prior to 2010 CRMS6303 was classified as brackish marsh.**

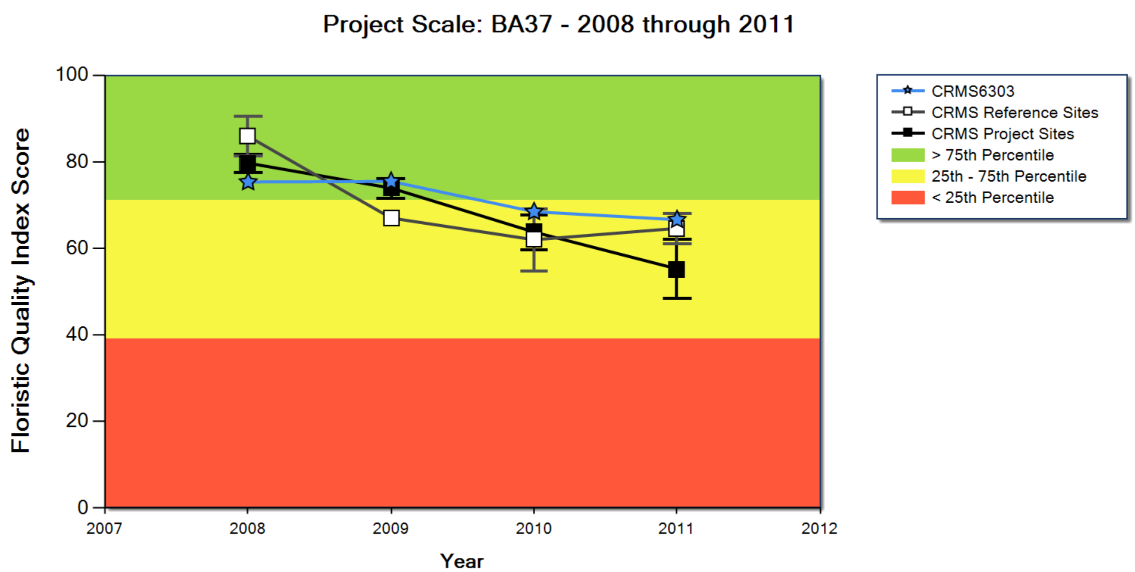


Figure 24. **Floristic quality index (FQI) scores comparing the CRMS6303 site to other CRMS intermediate marsh sites in the Barataria Basin [project (n=5) and reference (n=3)] over time. Note that the FQI for CRMS6303 is slightly higher the other intermediate marsh sites in this basin.**

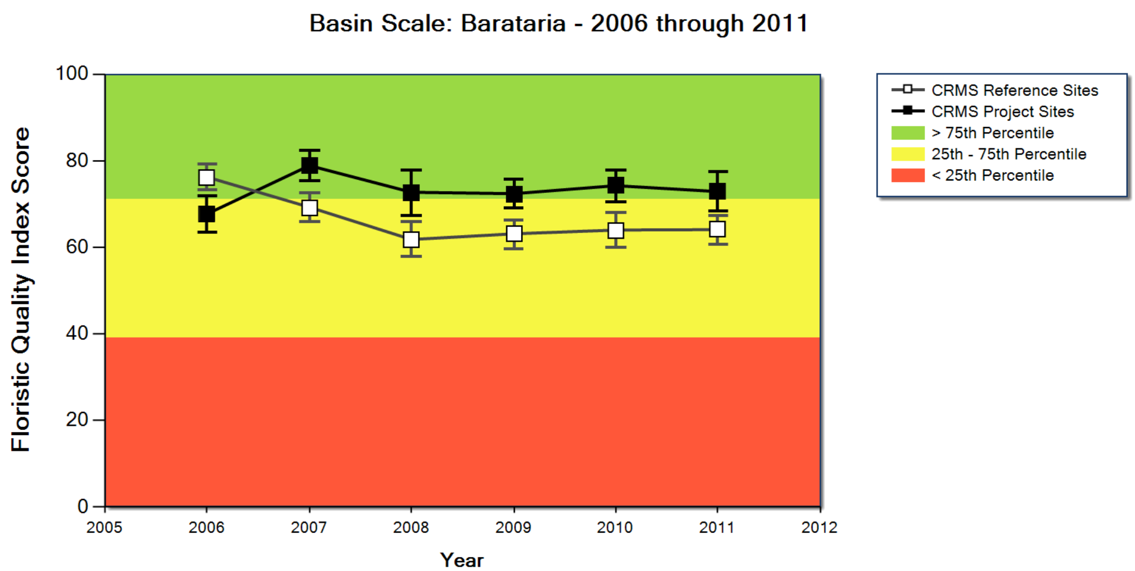


Figure 25. Floristic quality index (FQI) scores for all CRMS sites within the Barataria Basin [project (n=17) and reference (n=46)] over time. Note that the FQI scores for CRMS6303 is similar to the basin averages.

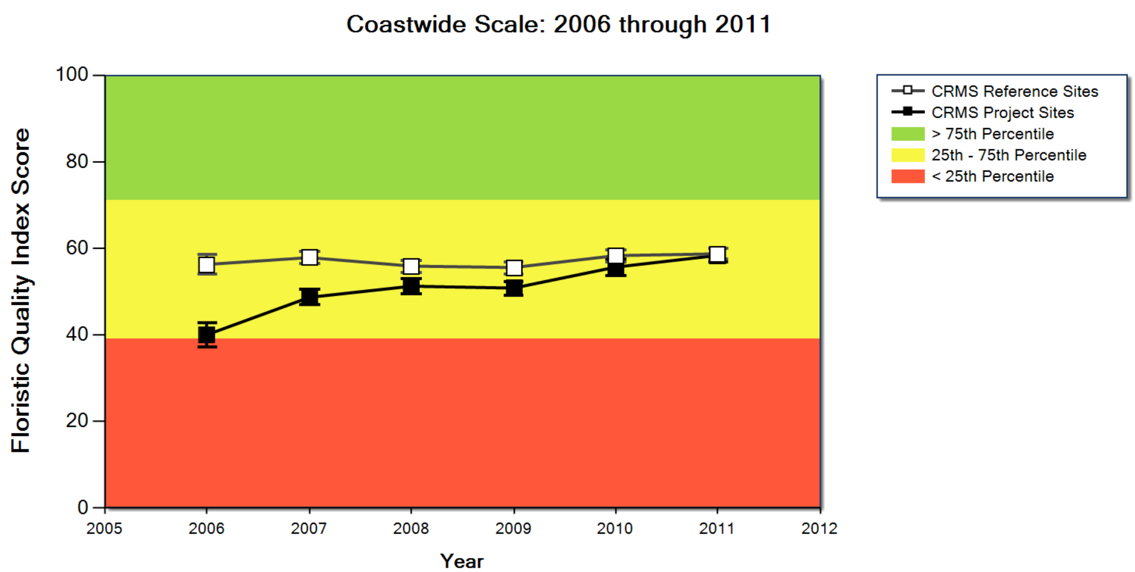


Figure 26. Floristic quality index (FQI) scores for all CRMS sites in coastal Louisiana [project (n=143) and reference (n=244)] over time. Note that the FQI scores for CRMS6303 and the Barataria Basin are higher than the coastwide averages.

Hydrologic Data CRMS6303

The CRMS6303 hydrologic data confirms the classification of Little Lake Shoreline Protection/Dedicated Dredging Near Round Lake (BA-37) marsh creation area as intermediate or brackish tidal marsh. The mean salinity and water level for the period from Oct 2008 to Feb 2012 were 3.62 ± 0.02 ppt and 1.17 ± 0.004 ft (0.36 ± 0.001 m) NAVD 88. The daily mean salinities and water levels are shown in figures 27 and 28. The daily mean salinities ranged from 0.38 ppt (Jan 2010) to 17.00 ppt (Jun 2011). Though the salinity did spike above 10 ppt during the fall and spring of every year, the mean yearly salinity generally remained below 3 ppt. However, in 2011 the mean yearly salinity escalated to 5.66 ± 0.04 ppt. The site experienced a persistent heightened salinity level from Feb to Jul. Additional salinity data collection is required to determine if the rise in salinity in 2011 is an anomaly or if salinity in the BA-37 project area is increasing. The 2011 increase in salinity also resulted in a decrease in the site hydrologic index (HI). The 2010 HI score was 90 and the 2011 score was 27 (figures 29 and 30). In 2010, the site HI score was similar to the basin average for intermediate marshes (figure 30).

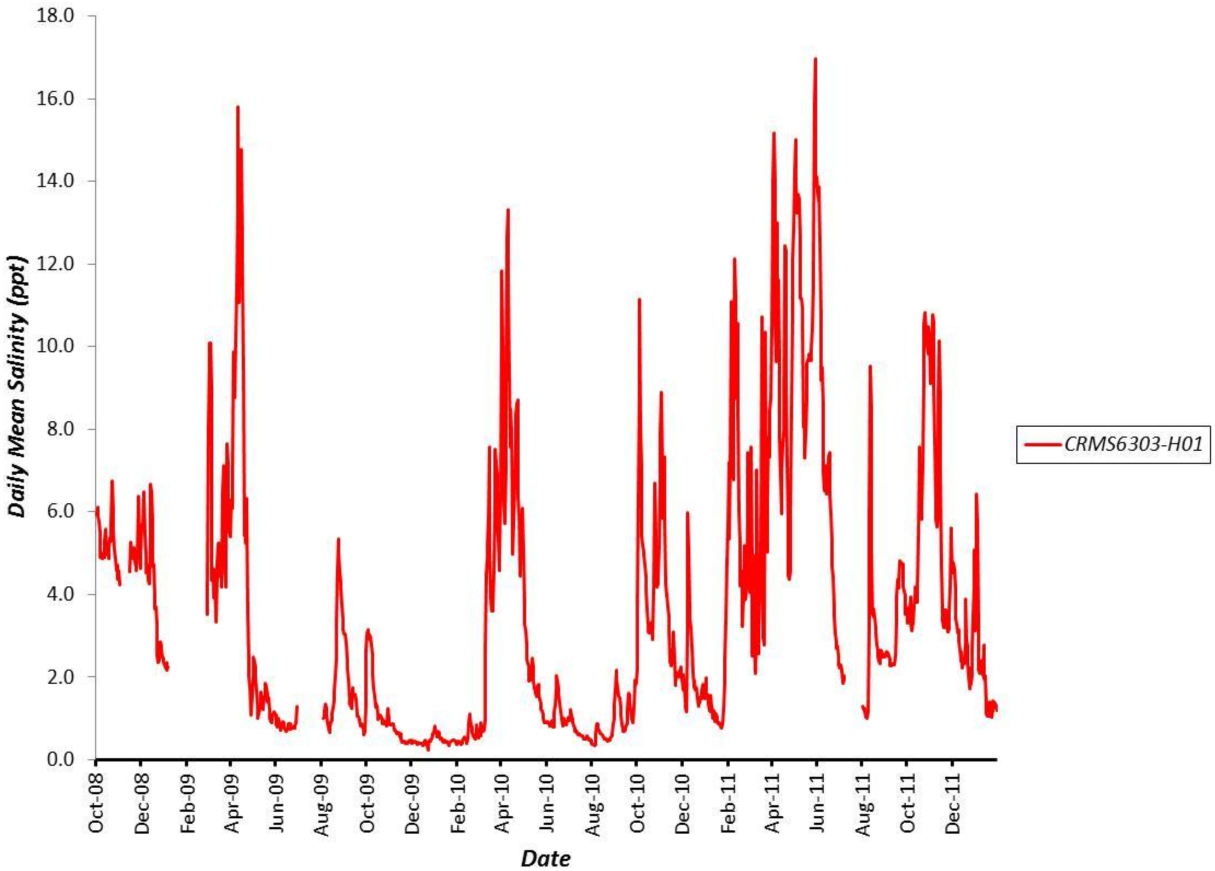


Figure 27. **Post-construction mean daily salinity (ppt) inside the CRMS6303 1 km square and the Little Lake Shoreline Protection/Dedicated Dredging Near Round Lake (BA-37) marsh creation and nourishment area.**

This considerable decline in the HI score was probably also influenced by the reclassification of the CRMS6303 site as intermediate marsh (figure 29) and by the site position, southern most intermediate marsh site in the Barataria Basin. While the HI score for CRMS6303 decreased, the HI score for the Barataria Basin was slightly higher than the coastwide average (figures 31 and 32). Because intermediate marshes have been classified as having salinities ranging from approximately 0.5 to 5 ppt (Cowardin et al. 1979), the CRMS6303 hydrologic data validates an intermediate marsh classification.

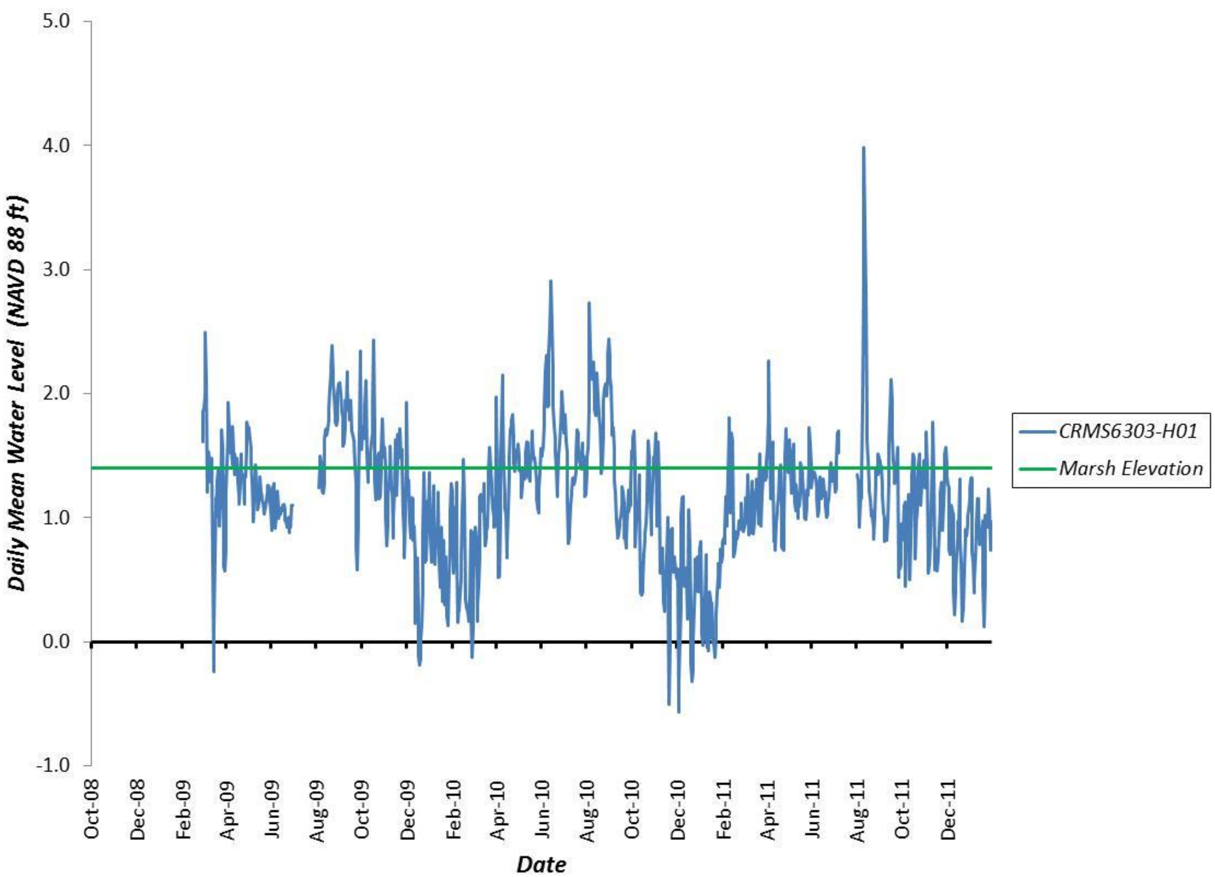


Figure 28. **Post-construction mean daily water levels (NAVD 88 ft) inside the CRMS6303 1 km square and the Little Lake Shoreline Protection/Dedicated Dredging Near Round Lake (BA-37) marsh creation and nourishment area.**

The daily mean water levels are outlined in figure 28. These daily means ranged from -0.57 ft (-0.17 m) (Dec 2010) to 3.98 ft (1.21 m) (Sep 2011). The rise in water levels in Sep 2011 was induced by Tropical Storm Lee. This storm caused extensive coastal inundation in the southern Barataria Basin. The marsh elevation in the vicinity of CRMS6303 has been documented as having a 1.40 ft (0.43 m) NAVD 88 elevation. Therefore, the marshes are flooded only when the water level exceeds the mean water level. For the duration of the hydrologic data collection, the project area marshes were only flooded 34.2 % of the time. In summary, the CRMS6303 hydrologic data endorse the BA-37 marsh creation and nourishment goals.

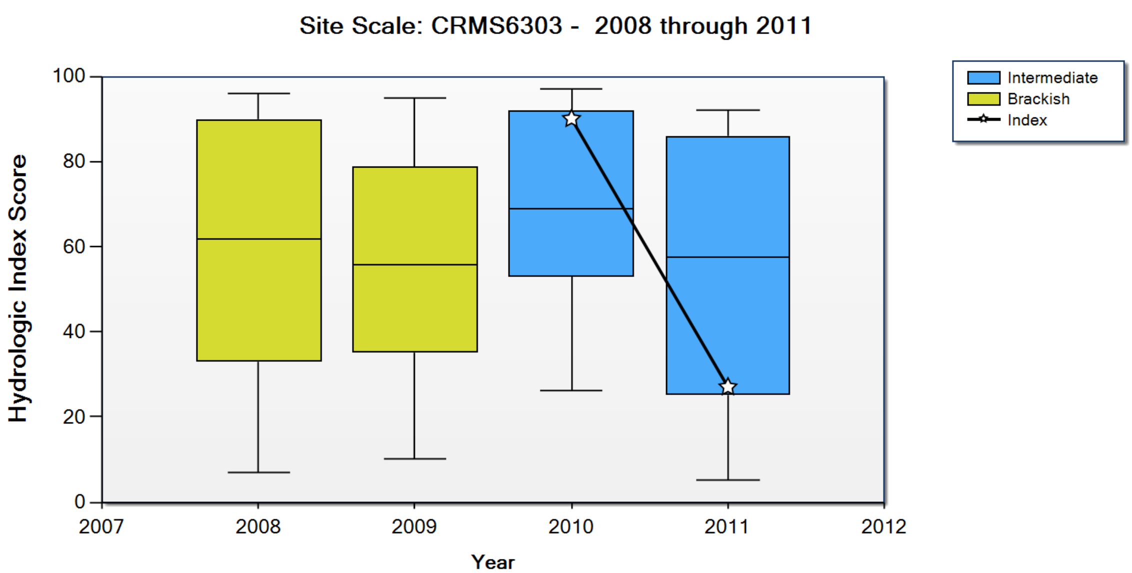


Figure 29. Hydrologic index (HI) for the CRMS6303 site over time. Note that this site is currently being classified as intermediate marsh, but prior to 2010 CRMS6303 was classified as brackish marsh.

The CRMS data show that vigorous intermediate or brackish marsh communities were established within the marsh creation area and hydrologic and elevation conditions support these habitats. The vegetation community that formed in this area has been fairly persistent to date (figure 22). This stability in the vegetation community was probably influenced by the slow rate of elevation change and the tidal regime. Although the salinity did spike to brackish and saline salinities, the mean salinity generally remained in the intermediate range. The tidal amplitude and elevation of the marsh creation area encourage the vegetative growth in this plant community because the marshes are periodically drained during low tides (Eleuterius and Eleuterius 1979; McKee and Patrick 1988). Therefore, the goals to create marsh at suitable elevations and nourish existing marsh are supported by the CRMS data.

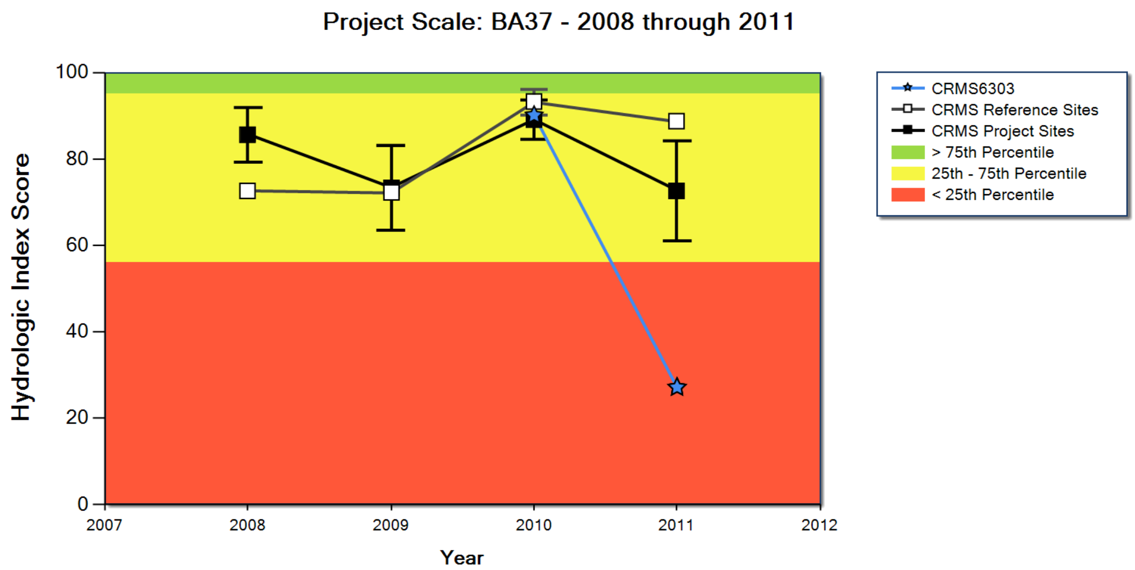


Figure 30. **Hydrologic index (HI) scores comparing the CRMS6303 site to other CRMS intermediate marsh sites in the Barataria Basin [project (n=5) and reference (n=2)] over time. Note that HI scores for 2008 and 2009 were not calculated for CRMS6303 because the data completeness did not exceed the 70% threshold.**

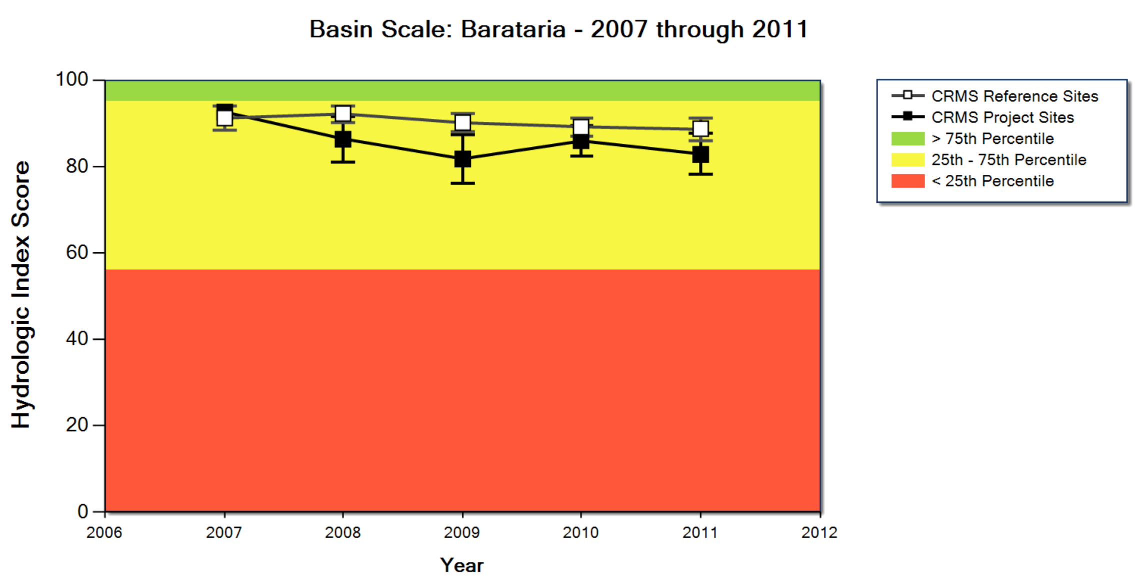


Figure 31. **Hydrologic index (HI) scores for all CRMS sites within the Barataria Basin [project (n=17) and reference (n=35)] over time. Note that the HI scores for CRMS6303 in 2011 is considerably lower than the basin averages.**

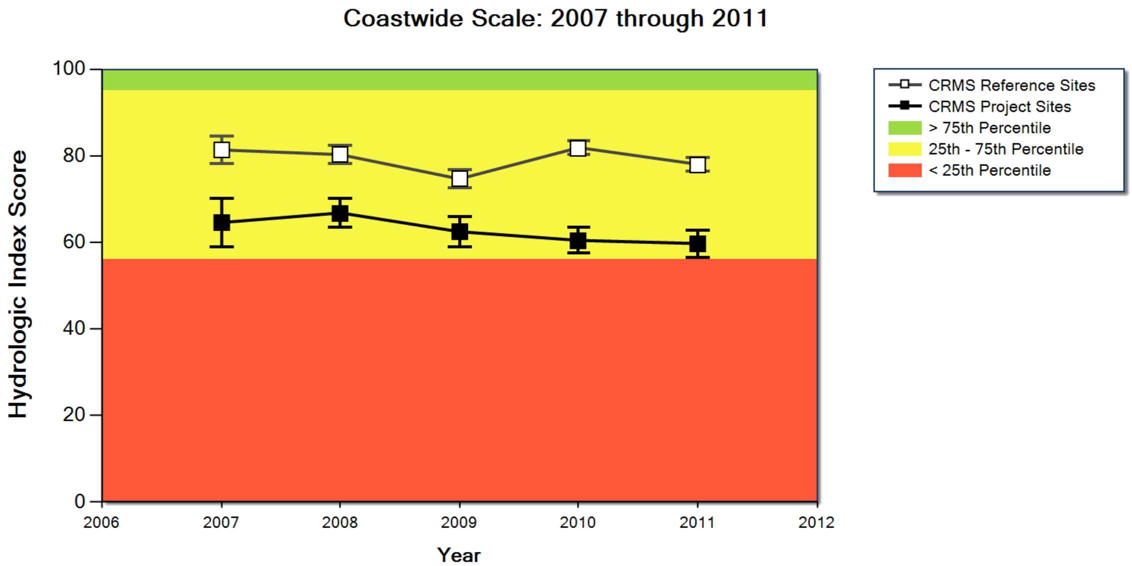


Figure 32. **Hydrologic index (HI) scores for all CRMS sites in coastal Louisiana [project (n=110) and reference (n=204)] over time. Note that the HI scores for the Barataria Basin are slightly higher than the coastwide averages.**

V. Conclusions

a. Project Effectiveness

The results of the Little Lake Shoreline Protection/Dedicated Dredging Near Round Lake (BA-37) reveal that three of the project goals were attained to date. The first goal to reduce the marsh edge erosion rate along the Little and Round Lake shorelines was realized because the shorelines fronting the marsh creation and lake rim areas have incurred reduced shoreline erosion rates since 2008. However, prior post-construction erosion rates showed that the lake rim shoreline was transgressing at the pre 2005 rate. The disparities between the marsh creation and lake rim erosion rates are probably related to differences in fetch and sediment additions to the marsh creation area shoreline. The input of mineral sediments may have strengthened the marsh creation area shoreline facilitating a stable and perhaps sustainable shoreline position. In contrast, the increased erosion in the lake rim area could have been initiated by the massive erosion that incurred during the 2005 hurricane season because remaining segments of the historical mineral lake rim likely eroded leaving organic soils exposed. The large fetch behind the lake rim reach of the rock dike also likely contributed to the high erosion rate behind this rock structure because waves have been shown to regenerate during high velocity winds when a large fetch lies between a coastal structure and a shoreline (Stone et al. 1999). However, the high post-construction shoreline erosion rate in the lake rim area is probably an effect of Hurricane Gustav, which impacted the Louisiana coast in Sep 2008 (figure 19). In the absence of large scale tropical storms, the lake rim shoreline seems to incur low erosion rates.

The second and third goals to create and nourish intermediate or brackish marshes were attained. Approximately, 372 ha (920 acres) of marsh were created or enhanced through construction of the BA-37 project, and the CRMS6303 vegetation and hydrologic data support an intermediate marsh classification. Furthermore, the constructed marsh is settling and subsiding in compliance with the projected consolidation curve. Therefore, these results provide evidence suggesting that marsh creation and nourishment area is condensing at a sustainable rate.

The fourth goal to maintain emergent marsh at the end of the 20 year project life appears to be attainable because the marsh creation and nourishment area is following the anticipated consolidation curve. Therefore, the project is following a trajectory to maintain constructed marshes past the end of the project life.

b. Recommended Improvements

Based on the visual observations during the annual inspection and the settlement plate data from the post-construction surveys, the rock dike segments have experienced some settlement. Settlement is typical and anticipated for a rock dike structure of this type. We have reviewed the data from the 2011 survey, and by comparing the survey profile of all 24 rock dike segments to their constructed height, we have determined that a rock lift is not necessary at this time. Currently we are not recommending any corrective actions or maintenance of the shoreline protection. Although settlement occurred approximately 6 years faster than was anticipated (due to added weight of the third rock lift), this rapid settlement is not expected to continue. Further recommendations regarding potential rock lifts will be re-evaluated after annual visual inspections and review of the elevation data obtained from the 10 and 15 year surveys.

The marsh creation area appears to be completely vegetated and the surveys indicate its elevations are approaching the average marsh elevation for the area. There are no funds allocated for the marsh creation portion of the project other than the surveying of the area grid points. We recommend that the 2011 survey be the last of the first five annual surveys as we will have five total data sets for post-construction analysis, in addition to the 10 and 15 year survey as per the O&M Plan. The survey data along with the annual visual inspections will monitor the consolidation and settlement of the fill material and the resulting elevations within the marsh creation area.

c. Lessons Learned

Three lessons were learned from the first five years of the Little Lake Shoreline Protection/Dedicated Dredging Near Round Lake (BA-37) project. The first lesson is that the marsh creation and nourishment area could have been expanded to include marsh creation along the lake rim reach extending southward from the southern end of the Little Lake marsh creation area to the mouth of Breton Canal, although this would have increased the project cost considerably. The area surrounding the BA-37 project consists of large acreages of broken and subsided marsh. These areas have low contours that are conducive to marsh creation and nourishment. Nourishing the lake rim shoreline with mineral sediments may have been a viable alternative to lowering the shoreline erosion rates in the lake rim area. Adding mineral sediments to the lake rim shoreline may have reduced erosion rates along this reach because inputs of mineral sediments have substantially reduced the erosion rate along the marsh creation area shoreline.

The second lesson is that the marsh creation and nourishment area is settling in agreement with its consolidation curve. It is anticipated that this trend will continue and the future outcome of the project is already predicted. Consolidation data is site specific and dependent on many factors including soil type. The ability to accurately forecast the mean elevation in a constructed marsh twenty years after the project is built would allow engineers and scientists to build marsh creation projects to higher elevations and let them settle and subside to the desired elevation over time. This would increase the longevity and sustainability of the constructed marshes.

The last lesson is that habitat mapping or land/water classification data should have been collected to monitor habitats over time. The constructed marsh created several diverse plant communities that are only being assessed through elevation data. Habitat data could have qualitatively and quantitatively estimated changes in these communities during the 20 year project life.

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Appendix A
(Inspection Photographs)

Photo #1: View of the end of Rock Segment #1 closest to Benton Canal, looking south.

Photo #2: View along Rock Segment #1 closest to Benton Canal, looking east.

Photo #3: View of fish dip and warning sign between Rock Segment #1 & #2, looking southeast.

Photo #4: View of fish dip and warning sign between Rock Segment #1 & #2, looking southwest.

Photo #5: View along Rock Segment #2, looking southeast.

Photo #6: View of fish dip and warning sign between Rock Segment #2 & #3, looking southeast.

Photo #7: View of fish dip and warning sign between Rock Segment #2 & #3, looking southwest.

Photo #8: View of settlement plate in Rock Segment #4, looking southeast.

Photo #9: View of fish dip and warning sign between Rock Segments #5 & #6, looking southeast.

Photo #10: View of fish dip and warning sign between Rock Segments #6 & #7, looking east.

Photo #11: View of fish dip and warning sign between Rock Segments #6 & #7, looking south.

Photo #12: View of fish dip and warning sign between Rock Segments #6 & #7, looking west.

Photo #13: View along Rock Segment #7, looking southwest.

Photo #14: View of fish dip and warning sign between Rock Segments #7 and #8, looking southwest.

Photo #15: View along Rock Segment #8, looking southwest.

Photo #16: View of fish dip and warning sign between Rock Segments #8 and #9, looking southwest.

Photo #17: View along Rock Segment #9, looking southwest.

Photo #18: View of fish dip and warning sign between Rock Segments #9 and #10, looking southwest.

Photo #19: View along Rock Segment #10, looking southwest.

Photo #20: View of fish dip and warning sign between Rock Segments #10 and #11, looking southwest.

Photo #21: View along Rock Segment #11, looking southwest.

Photo #22: View of fish dip and warning sign between Rock Segments #11 and #12, looking southwest.

Photo #23: View of the Marsh Creation Area from the southern boundary of the containment dike, looking north.

Photo #24: View of the Marsh Creation Area from the southern boundary of the containment dike, looking north.

Photo #25: View of the Marsh Creation Area from the southern boundary of the containment dike, looking north.

Photo #26: View of the Marsh Creation Area from the southern boundary of the containment dike, looking north.

Photo #27: View of the Marsh Creation Area from the southern boundary of the containment dike, looking north.

Photo #28: View of the Marsh Creation Area from the southern boundary of the containment dike, looking north.

Photo #29: View along Rock Segment #14, looking southwest.

Photo #30: View of fish dip and warning sign between Rock Segments #15 and #16, looking south.

Photo #31: View of fish dip and warning sign between Rock Segments #15 and #16, looking southeast.

Photo #32: View of fish dip and warning sign between Rock Segments #20 and #21, looking southeast.

Photo #33: View of Rock Segment #24 closest to John the Fool Bayou, looking southwest.

Photo #34: View of Rock Segment #24 closest to John the Fool Bayou, looking southwest.

Photo #35: View of Rock Segment #24 closest to John the Fool Bayou, looking northwest.

Photo #36: View of water level reading of 0.6’ NAVD88 @ 1:20pm from station BA-02-57.

Appendix B
(Three Year Budget Projection)

LITTLE LAKE SHORELINE PROTECTION & DEDICATED DREDGING / BA37 / PPL11

Three-Year Operations & Maintenance Budgets 07/01/2012 - 06/30/2015

Project Manager	O & M Manager	Federal Sponsor	Prepared By
	Ledet	NMFS	Ledet

	2012/2013	2013/2014	2014/2015
Maintenance Inspection	$ 5,662.00	$ 5,843.00	$ 6,030.00
Surveys			
Administration (NMFS)	$ 1,459.00	$ 1,506.00	$ 1,555.00
Maintenance/Rehabilitation			

12/13 Description

	2012/2013
E&D	
Construction	$ -
Construction Oversight	$ -
Sub Total - Maint. And Rehab.	$ -

13/14 Description:

	2013/2014
E&D	$ -
Construction	$ -
Construction Oversight	$ -
Sub Total - Maint. And Rehab.	$ -

14/15 Description:

	2014/2015
E&D	$ -
Construction	$ -
Construction Oversight	$ -
Sub Total - Maint. And Rehab.	$ -

	2012/2013	2013/2014	2014/2015
Total O&M Budgets	$ 7,121.00	$ 7,349.00	$ 7,585.00

O&M Budget (3-yr Total)	$ 22,055.00
Unexpended O&M Funds	$ 84,720.44
Remaining O&M Budget (Projected)	$ 62,665.44

OPERATIONS & MAINTENANCE BUDGET WORKSHEET

Project: **BA-37 Little Lake Shoreline Protection / Dedicated Dredging Near Round Lake**

FY 12/13 –

Administration (NMFS)			$	1,459
O&M Inspection & Report			$	5,662
Operation:			$	0
Maintenance:			$	0
E&D:	$	0		
Construction:	$	0		
Construction Oversight:	$	0		

Operation and Maintenance Assumptions:

FY 13/14 –

Administration (NMFS)			$	1,506
O&M Inspection & Report			$	5,843
Operation:			$	0
Maintenance:			$	0
E&D:	$	0		
Construction:	$	0		
Construction Oversight:	$	0		

Operation and Maintenance Assumptions:

FY 14/15 –

Administration (NMFS)			$	1,555
O&M Inspection & Report			$	6,030
Operation:			$	0
Maintenance:			$	0
E&D:	$	0		
Construction:	$	0		
Construction Oversight:	$	0		

Operation and Maintenance Assumptions:

2012-2015 Accounting

OCPR Expenditures:	$138,870.74
NMFS Expenditures:	$ 29,204.82
Total Expenditures:	$168,075.56
O&M Budget (from Lana Report)	**$252,796.00**
Unexpended Funds:	**$ 84,720.44**

Appendix C
(Elevation Grid Models)

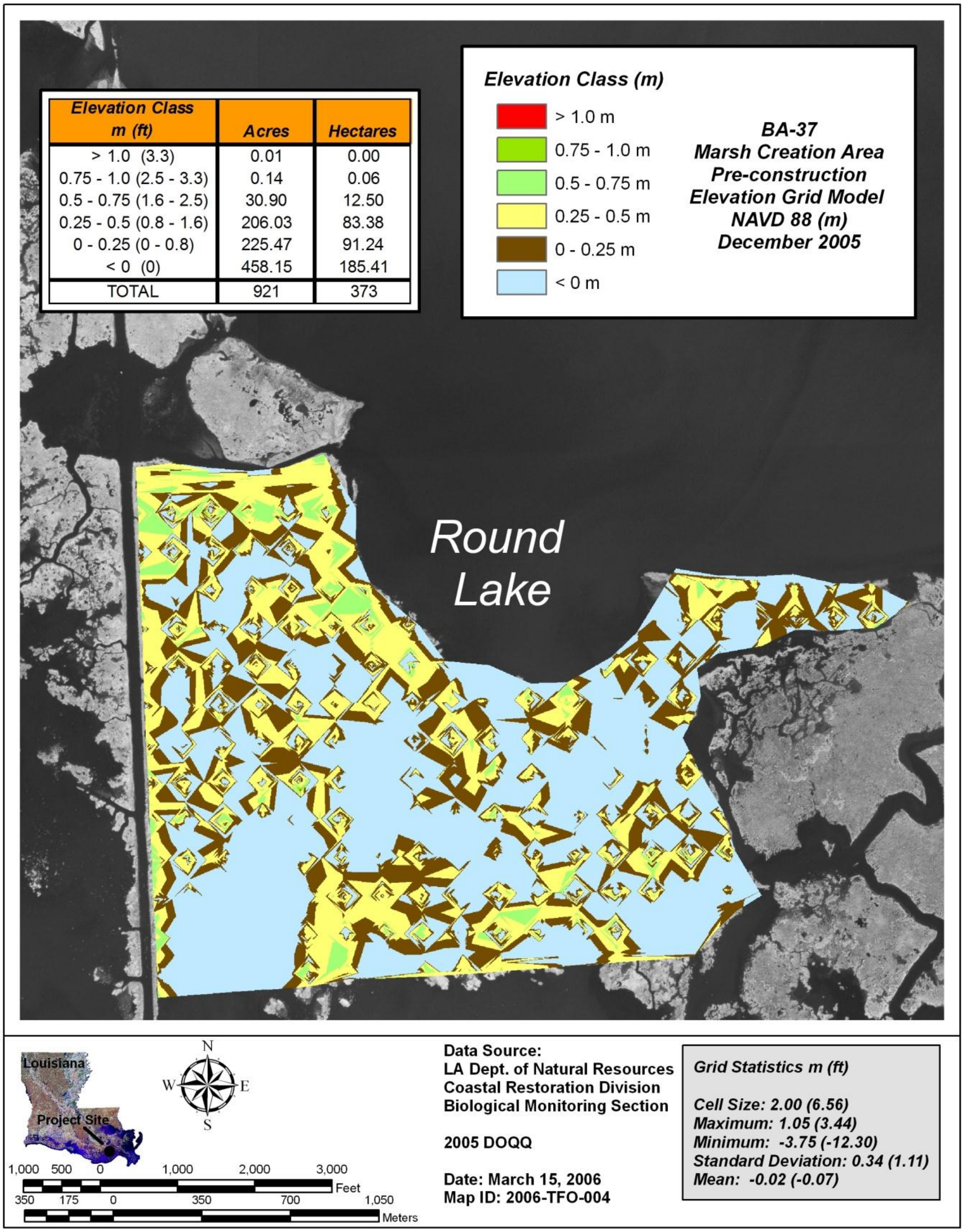

Figure. **Pre-construction (Dec 2005) elevation grid model at the Little Lake Shoreline Protection/Dedicated Dredging Near Round Lake (BA-37) project.**

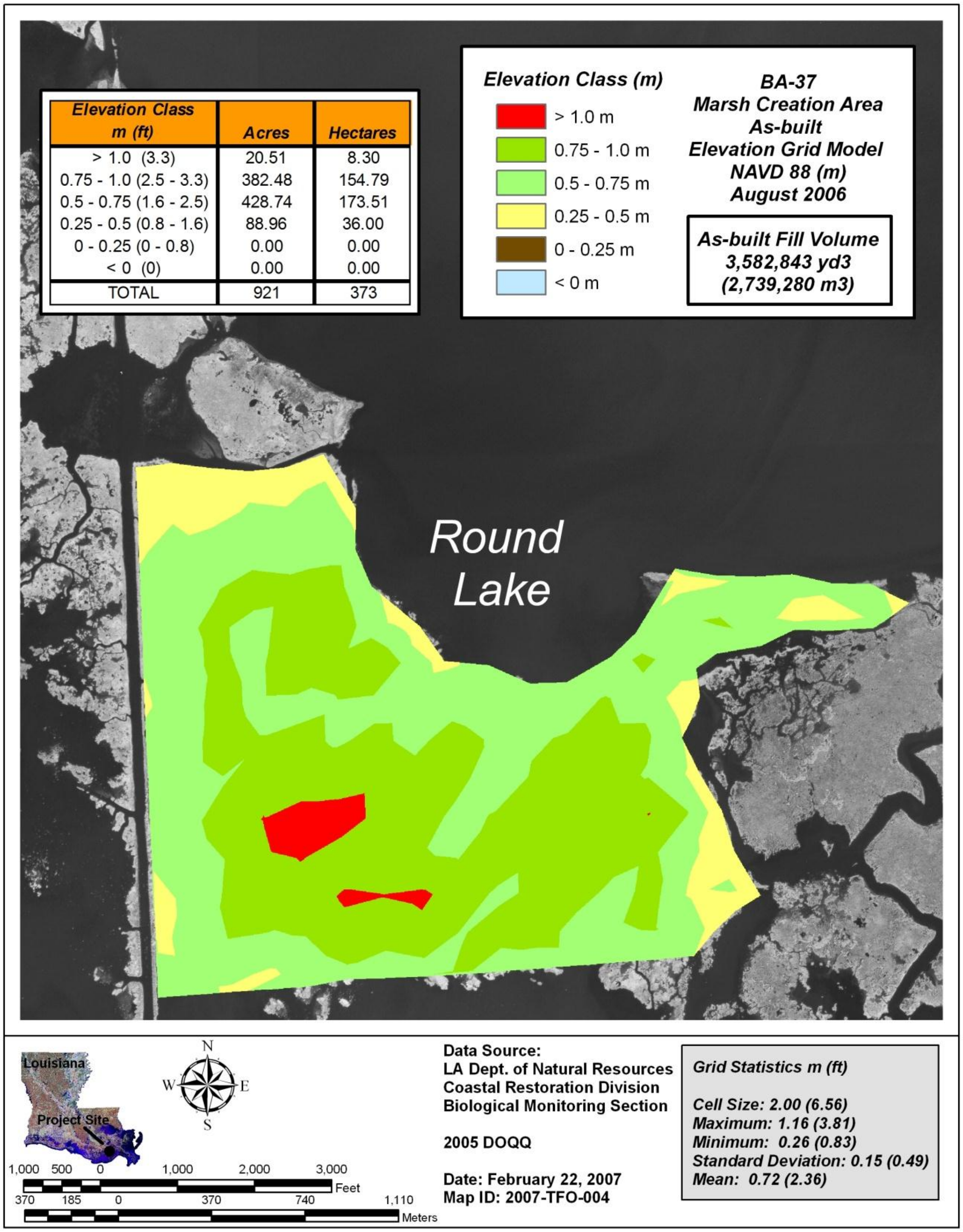

Figure. **As-built (Aug 2006) elevation grid model at the Little Lake Shoreline Protection/Dedicated Dredging Near Round Lake (BA-37) project.**

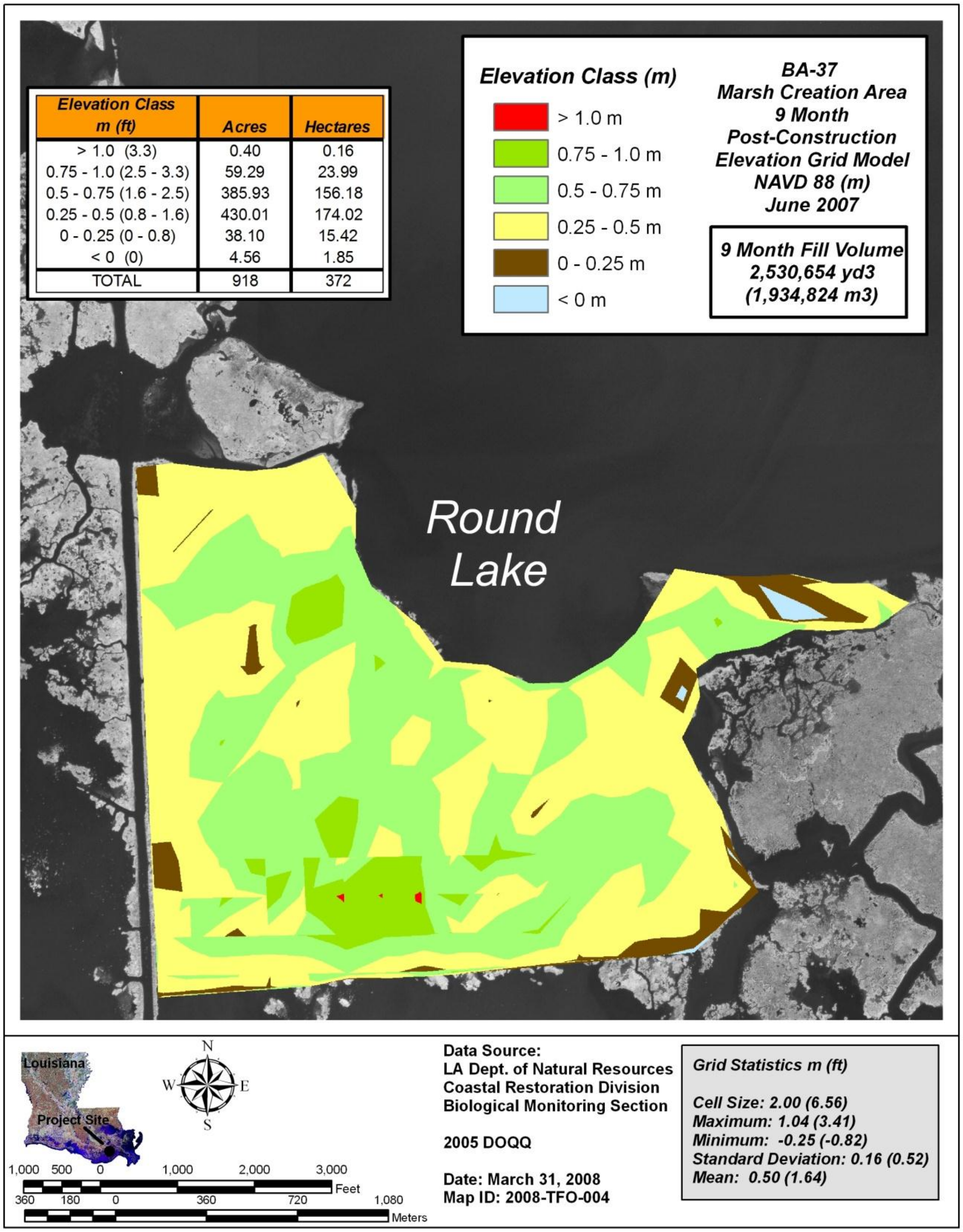

Figure. **Post-construction (Jun 2007) elevation grid model at the Little Lake Shoreline Protection/Dedicated Dredging Near Round Lake (BA-37) project.**

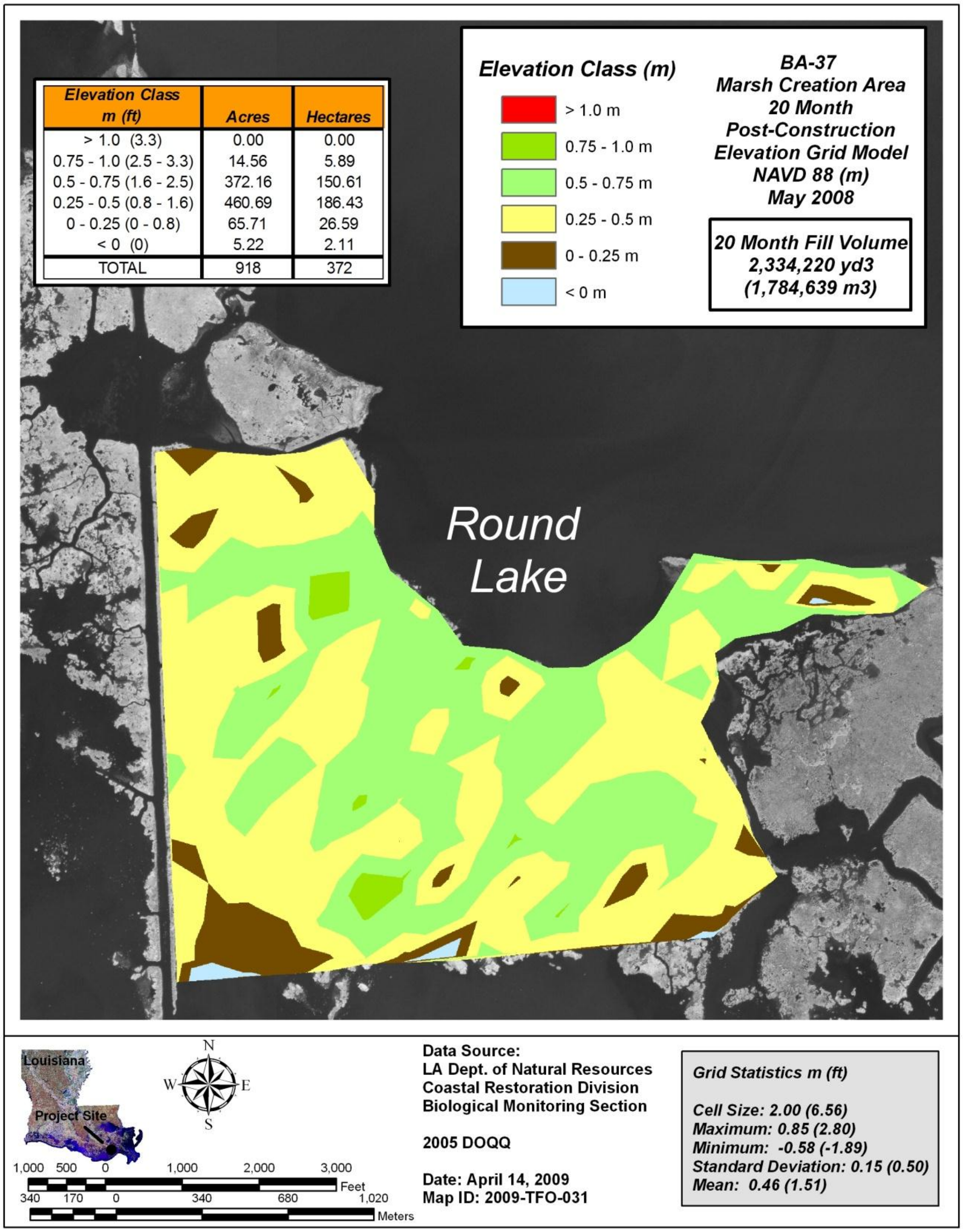

Figure. **Post-construction (May 2008) elevation grid model at the Little Lake Shoreline Protection/Dedicated Dredging Near Round Lake (BA-37) project.**

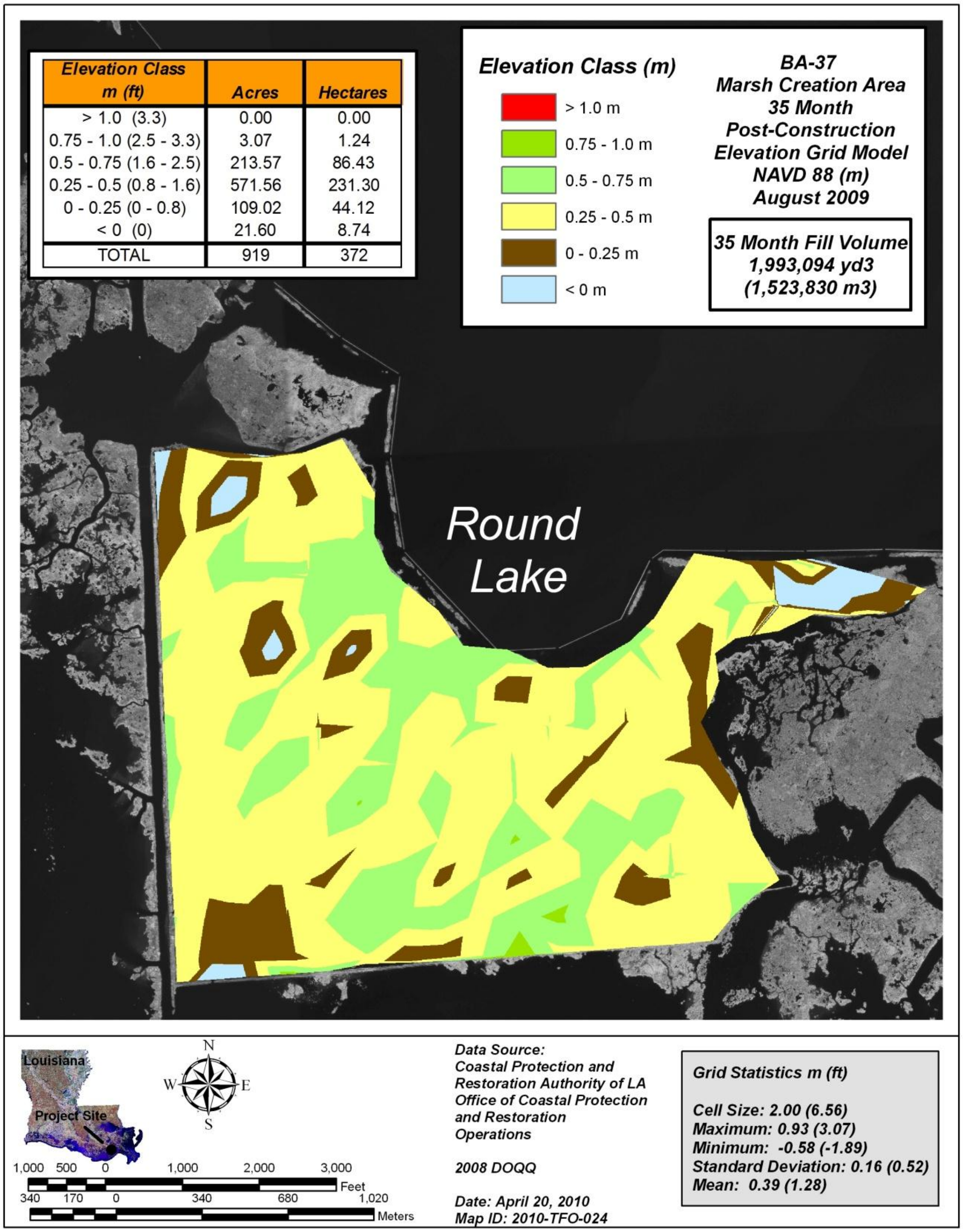

Figure. **Post-construction (Aug 2009) elevation grid model at the Little Lake Shoreline Protection/Dedicated Dredging Near Round Lake (BA-37) project.**

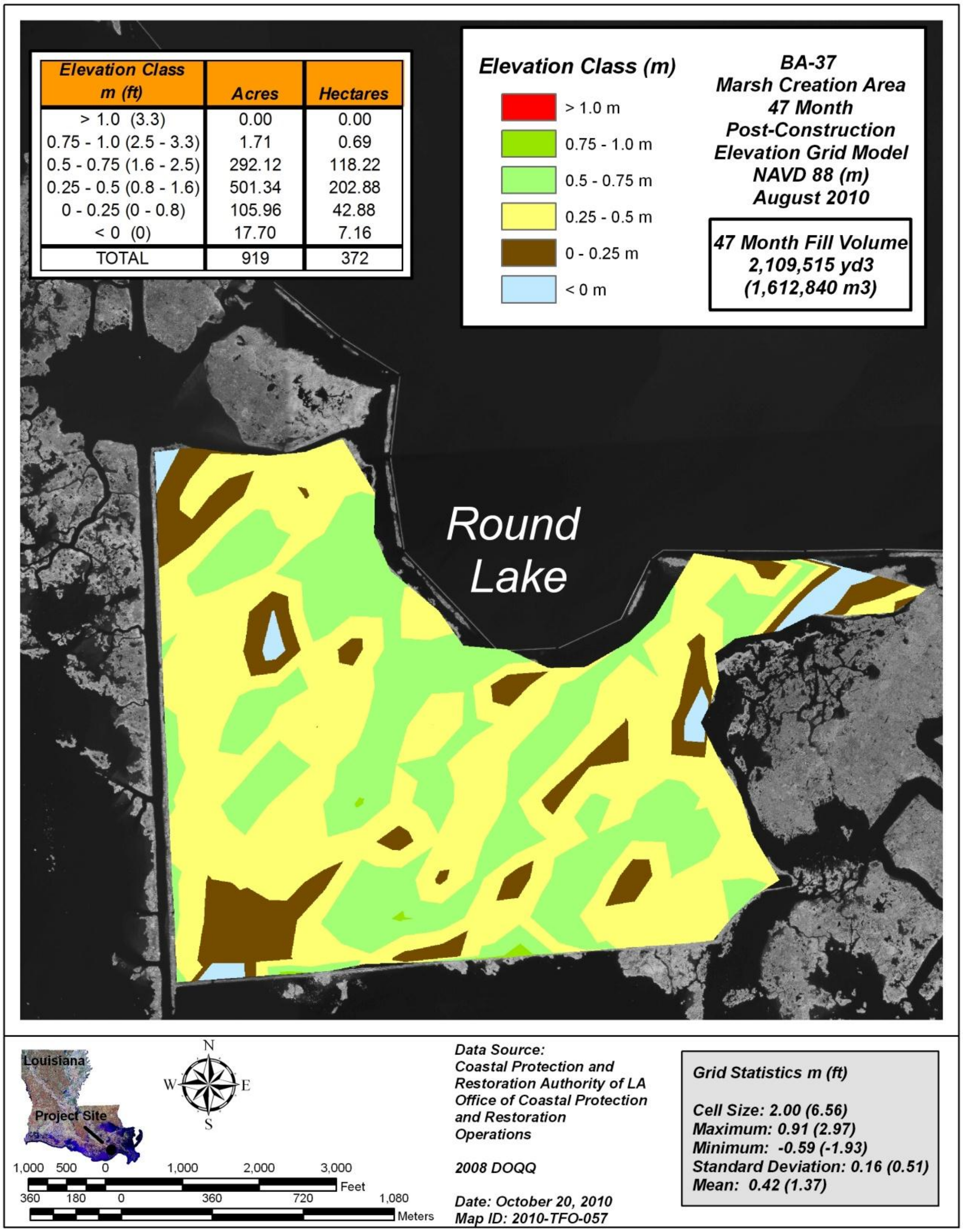

Figure. **Post-construction (Aug 2010) elevation grid model at the Little Lake Shoreline Protection/Dedicated Dredging Near Round Lake (BA-37) project.**

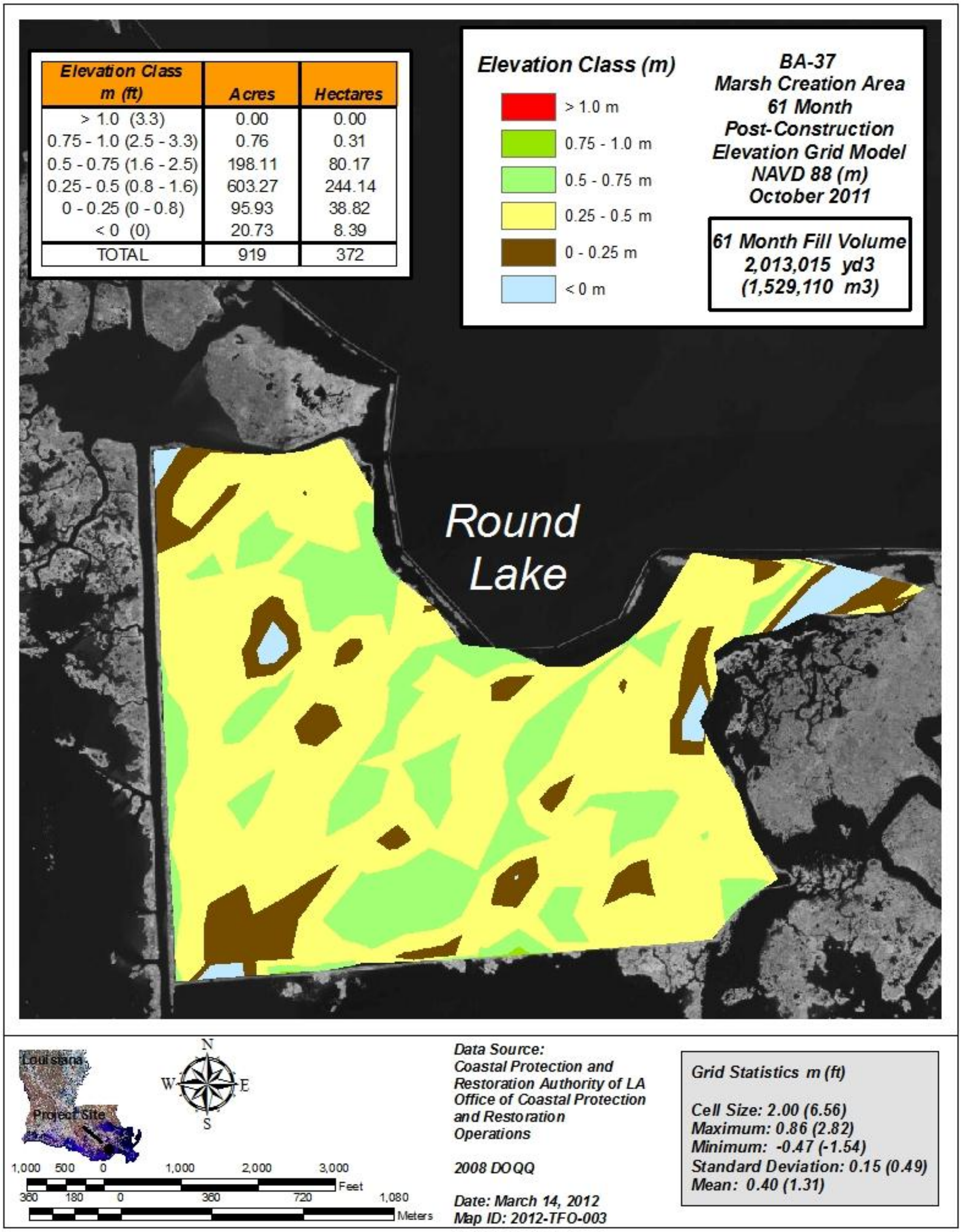

Figure. **Post-construction (Oct 2011) elevation grid model at the Little Lake Shoreline Protection/Dedicated Dredging Near Round Lake (BA-37) project.**

Appendix D
(Shoreline Change Graphics)

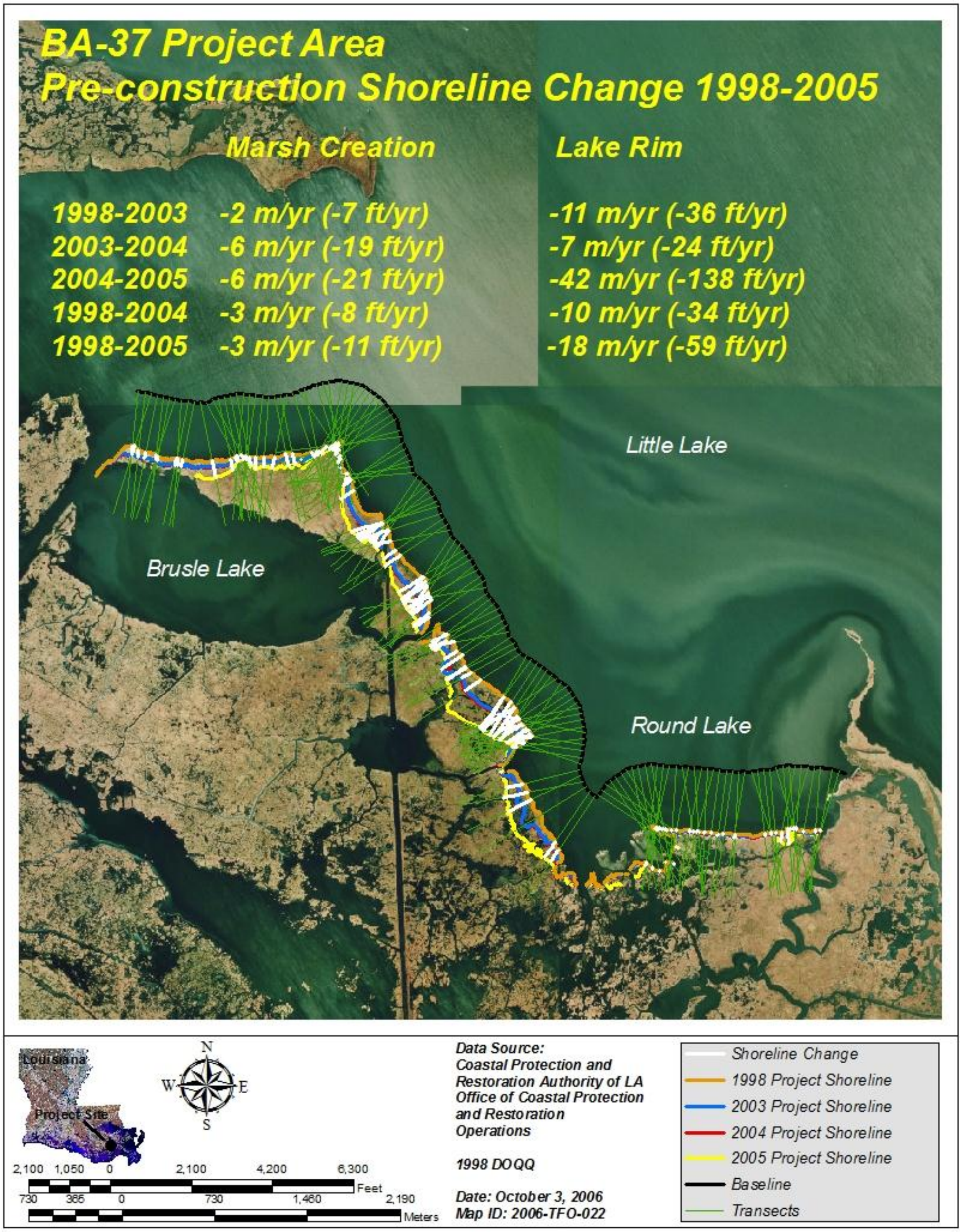

Figure. **Pre-construction (1998-2005) shoreline change at the Little Lake Shoreline Protection/Dedicated Dredging Near Round Lake (BA-37) project.**

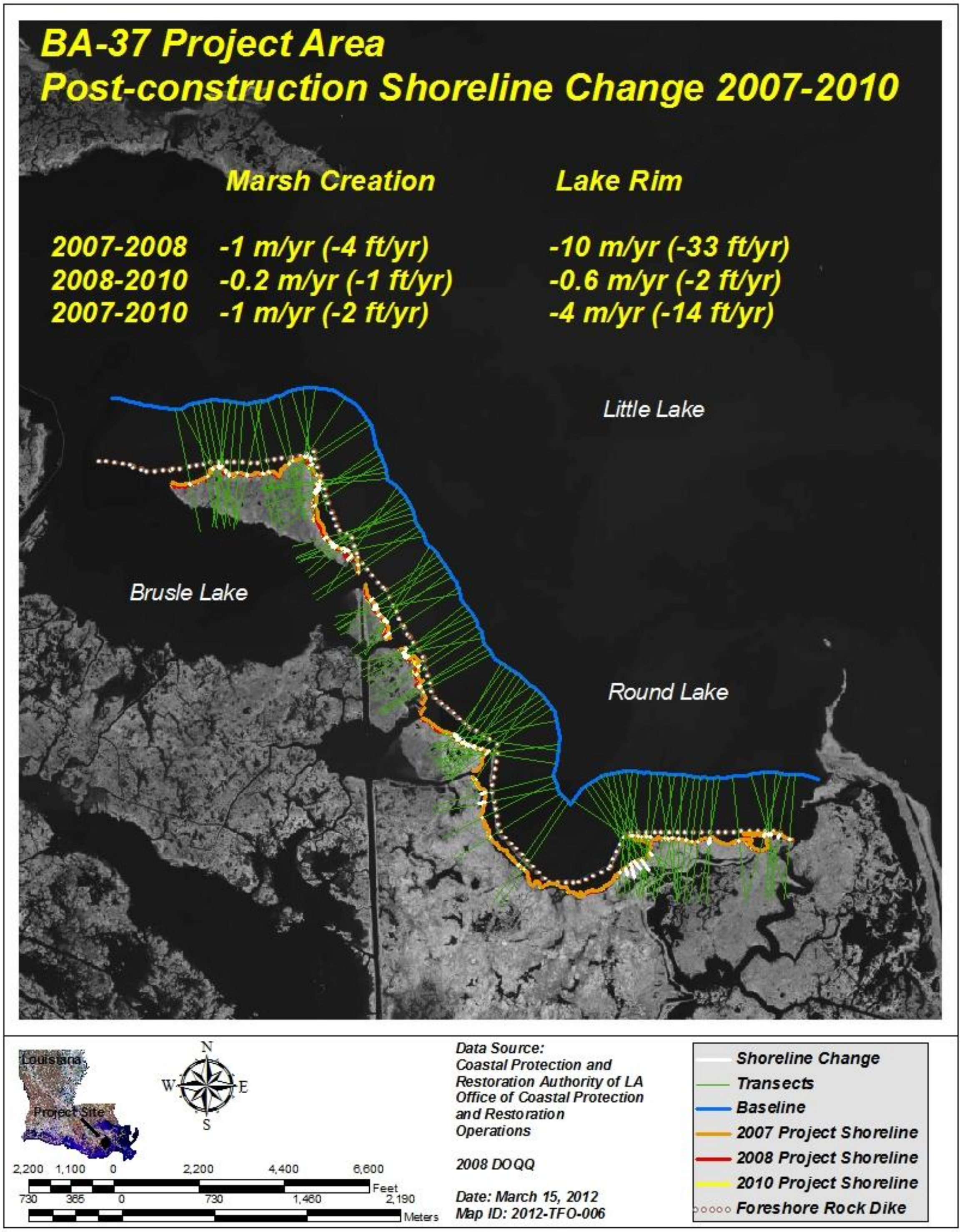

Figure. **Post-construction (2007-2010) shoreline change behind the foreshore rock dike at the Little Lake Shoreline Protection/Dedicated Dredging Near Round Lake (BA-37) project.**

Appendix E
(CRMS Land/Water Maps)

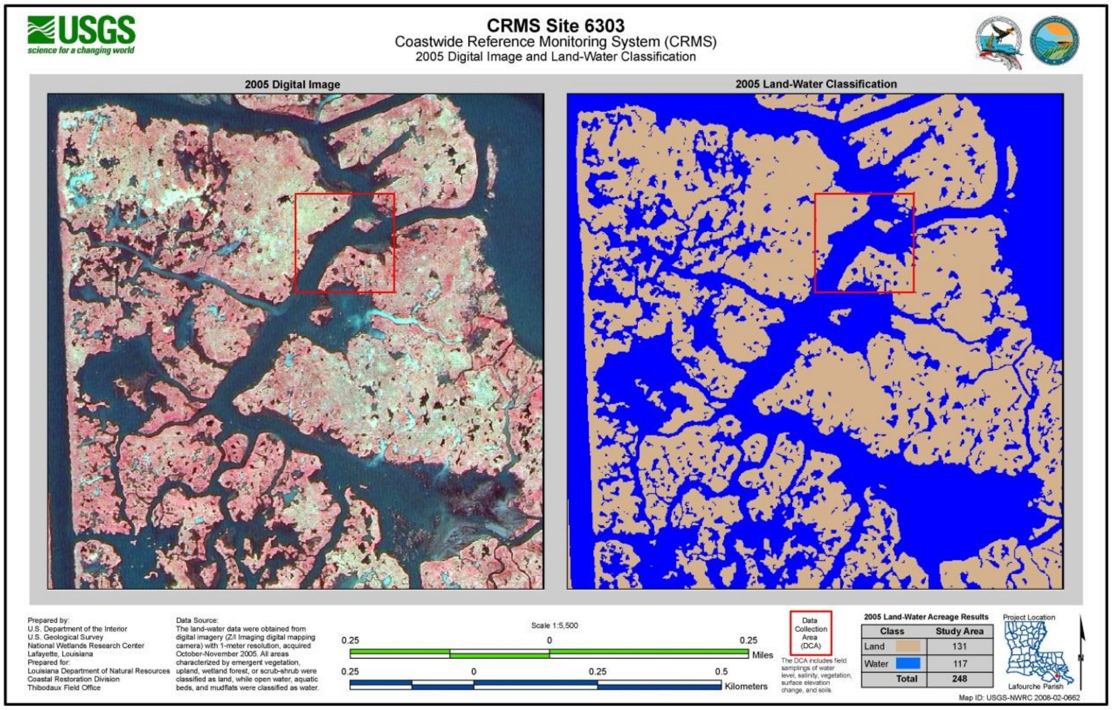

Figure. **2005 land/water classification of the CRMS6303 1 km square.**

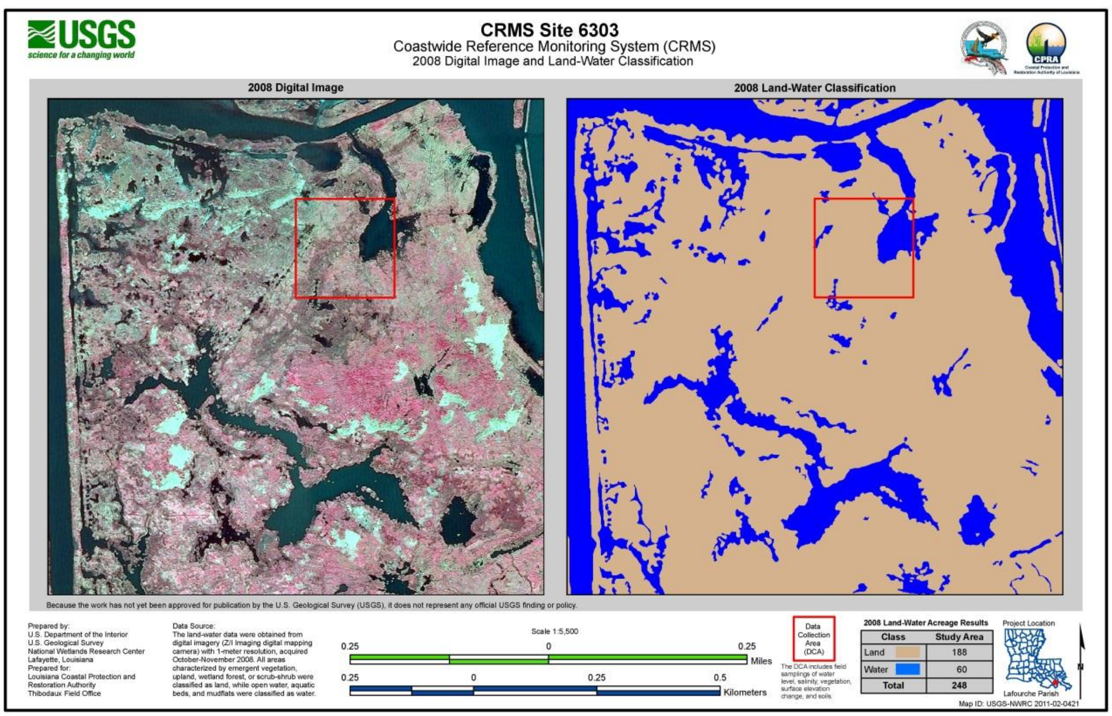

Figure. **2008 land/water classification of the CRMS6303 1 km square.**