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Coast 2050 Region 4

SABINE REFUGE PROTECTION
CS-18 (CS-18)

First Priority List Shoreline Protection Project
of the Coastal Wetlands Planning, Protection, and Restoration Act
(Public Law 101-646)

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Acknowledgments

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Abstract

Several factors, both natural and anthropogenic, have led to loss of freshwater marsh or conversion to more saline habitat in the Chenier plain marshes between the Calcasieu and Sabine Rivers in Louisiana. The Sabine National Wildlife Refuge, impounded by the U.S. Fish and Wildlife Service in 1951, is located between the higher salinity Starks Central, Burton-Sutton, Starks North, and Beach Canals in Cameron parish. This impoundment is now the only freshwater marsh that exists between the Calcasieu and Sabine River systems. In order to protect the western bank of the impoundment from wave-induced erosion, a 5.5 linear mi (8.9 km) rock dike was constructed in 1995 along the Burton-Sutton Canal (BSC) impoundment levee. To assess the effectiveness of the rock dike, shoreline position changes were measured using survey points along the edge of bank vegetation. Aerial photography was used to document changes in the land to water ratio within the impoundment that could result from a failure of the levee to prevent the intrusion of more saline waters from surrounding canals. Analysis of the pre- and post-construction shoreline surveys indicated that the shoreline along the BSC has not eroded further nor has water from the BSC impacted the impoundment. The interpretation of aerial photography acquired both pre- and post-construction, indicated that apparent land loss within the impoundment was most likely a function of differing water levels during the photography collection. The reference area exhibited no land loss during this period.

Introduction

The Sabine Refuge Protection project (CS-18) is a shoreline protection project from the 1st priority list of the Coastal Wetlands Planning, Protection, and Restoration Act (CWPPRA). The project area is located approximately 20 mi (32.2 km) west-southwest of Hackberry, Louisiana, along the east levee of the Burton-Sutton Canal (BSC) adjacent to the Sabine National Wildlife Refuge (SNWR) Impoundment 3 (figure 1). The project was designed to protect 13,000 acres (5,261 ha) of impounded freshwater wetlands within the SNWR from the saline waters of the adjacent BSC. This freshwater impoundment, comprising 27,000 acres (10,927 ha), contains emergent, floating, and submerged aquatic vegetation (SAV) which provides habitat for freshwater game fish, alligators, furbearers, and migratory and resident waterfowl. Currently, the salinity in Impoundment 3 is believed to be stable at ≤1.0 ppt, indicated by the presence of freshwater vegetation such as *Zizaniopsis miliacea* (giant cutgrass) and *Nelumbo lutea* (American lotus) within the impoundment. Water level within the impoundment is maintained at approximately 1.8 ft (0.55 m) (National Geodetic Vertical Datum [NGVD] of 1929) using three 90 ft (27.4 m) long variable-crest weirs (Castellanos 1998).

Historical records indicate that in the 1930s, the extensive marshes of the chenier plain near the project area were freshwater marshes dominated by *Cladium mariscus* ssp. *jamaicense* (saw grass) and *Schoenoplectus californicus* (giant bulrush) (U.S. Department of Agriculture [USDA] 1931; USDA, Natural Resources Conservation Service 2001). Through intrusion of saline Gulf waters, much of the area of freshwater marsh was converted to brackish and intermediate forms. By 1988, the majority of the area surrounding the impoundment consisted of brackish marsh except for a large expanse of intermediate marsh south of the impoundment area (Chabreck and Linscombe 1988). Today, the SNWR impoundment is essentially the only remaining expanse of coastal freshwater marsh between the Calcasieu and Sabine Rivers.

Saltwater intrusion, a major contributor to wetland loss in coastal Louisiana, can be linked to several natural and anthropogenic causes. An example is the construction of channels and canals for navigation and exploration of oil and gas, which allow greater flow velocities and greater intrusion of saline Gulf waters into interior wetlands. These secondary losses of wetlands occur more gradually than the primary losses caused by dredging and disposal of spoil into adjacent wetlands. When saline water rapidly invades freshwater marsh, mortality of existing vegetation may expose highly erodible soils, which can export from the system before more salt tolerant plant species can become established in the area (Turner and Cahoon 1987). Waterlogging of soils can intensify the detrimental effects of saltwater intrusion by increasing stress and mortality of vegetation, resulting from highly reduced conditions and the accumulation of sulfides (Turner and Cahoon 1987). Freshwater impoundments are especially susceptible to vegetation loss caused by saltwater intrusion as a result of poor drainage and ponding of saline water in interior marshes when levee banks are breached or overtopped.

The levees which encompass Impoundment 3, constructed in 1951, border the east bank of the BSC. Constructed in the early 1900's, the BSC is used by barges and boats to reach two oil and gas

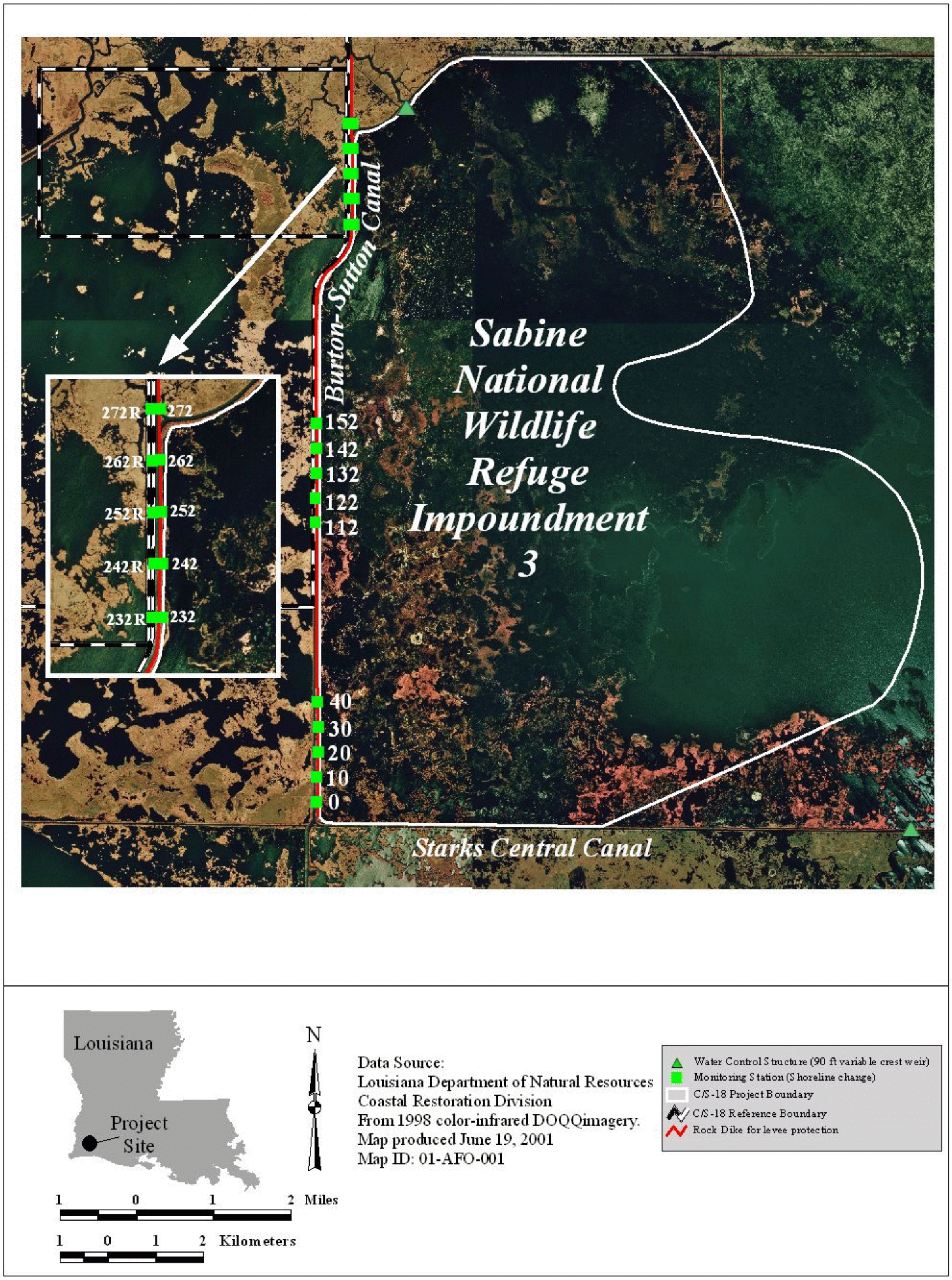

Figure 1. Sabine Refuge Protection (CS-18) project boundary, reference boundary, rock dike along the Burton-Sutton Canal, and shoreline change monitoring station locations.

production fields located on the southern part of the refuge. Boat wake-induced erosion resulted in sloughing of levee material into the BSC and it is estimated that the levee was eroding at the rate of 0.27 ft/yr (0.08 m/yr) (Louisiana Coastal Wetlands Conservation and Restoration Task Force [LCWCRTF] 1991; U. S. Fish and Wildlife Service [USFWS] 1991). Continued erosion could result in breaches of the levee, allowing higher salinity waters from the Calcasieu Ship Channel and Sabine Lake to enter the impoundment via the BSC. Salinity as high as 14.7 ppt has been recorded in the BSC by SNWR personnel. Saltwater intrusion and increased tidal exchange would likely convert as much as 13,000 acres (5,261 ha) of the impoundment to shallow open water, due to the highly organic nature of the freshwater marsh within the impoundment (LCWCRTF 1991; USFWS 1991). Increased wind-induced wave erosion of the remaining marsh within the impoundment would then be expected through the loss of floating vegetation and SAV. Weathering of, and erosion along, the unprotected spoil bank necessitated shielding it from further deterioration through the use of a continuous rock dike. The integrity of this spoil bank is critical to maintaining the impoundment as a freshwater marsh.

Waves produced by boat traffic cause erosion of navigation channel banks and damage to nearby vegetation communities (Good et al. 1995). Water displaced from the channel by passing vessels may overtop the banks of channels into the adjacent wetlands causing soil scour, vegetation damage, and rapid water level changes. Erosion of interior wetlands is accelerated by "blowouts" where a connection is formed between a channel and an inland water body (Good et al. 1995).

Rock dikes have been designed to prevent shoreline erosion and allow sediment accretion behind the dike through wave overtopping. A similar shoreline protection project along the GIWW at Cameron Prairie (ME-09) has resulted in observed sediment buildup between the rock dike and original shoreline (Courville 1997). The Sabine Refuge Protection project (CS-18) is designed to prevent further erosion of the Impoundment 3 west levee, and protect the existing freshwater wetlands from saltwater intrusion. Construction of approximately 5.5 linear mi (8.9 km) of free-standing, continuous rock dike was completed in January 1995 (Vincent 1997) (figure 2). The breakwater was constructed using limestone rubble in the 125-275 lb. range placed above a layer of geotextile fabric (to prevent settling). No settlement plates were installed for this project.

The project objectives are to protect the existing freshwater vegetation within Impoundment 3 of SNWR adjacent to the BSC and to prevent the introduction of higher salinity water from the BSC into the impoundment. The specific goals needed to achieve these objectives are to:

1. Restore and protect the west levee of Impoundment 3 using dredge material and a free-standing rock breakwater.

2. Protect existing freshwater vegetation in Impoundment 3 from saltwater intrusion via the Burton-Sutton Canal.

Figure 2. Photograph of the Sabine Refuge Protection (CS-18) project following construction in August 1995, illustrating the shoreline of the impoundment and the installed rock breakwater. Photograph faces north along the eastern bank of the BSC.

Methods

Aerial Photography: Near-vertical color-infrared aerial photography (1:24,000 scale) was used to measure vegetated and non-vegetated areas for the project and reference areas. The photography was obtained on November 1, 1993 prior to construction and on January 7, 1997, 2 yr following project construction. The original photography was checked for flight accuracy, color correctness, and clarity and was subsequently archived. Duplicate photography was produced for scanning and analysis. Aerial photography was scanned, mosaicked, and georectified by USGS/NWRC personnel according to standard operating procedures (Steyer et al. 1995, revised 2000).

A digital Tagged Image File Format (TIFF) image file with resolution of 300 pixels per inch (ppi) was created from the photography for each of the two data sets. Using ERDAS Imagine™ image processing software, the photography was mosaicked and used to produce base maps. Optimal Global Positioning System (GPS) points were collected in the field to georeference the base maps with the proper Universal Transverse Mercator (UTM) coordinate system. The resulting preconstruction and post-construction maps were then analyzed with ERDAS Imagine™ geographic information system (GIS) software components. The unsupervised GIS classifications, computer-automated pixel classifications based on gradients of color, determined the project and reference area land to water ratios for the 1993 and 1997 flights.

Shoreline Change: To document shoreline movement, shoreline markers to be used for determining the distance to the edge of marsh vegetation were established at 1,000 ft (305 m) intervals on the crown of the west spoil bank of Impoundment No. 3, along the east bank of the BSC adjacent to the northernmost, central, and southernmost portions of the rock dike (figure 1). Shoreline markers were also established on the west bank of the BSC adjacent to the reference area. In August 1995, Professional Engineering and Environmental Consultants of New Orleans completed a shoreline and cross-sectional survey of the BSC. This information was intended to serve as the baseline location of the vegetated shoreline for the project and reference areas. However, examination of the data by Coastal Restoration Division (CRD) personnel showed discrepancies between the August 1995 shoreline survey and the results of a supplemental direct measurement shoreline survey conducted by CRD in October 1995 in interpretations of the location of the vegetated shoreline. In this survey, measurement of the distance (in ft) from the landward shoreline markers toward the edge of bank vegetation was collected, using a graduated tape, at each of the twenty stations. This survey method was repeated in August 2000 to determine shoreline change. Due to the heavy cover present on the levee near survey markers, stations were marked at the canal edge of the rock dike with both flagging tape and paint to facilitate retrieval of survey hubs in the future. It was determined that the October 1995 survey should be compared to the August 2000 survey for the purpose of consistency in interpretation of the vegetated shoreline and thus to evaluate project effectiveness in protecting the west levee of the impoundment. Shoreline change rates were calculated from the measured distances for both the pre- and post-construction datasets. Descriptive and summary statistics were generated from the data and then compared. A two-sample, two-tailed t-test, using "=0.05, was performed to determine if the calculated shoreline change rates differed significantly between the project and reference areas.

Results

Preliminary examination of the aerial photography suggested that water levels were higher during the post-construction flight relative to the flight preceding project construction. Consultation with SNWR personnel confirmed that water levels during January 1997 were indeed higher than was the case in the preconstruction photography, complicating the computerized classification process and interpretation of the subsequent results.

The findings of the unsupervised GIS classification for the preconstruction and post-construction project and reference area land to water ratios are illustrated in figures 3 and 4. Unusually high water levels at the time of the 1997 photo acquisition led to very high water to land ratios in the 1997 project area analysis, equating to an increase of 738 acres [299 ha] of open water area from the preconstruction to post-construction analyses. Relatively small changes in the land to water ratio were detected for the reference area, indicating that the reference area exhibited only slight loss of land (11 acres [4.5 ha]) during the study period. This rate of loss equates to approximately 3.6 acres/yr (1.5 ha/yr). Such a change could also relate to water level and not be the result of subsidence or erosional processes.

Shoreline survey results, presented in figures 5a and 5b, show shoreline position change during the study period differing by less than 7.7 ft (2.3 m) at any one station for both the project and reference areas. Shoreline advance was detected at all project stations except stations 30 and 112 and for all reference stations except 252R during the period between 1995 and 2000 (figure 6). Mean shoreline advance rates were calculated to be 1.3 $\pm$ 1.1 ft/yr (0.4 $\pm$ 0.3 m/yr) and 0.9 $\pm$1.9 ft/yr (0.3 $\pm$ 0.6 m/yr) for the project and reference areas, respectively. The results of the two-sample t-test indicated that there was no significant difference in shoreline change rate detected between the project and reference areas ($\boldsymbol{P}$ = 0.90).

Examination of the engineers' first annual inspection report (October 1996) and inspection by LDNR monitoring personnel in December 1997 and August 2000 provided evidence that the Sabine Refuge Impoundment 3 levee and the protective rock dike are in good condition.

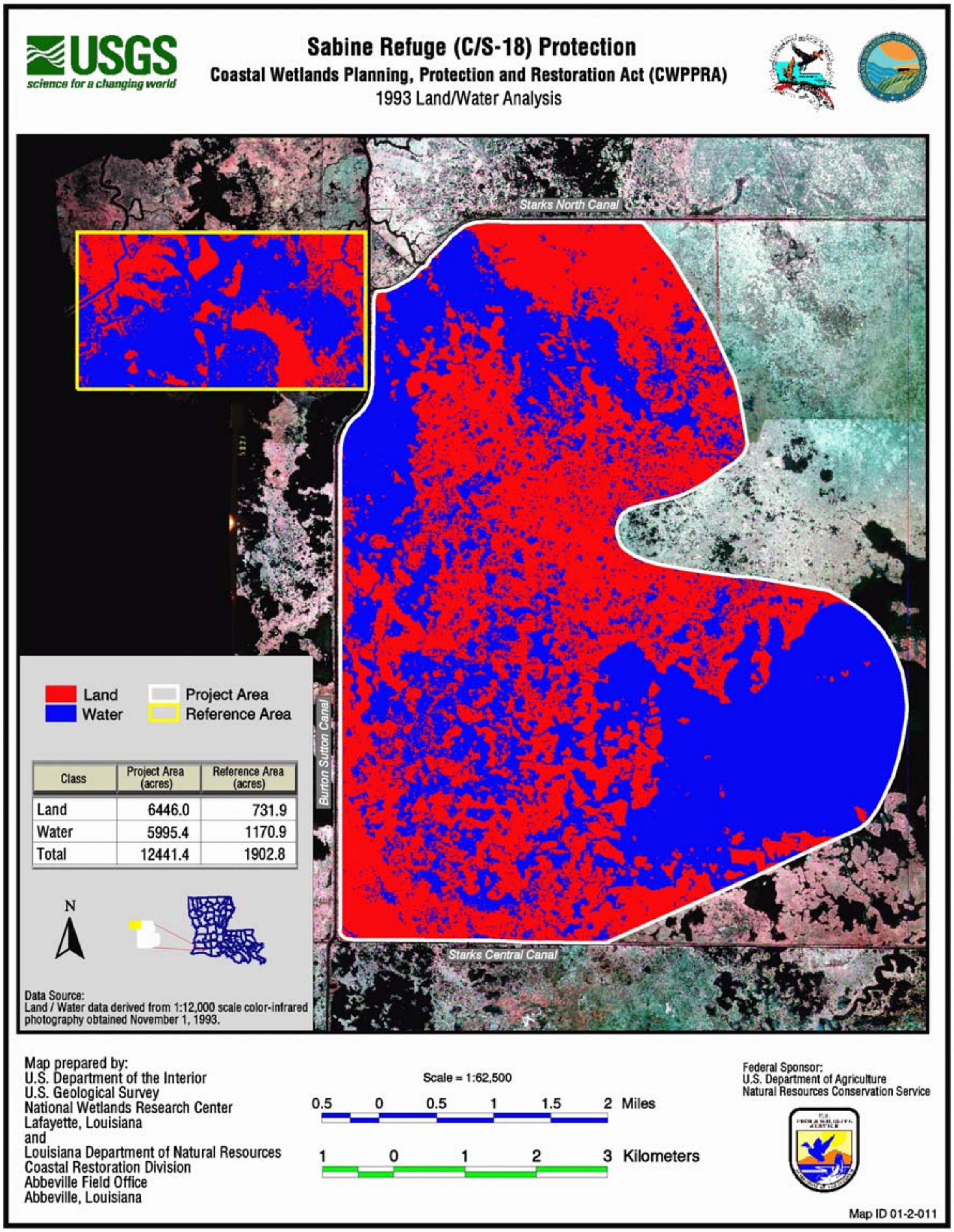

Figure 3. Sabine Refuge Protection (CS-18) GIS analysis of project and reference area preconstruction aerial photography (1993).

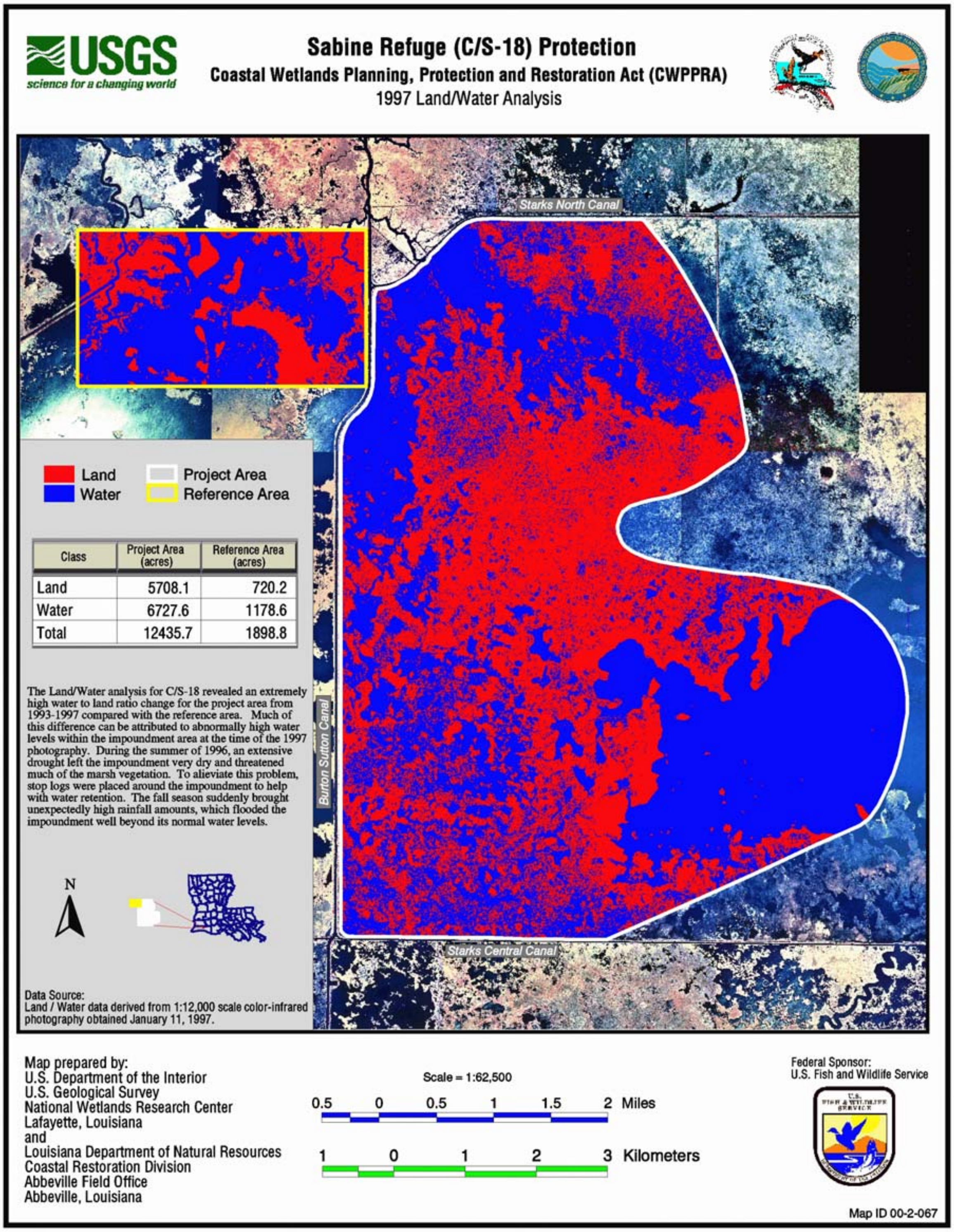

Figure 4. Sabine Refuge Protection (CS-18) GIS analysis of project and reference area post-construction aerial photography (1997).

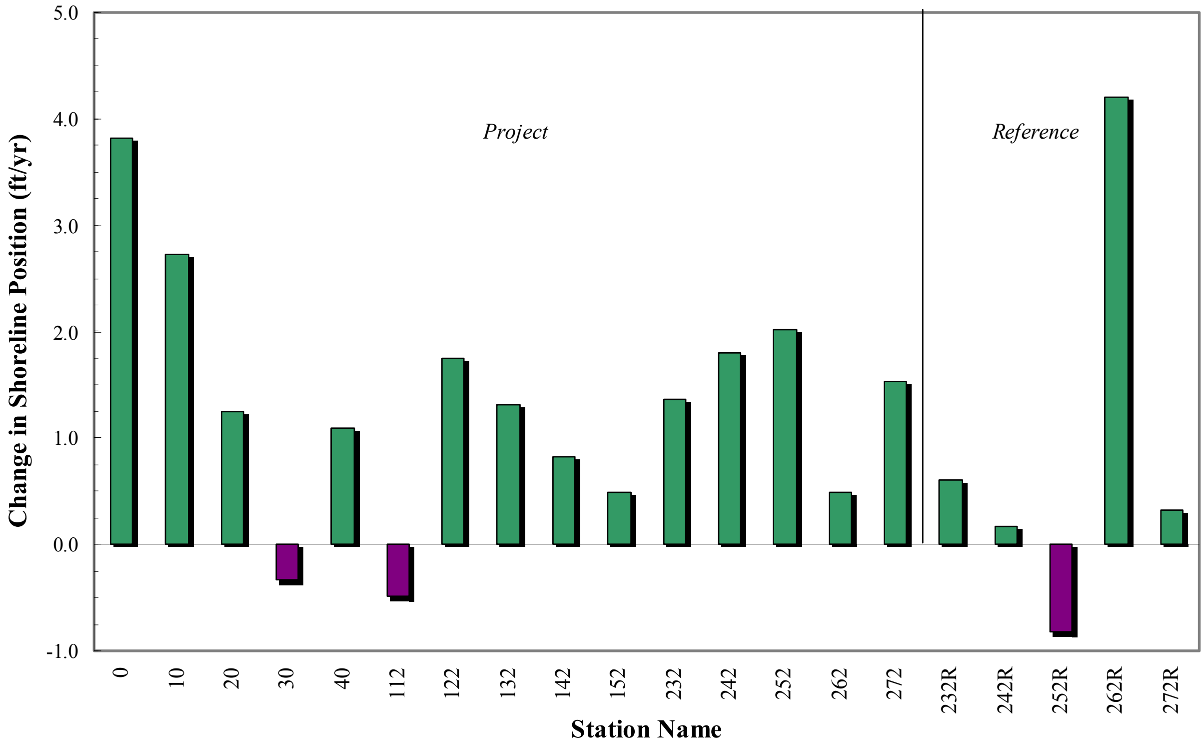

Figure 5a. Sabine Refuge Protection (CS-18) shoreline position change. Rates are calculated (in ft/yr) for the period 1995-2000.

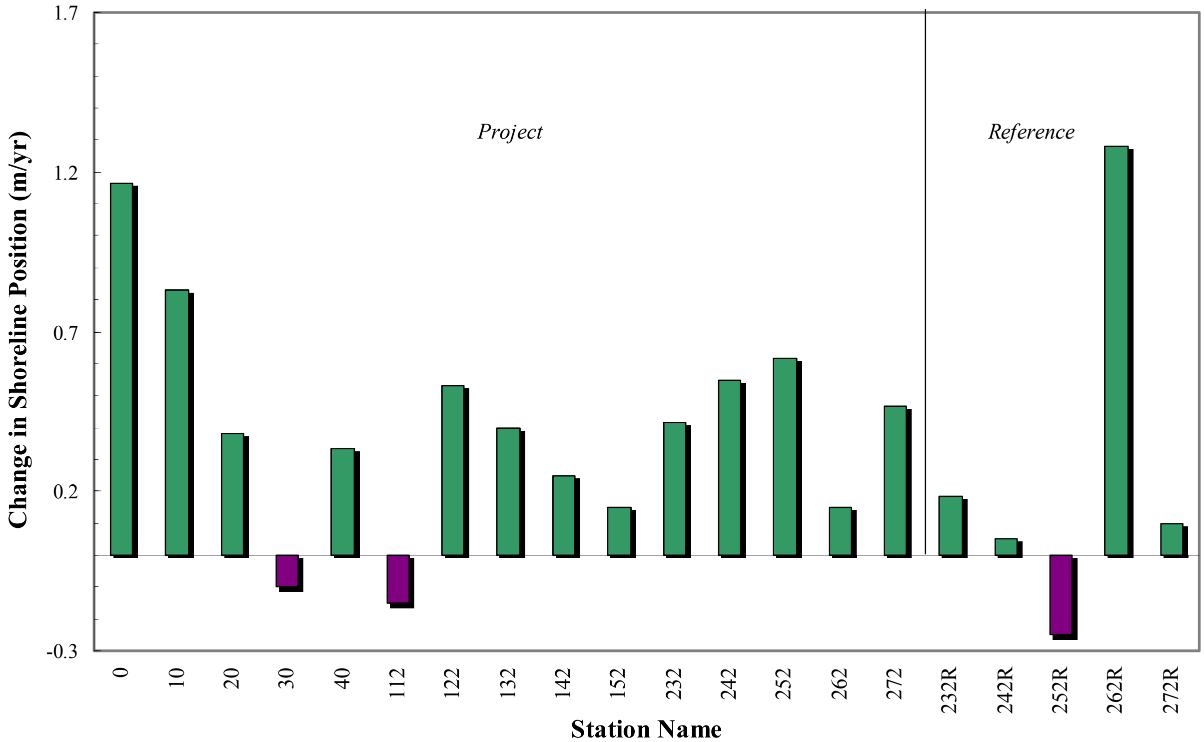

Figure 5b. Sabine Refuge Protection (CS-18) shoreline position change. Rates are calculated (in m/yr) for the period 1995-2000.

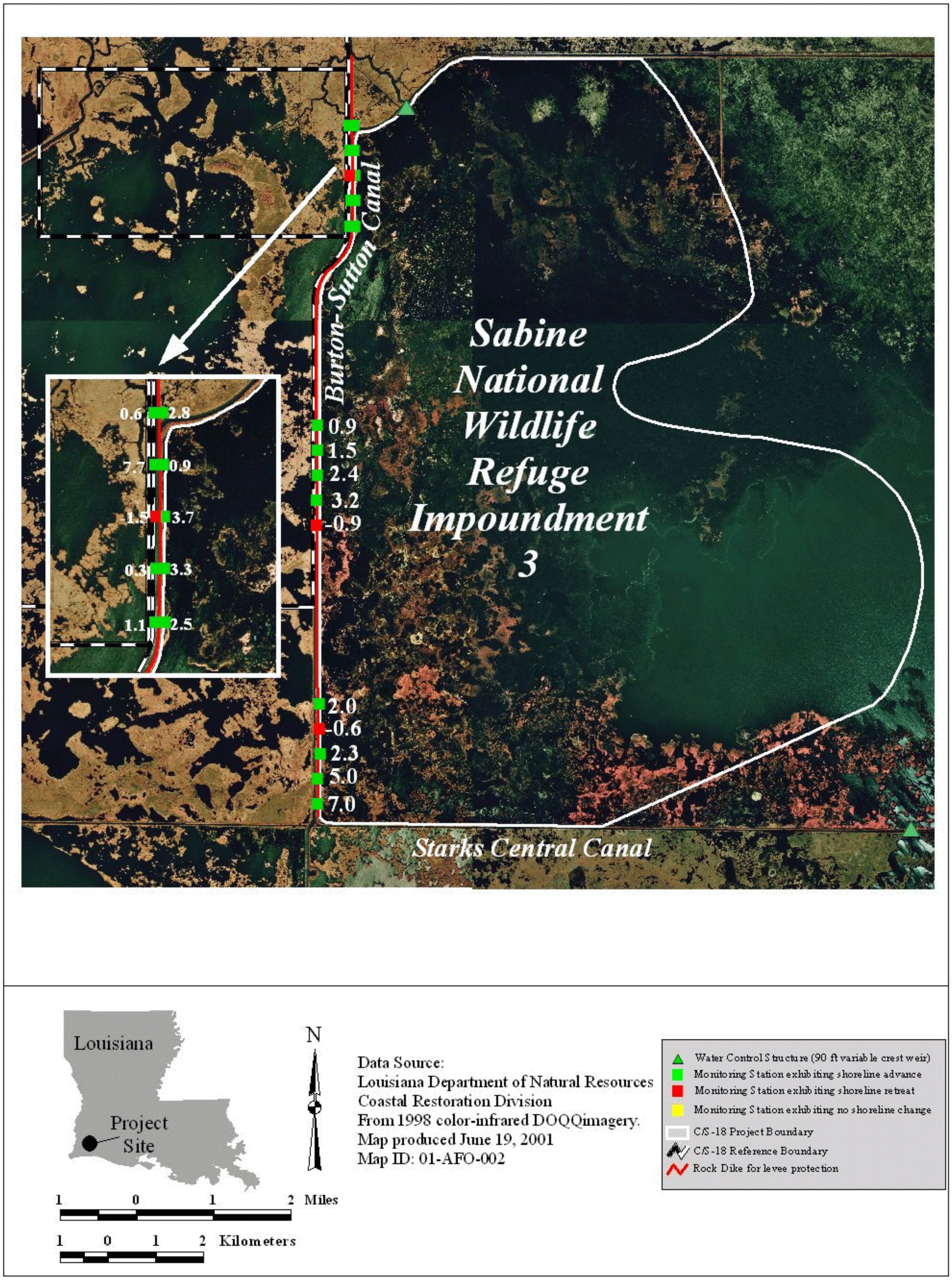

Figure 6a. Sabine Refuge Protection (CS-18) shoreline change (ft) at project and reference area monitoring station locations between October 1995 and August 2000.

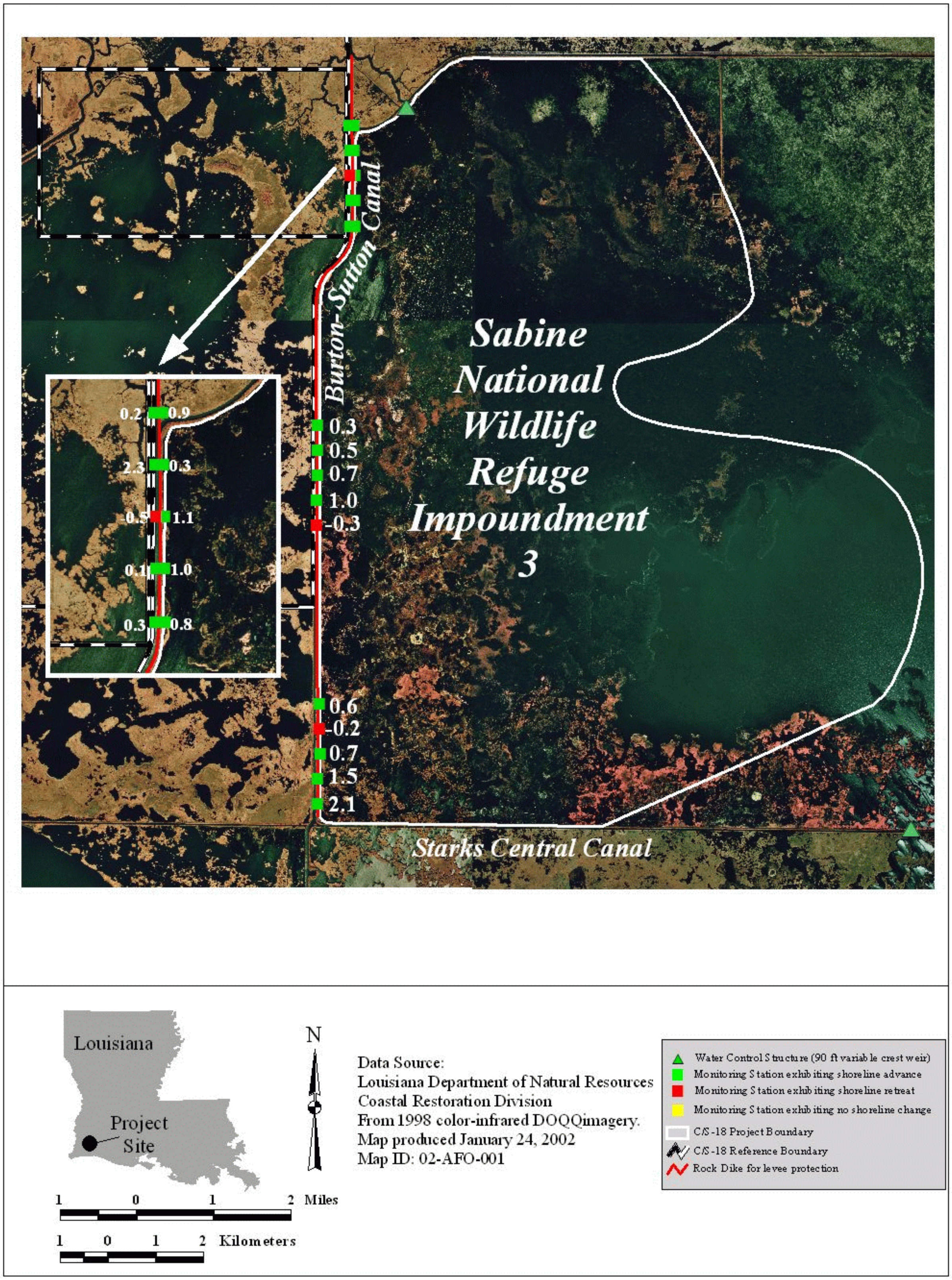

Figure 6b. Sabine Refuge Protection (CS-18) shoreline change (m) at project and reference area monitoring station locations between October 1995 and August 2000

Discussion

Analyses of preconstruction and post-construction aerial photography, which showed drastic loss of land between 1993 and 1997, may be misleading because this loss may be attributed to variations in impoundment water level rather than an actual decrease in the land to water ratio. During December 1993, the nearest available dataset for water level to the date of preconstruction photography acquisition, mean water level within Impoundment 3 was 1.7 ft (0.52 m), 0.1 ft (0.03 m) less than the SNWR target water level of 1.8 ft (0.55 m). During January of 1997, the time of post-construction photo acquisition, the weirs which control impoundment water levels were set to retain the maximum quantity of water possible. This was done to maximize the benefits of the winter rainfall events following a severe drought during the summer of 1996. Therefore, the impoundment water level was higher during this time as compared to the preconstruction flight. Water levels as high as 2.2 ft (0.67 m) were recorded by SNWR personnel. This event had an important impact on land area within the impoundment as large expanses of freshwater marsh were completely inundated. These areas were classified as open water during the GIS classification of the post-construction aerial photography dataset. In later years, as was the case during the drought of 2000, mean water levels dropped to as low as 1.1 ft (0.34 m). This demonstrates the highly variable nature of water level measurements taken within the impoundment due to environmental conditions, primarily precipitation. Consequently, the land to water ratios calculated are not an adequate assessment of project success due not only to the issue of differing water levels, but also to the fact that the interior fresh marshes would not be impacted by the project unless it failed to protect the levee which makes up the west bank of the impoundment. The relatively small changes in the land to water ratio detected for the reference area during the study period could also relate to water level fluctuations and not be the result of subsidence or erosional processes.

Observations while at the project site and data collected during the shoreline surveys demonstrate that the integrity of the west bank of the SNWR Impoundment No. 3 has been maintained and the freshwater vegetation within the impoundment has been preserved (Louisiana Department of Wildlife and Fisheries, Fur and Refuge Division and USGS/NWRC 1997). The results of the shoreline surveys indicated no significant difference in shoreline change rates between the project and reference areas. This is important because, not only did the project and reference areas exhibit the same shoreline change rates, both showed minor amounts of shoreline advance. This is contrary to the assumption that the lack of any significant difference in shoreline change rates between a project and reference area usually indicate negative effects of the project. According the survey results, this is clearly not the case. It is important to note that the shoreline advanced observed, as well as any future advance, is expected to be restricted to the area behind the rock breakwater in the project area. The impoundment levee appears to be stable and the rock dike seems to be in good condition at this time, according to observations made by CRD personnel in 1997 and 2000. No breaches of the levee were found (figure 7).

Wave-induced erosion was believed initially to be the primary cause of levee degradation in the project area. Boat traffic on the BSC has not increased to the levels anticipated during project planning and thus the threat of wave erosion remains relatively low. This is clearly illustrated in the lack of wave- induced erosion present in the unprotected reference area along the west bank of the BSC.

Figure 7. Photograph of the Sabine Refuge Protection (CS-18) project 5 yr following construction in August 2000, showing shoreline advance to the rock breakwater at one of the project stations.

Conclusions

The goals and objectives of the monitoring plan appear to have been met thus far. The project has been effective in preventing saltwater intrusion into the SNWR impoundment number 3. The BSC has not compromised the levee and freshwater vegetation remains dominant in the impoundment. Extensive levee erosion has not been observed during active monitoring of this project. Additionally, little change was observed in the shoreline position of the unprotected reference area. Scheduled shoreline change surveys (for years 2005, 2010, and 2014), and comprehensive monitoring reports for years 2006, 2011, and 2015 will be completed and will provide further monitoring documentation for this shoreline protection project. Future inspections of the project area by CRD engineers will be conducted at regular intervals to document the condition of the rock breakwater and any required maintenance.

References

Castellanos, D. L. 1998. Sabine Refuge Protection (CS-18) Three-year comprehensive monitoring report. Open file monitoring series CS-18-MSTY-0198-1, for the period 27 January 1995 to 27 January 1998. Baton Rouge: Louisiana Department of Natural Resources, Coastal Restoration Division. 17 pp.

Chabreck, R., and G. Linscombe 1988. Vegetative type map of the Louisiana coastal marshes. New Orleans: Louisiana Department of Wildlife and Fisheries. Scale 1:62,500.

Courville, C. J. 1997. Cameron Prairie Refuge Protection (ME-09) Three-year comprehensive monitoring report. Open file monitoring series ME-09-MSTY-0797-1, for the period 3 August 1994 to 4 August 1997. Baton Rouge: Louisiana Department of Natural Resources, Coastal Restoration Division. 17 pp.

Good, B., J. Buchtel, D. Meffert, J. Radford, K. Rhinehart, and R. Wilson, eds. 1995. Louisiana's major coastal navigation channels. Unpublished report. Baton Rouge: Louisiana Department of Natural Resources, Coastal Restoration Division. 57 pp.

Louisiana Coastal Wetlands Conservation and Restoration Task Force 1991. Coastal Wetlands Planning, Protection, and Restoration Act, first priority project list report. Appendix E, Tab F. Baton Rouge: Louisiana Coastal Wetlands Conservation and Restoration Task Force. 13 pp.

Louisiana Department of Wildlife and Fisheries, Fur and Refuge Division, and U.S. Geological Survey, National Wetlands Research Center 1997. Louisiana coastal marsh vegetative type map. Lafayette: Louisiana Department of Wildlife and Fisheries, Fur and Refuge Division, and U.S. Geological Survey, National Wetlands Research Center.

Steyer, G. D., R. C. Raynie, D. L. Steller, D. Fuller, and E. Swenson 1995 (revised 2000). Quality management plan for Coastal Wetlands Planning, Protection, and Restoration Act monitoring program. Open-file series no. 95-01. Baton Rouge: Louisiana Department of Natural Resources, Coastal Restoration Division. 112 pp.

Turner, R. E., and D. R. Cahoon, eds. 1987. Causes of Wetland loss in the Coastal Central Gulf of Mexico. Volume II: Technical Narrative. Final report submitted to Minerals Management Service, New Orleans, LA. Contract No.14-12-0001-30252. OCS Study/MMS 87-0120. 400 pp.

U. S. Department of Agriculture 1931. Sabine Lake migratory bird refuge. Cameron Parish, Louisiana. USDA.

USDA, Natural Resources Conservation Service. 2001. The PLANTS Database, Version 3.1 (http://plants.usda.gov). National Plant Data Center, Baton Rouge, LA 70874-4490 USA. State of Louisiana PLANTS list downloaded July 25, 2001.

U. S. Fish & Wildlife Service 1991. Reconstruction of the [Sabine National Wildlife Refuge] Impoundment 3 west levee. Proposed project information sheet [for wetland value assessment]. Lafayette, Louisiana: U.S. Fish & Wildlife Service. 4 pp.

Vincent, K. 1997. Sabine Refuge Protection (CS-18) Monitoring Series Progress Report No. 4. Baton Rouge: Louisiana Department of Natural Resources, Coastal Restoration Division. 5 pp.

For further information on this report, please contact Troy Barrilleaux at (337) 898-1758 or the LDNR and CWPPRA homepages at http://www.savelawetlands.org and http://www.lacoast.gov, respectively.