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THREE-YEAR COMPREHENSIVE MONITORING REPORT

BOSTON CANAL/VERMILION BAY SHORELINE PROTECTION
T/V-09

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

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ABSTRACT

The Boston Canal/Vermilion Bay Shoreline Protection project area consists of approximately 466 ac (186 ha) of brackish marsh and open water, located in Vermilion Parish, approximately 12 mi (19.3 km) south of Delcambre, Louisiana. Construction of the Gulf Intracoastal Waterway (GIWW), Boston Canal, and oilfield canals have greatly increased tidal exchange between Vermilion Bay and the marshlands along its northern shoreline. Rapid tidal exchange, wave action, and wave wash from boat traffic have contributed to intense shoreline erosion along Boston Canal, especially at its mouth on Vermilion Bay. The shoreline retreat from 1948 to 1972 for Vermilion Bay (Mud Point to Lake Cleodis) as estimated by the Louisiana Department of Transportation and Development was 2.6 ft/yr (0.8 m/yr).

Constructed in 1995, this project was designed to abate wind-driven wave erosion along Vermilion Bay and at the mouth of Boston Canal. Project structures and features include rock breakwaters, sediment fences and transplants of *Spartina alterniflora* along 14.3 mi (23 km) of bay shoreline. The goals of the project are (1) to increase the deposition of sediment adjacent to sediment fences behind the breakwater, (2) establish *S. alterniflora* along the shoreline to decrease the rate of erosion and maintain the integrity of interior marsh, and (3) to decrease the rate of shoreline erosion by armoring the mouth of Boston Canal with rock breakwaters.

To assess sediment deposition, pre and postconstruction (October 1994 and December 1995) elevation profiles were surveyed across 11 transects at the mouth of Boston Canal. To monitor vegetation plantings, percent survival and percent cover were measured at 6 mo and 12 mo post installation. To document shoreline movement, differential Global Positioning System (GPS) coordinates were taken in the reference area preconstruction (November 1995) and postconstruction in the project and reference area (March 1998).

Analysis of elevation profiles indicates that between 1.4– 4.5 ft (0.46–1.4 m) of sediment was deposited between the breakwaters and the shoreline. *S. alterniflora* survivorship decreased from 0.93 at 6 mo post construction to 0.91 at 12 mo postconstruction. However, percent cover increased from 27.6 to 69.8 during the same period. Comparisons of GPS coordinates taken in the reference area indicate some shoreline regression, with an average rate of 5.17 ft/yr (1.58 m/yr) of shoreline retreat. Project area shoreline change will be determined after future postconstruction surveys.

The project appears to be functioning in maintaining the integrity of the wetlands and stabilizing the Vermilion Bay shoreline. Other benefits to the project area include the deposition of sediments that would otherwise be lost to the surrounding open water bays.

INTRODUCTION

Erosion of the banks of navigation channels results primarily from the wakes and wave washes of vessels using the channels. Passing vessels create boat wakes which break along channel banks, eroding fragile wetland soils and adversely impacting the vegetative communities. Vessels may also displace significant quantities of water from the channel, pushing the water into adjacent wetland areas, which causes severe and rapid changes in water levels and scours soil and vegetation substrate. As erosion progresses beyond channel or spoil banks and into fragile, interior wetland areas, erosion accelerates dramatically (Good et al. 1995).

Bank erosion is a common problem in the bays, sounds and estuaries of the coastal United States. A wide variety of structures have been developed and used to control erosion in these areas. However, due to environmental objectives and cost limitations it is often impractical to use even the most innovative of these structures. Low cost, non-structural techniques have been developed to control erosion in these areas using native marsh plants. Studies have identified several marsh plants that have been effective stabilizers. Major research emphasis has focused upon several representatives of the genus *Spartina*, which perform two functions in abating erosion. The root systems of *Spartina* stabilize the sediments in which they grow, and aerial parts form a mass that dissipates wave energy (Knutson 1977). Once established, *Spartina alterniflora* provides an effective means of shoreline erosion protection. Preliminary results of a study performed by Seidensticker and Nailon in Galveston Bay, Texas, show some benefits in reducing shoreline erosion. The short-term results of cross-sectional data also indicate a slight increase in sediment accumulation within a transplanted grass colony (Seidensticker and Nailon 1990).

The Boston Canal/Vermilion Bay Shoreline Protection (T/V-09) project is located in Vermilion Parish, approximately 12 mi (19.3 km) south of Delcambre, LA. The project boundaries extend from Mud Point on the western end to Oaks Canal on the eastern end (figure 1). The northern boundary is brackish marsh, and the southern boundary is Vermilion Bay. *Spartina patens* (marshhay cordgrass) and *Scirpus americanus* (Olney bulrush) compose 64% of the marsh vegetation. *Spartina cynosuriodes* (big cordgrass) composes 19% of marsh vegetation and is found typically on elevated bayou banks. The open water area contains submerged and floating aquatics, which are confined to a narrow band along the shore due to the tidal influence. The shoreline retreat from 1948 to 1972 for Vermilion Bay (Mud Point to Lake Cleodis) as estimated by the Louisiana Department of Transportation and Development was 2.6 ft/yr (0.8 m/yr) (Adams et al. 1978).

The Boston Canal/Vermilion Bay Shoreline Stabilization (T/V-09) project was designed to abate wind-driven wave erosion along Vermilion Bay and at the mouth of Boston Canal. In December 1994, rock breakwaters were constructed parallel to the banks of Boston Canal, extending into Vermilion Bay and then turning 90 degrees to follow the bay shoreline (figure 2). Behind the breakwaters, sediment fences were installed to capture sediment during overwash events. In October 1995, approximately 34,000 trade gallon-size plants of *S. alterniflora* were installed along 14.3 mi (23 km) of bay shoreline, from Mud Point on the western end to Oaks Canal on the eastern end.

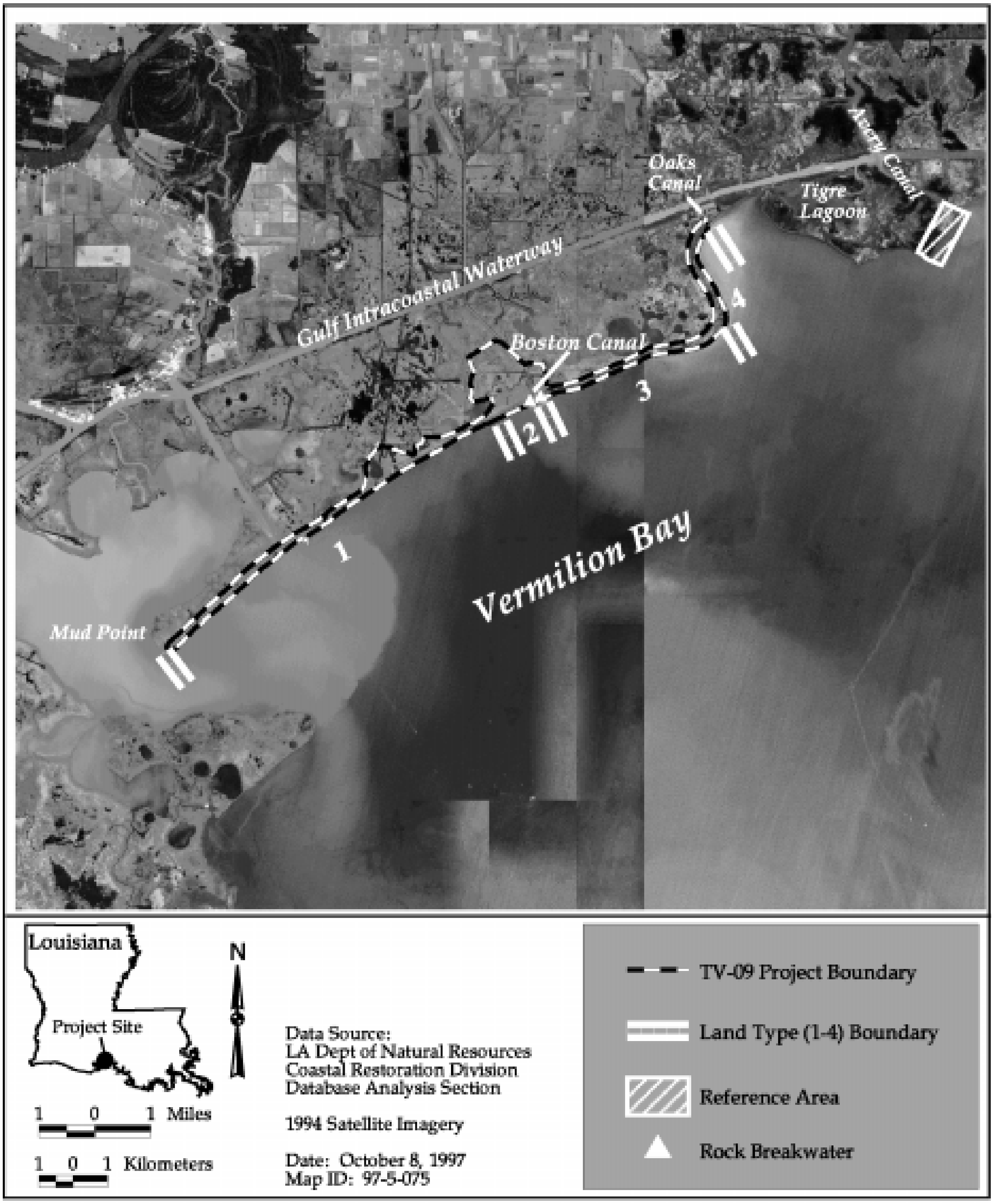

Figure 1. Boston Canal/Vermilion Bay Shoreline Protection (T/V-09) project showing the project and reference areas.

Figure 2. Boston Canal/Vermilion Bay Shoreline Protection (T/V-09) rock breakwaters and sediment fences at the mouth of Boston Canal.

The project objectives are to maintain the integrity of approximately 466 ac (186 ha) of wetlands between Mud Point and Oaks Canal; to stabilize 14.3 mi (23 km) of the Vermilion Bay shoreline; and to prevent further regression of the banks at the mouth of Boston Canal. The specific goals are (1) to increase the deposition of sediment adjacent to sediment fences behind the breakwater, (2) establish *S. alterniflora* along 14.3 mi (23 km) of shoreline to decrease the rate of erosion and maintain the integrity of approximately 466 ac (186 ha) of interior marsh on the northern edge of Vermilion Bay, and (3) to decrease the rate of shoreline erosion at the confluence of Boston Canal and Vermilion Bay by armoring the mouth of the canal with rock breakwaters.

METHODS

A detailed description of the monitoring design over the entire project life can be found in Weifenbach (1995, revised 1998). Pursuant to a CWPPRA Task Force decision on April 14, 1998, the updated monitoring plan was modified due to budgetary constraints. Specifically, the goal to increase sediment elevation was dropped and the elevational surveys were eliminated.

Sediment deposition behind the breakwater was surveyed along 5 east-west transects and 6 north-south transects to document the accumulation or erosion of sediment in the vicinity of the sediment-trapping fences. In October 1994, the Natural Resources Conservation Service (NRCS) completed preconstruction elevation profiles across the proposed rock breakwaters. Data was compared with a subsequent survey performed by Pyburn and Odom, Inc. Consulting Engineers in May 1995.

To document planting success, the planting area was divided into four land types based on topography (figure 1). Land type 1 is a straight mineral shoreline with a gradual slope. The shoreline of land type 2 is deeply scalloped, consisting of cutbanks and gently sloped inlets with high organic content. Land type 3 is a gently scalloped shoreline with a mineral soil. Land type 4 is gently scalloped with a mineral soil, but is recognized as a different land type due to its north-south orientation and the protection it receives from Tigre Lagoon. In land type 1, a small percentage of the initial plantings were installed amid stands of *Phragmites australis* (roseau cane). In land types 3 and 4, the initial plantings were installed bayward of the stands of *P. australis* in approximately 1 ft (0.3 m) of water. A 3% sample of the vegetation plantings in each land type, consisting of 64 randomly selected plots of 16 plants each, was monitored for percent survival, species composition, and percent cover at 6 and 12 mo, and at year 3. The 6 and 12 mo postplanting monitoring were conducted on December 6, 1995, and June 6, 1996, respectively. *P. australis* coverage was measured at 6 mo post-construction was divided into four levels: none (0%), low ($0\% < x \leq 30\%$), medium ($30\% < x < 60\%$), and high ($x \geq 60\%$).

A reference area was selected east of the project area located west of Avery and (east of Tigre Lagoon) Canal. This area is similar in vegetative community, soil type, and hydrology to the project area.

Planting survival was measured in terms of four variables (Harper 1977), which are defined and calculated as follows:

$$\text{survival frequency} = \text{number of live plants inside plot at timepoint } x$$

$$\text{survivorship } (l_x) = \text{probability (at planting time) of surviving until age } x = \frac{\text{no. live plants inside plot at timepoint } x}{\text{original no. plants inside plot}}$$

$$\text{mortality } (d_x) = \text{probability (at planting time) of dying during age interval } x, x+1 = l_x - l_{x+1}$$

$$\text{mortality rate } (q_x) = \text{probability of a planting at age } x \text{ dying before the age of } x+1 = \frac{l_x - l_{x+1}}{l_x} = \frac{d_x}{l_x}$$

Statistical comparisons of survivorship and of percent survival of *S. alterniflora* plantings were limited because data were not normally distributed. Attempts to transform data to improve normality were unsuccessful; therefore, a repeated measures analysis of variance with multi-level comparisons was not possible. Comparisons of survivorship and percent cover of *S. alterniflora* at 6 mo and 12 mo postplanting were made among land types and levels of *P. australis* coverage with a non-parametric ANOVA. Tests of significance were conducted at the $\alpha=0.05$ level.

To document changes in shoreline position over time, continuous differential Global Positioning System (GPS) coordinates were established at the mean high water line along the existing shoreline adjacent to vegetative plantings in the project area, and at a reference site located east of Oaks Canal. GPS data were obtained during pre-construction for the reference area only. Difficulties in securing a surveying contractor precluded data collection in the project area. The lack of this GPS data at more than one time in the project area prevents quantifying benefits of the shoreline plantings. GPS data were obtained at year 3 (post-construction) for the project and reference area.

To document land to water ratios, the National Wetlands Research Center (NWRC) in Lafayette, Louisiana obtained 1:12,000 scale near-vertical color-infrared aerial photography once prior to project construction (December 26, 1994) and once after construction (November 24, 1997). The photography was scanned at 300 dots per inch, indexed and archived. Personnel from NWRC used ERDAS Imagine, an image processing and geographic information systems (GIS) software, to first georectify the individual frames with ground control points collected in the field and then produce a photomosaic for each year of photography. A GIS analysis was then performed on the photomosaicks to determine land-to-water ratios within the project and reference areas. The analysis was complicated by the burning of the marsh near the time of the aerial photography flight. The resulting pre- and post-construction maps were analyzed with ERDAS Imagine to determine land and water acreages. The GIS analysis results were compiled, showing pre and post construction acreages and change summaries. Accuracy assessments were run, and confidence levels were all above 94%.

RESULTS

Sediment accumulation was documented in all east-west and north-south transects. Appendix A contains figures representing the 11 profiles of the cross-sectional survey from 1994 overlaid with the 1995 survey. These data indicate that approximately 1.5 to 4.5 ft (0.46 to 1.4 m) of sediment was deposited between the breakwaters and the existing shoreline (figures A1–A12). Greatest gains were documented adjacent to the bayward breakwaters. The exposed mudflats are being colonized by *Echinochloa walteri* (Walter's millet) and *Bacopa monnieri* (coast water-hyssop).

Summary statistics from the vegetation surveys conducted at 6 and 12 mo postplanting indicated that survivorship of *S. alterniflora* decreased from 0.93 at 6 mo to 0.91 at 12 mo (table 1). However, the mortality rate decreased over the same period, from 0.07 between 0 and 6 months, to 0.02 between 6 and 12 mo, suggesting that the surviving plantings became established by 12 mo postplanting. Percent cover increased from 27.6 to 69.8 from 6 mo postplanting to 12 mo postplanting. Visual observations of the shoreline made on October 10, 1996 (16 mo post-planting) indicated that plant height ranged from 3–6 ft (0.9–1.8 m), and individual plants were indistinguishable from each other.

Table 1. Partial life table of smooth cordgrass (*Spartina alterniflora*) plantings in the Boston Canal/Vermilion Bay Shoreline Protection(T/V-09) project area, based on means of data collected from sixty-four 16-plant sampling plots, from December 1995 to June 1996, at 6 and 12 mo postplanting.

Age (mo)	Survival Frequency (n)	Survivorship	Mortality	Mortality Rate
0	16	1	0.00	0.07
6	14.82	0.93	0.07	0.02
12	14.57	0.91	0.02	

n = mean # plants living per plot

Among land types, survivorship of *S. alterniflora* plantings differed significantly only at 6 mo postplanting (F = 3.16, $P = 0.03$). Average percent survival among land types ranged from 80.43 to 100% at 6 mo and from 75.25 to 100% at 12 mo postplanting (figure 3). Percent cover differed significantly among land types at both 6 mo (F = 4.76, $P < 0.01$) and 12 mo (F = 3.86, $P < 0.01$) postplanting (figure 4). Some differences in survival and percent cover of plantings among land types may have been attributed to differences in *P. australis* coverage within land types (table 2); however, due to non-normality, we could not check for interactions between land type and *P. australis* cover. Among levels of *P. australis* coverage, survivorship of *S. alterniflora* differed

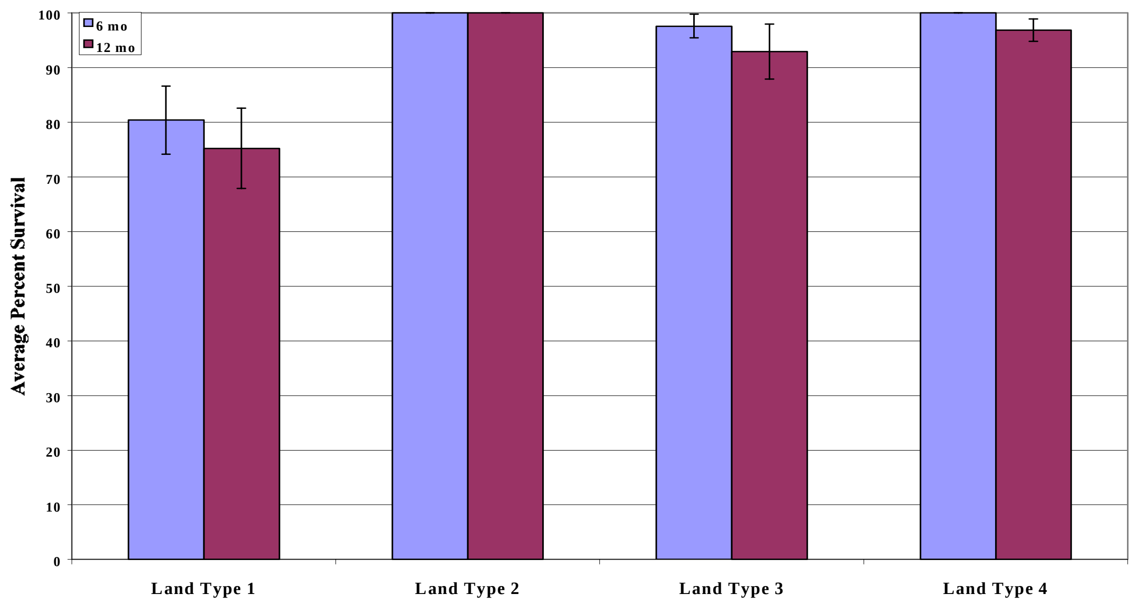

Figure 3. Boston Canal/Vermilion Bay Shoreline Protection (T/V-09) average percent survival of *Spartina alterniflora* plantings in land types 1–4 observed at 6 and 12 months postplanting, 1995 and 1996, means ± SE.

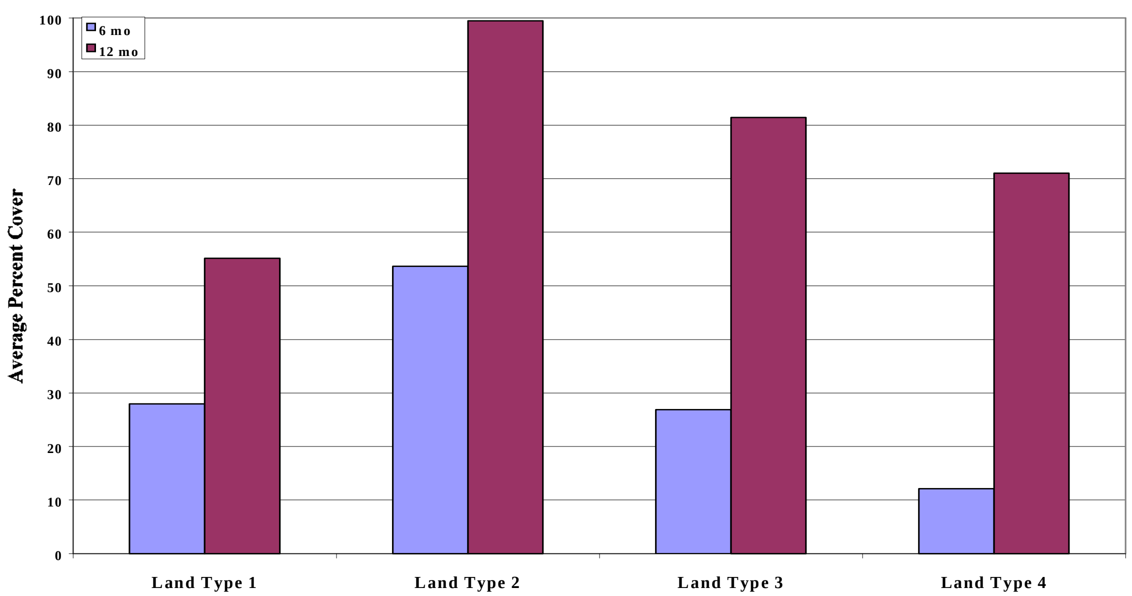

Figure 4. Boston Canal/Vermilion Bay Shoreline Protection (T/V-09) average percent cover of *Spartina alterniflora* plantings land types 1–4 observed at 6 and 12 months.

significantly at 6 mo (F = 7.85, $P < 0.01$) and 12 mo (F = 6.11, $P < 0.01$) postplanting, as did percent cover at 6 mo (F = 5.91, $P < 0.01$) and 12 mo (F = 11.57, $P < 0.01$) post planting. The highest mean survival and mean percent cover of plantings occurred at the lowest levels of *P. australis* coverage during both sampling periods (figures 5 and 6).

Table 2. Mean percent cover *of Phragmites australis* in each land types 1–4 at 6 mo post-planting.

Land Type	n	mean	min	max
1	29	12.9	0	68.3
2	5	0	0	0
3	23	7.6	0	33.8
4	8	5.2	0	33.1

Initially, lower *S. alterniflora* percent cover values of 28.0%, 26.9%, and 12.1% were recorded in land types 1, 3, and 4, where plantings were interspersed with existing, intermittent stands of *Phragmites australis*, than in land type 2 (cover value = 53.6%), where *P. australis* was absent. In land type 1, plants installed within the *P. australis* were spindly or absent at 6 mo, and those plants were dead or absent at 12 mo, presumably due to competition for light and nutrients. Percent cover of *S. alterniflora* increased in land type 1 from 28.0% at 6 mo to 55.1% at 12 mo. In land types 3 and 4, the initial plantings were installed bayward of the stands of *P. australis* in approximately 1 ft (0.3 m) of water. At 6 mo, plants located in land types 3 and 4 had cover values of 26.9% and 12.1% respectively, and appeared water-logged and spindly. At 12 mo, although plants remained stressed from water-logged conditions as exhibited by lower stem height and greater space between tillers, percent cover increased to 81.4 and 71.0, respectively. Drought conditions in the spring and summer of 1996 resulted in water levels that were lower than normal in Vermilion Bay, probably allowing the plants to become established.

Comparisons of GPS coordinates taken in the reference area in November 1995 and March 1998, indicate some shoreline regression (figure 7, map i.d. 98–2–054 and figure 8, map i.d. 98–2–055). A total of 51 measurements were taken to give an average rate of 5.17 ft/yr (1.58 m/yr) of shoreline retreat in the reference area.

As of 1997, the project is estimated to have protected and or created 57.4 acres (23.2 ha) of land (table 3). East of Boston Canal there were gains of 39.4 ft (12 m) in land type 3. Also, measurements taken behind the rock breakwater resulted in an average rate of 0.4 ac/yr (0.16 ha/yr) of gain between December 1994 and November 1997 (figure 9, map i.d. 98–2–053).

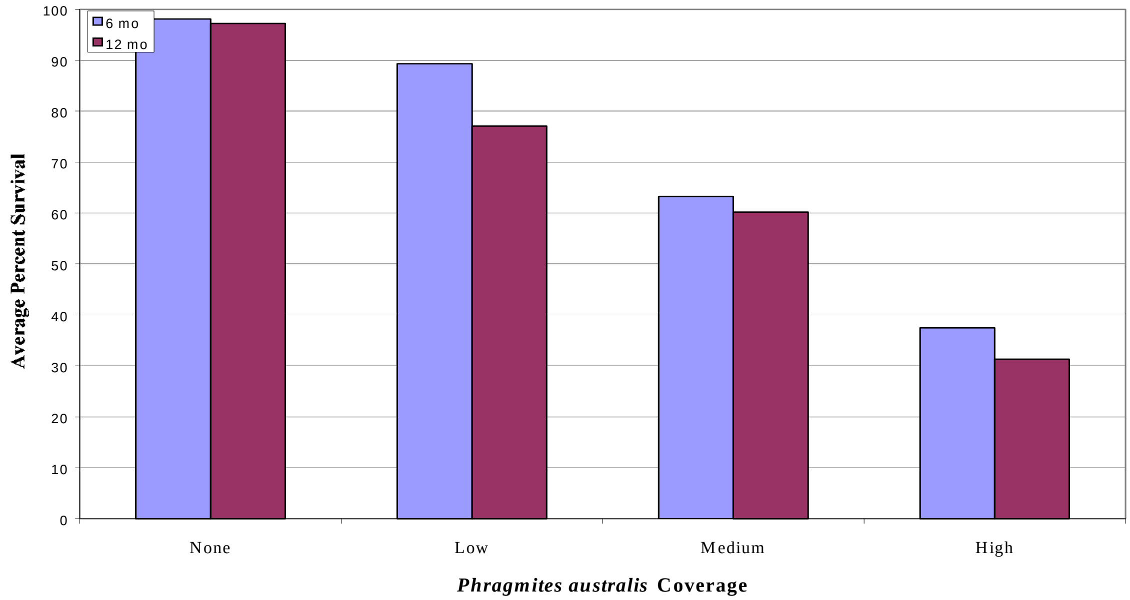

Figure 5. Boston Canal/Vermilion Bay Shoreline Protection (T/V-09) average percent survival of *Spartina alterniflora* plantings at 6 mo and 12 mo postplanting in none, low, medium, and high levels of *Phragmites australis* coverage.

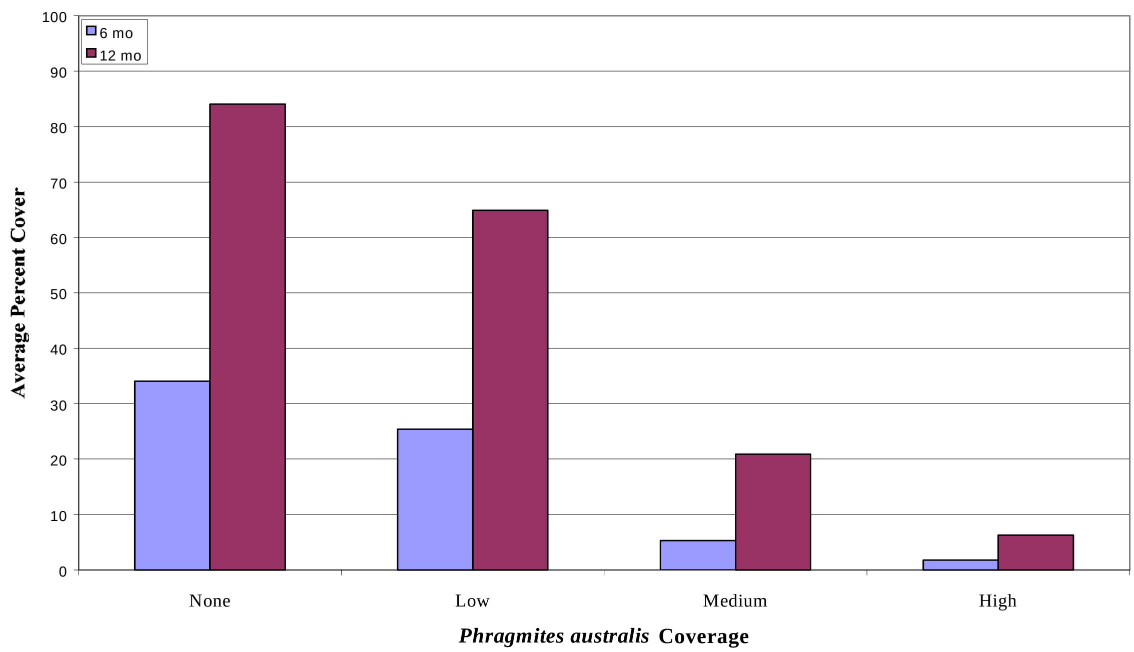

Figure 6. Boston Canal/Vermilion Bay Shoreline Protection (T/V-09) average percent cover of *Spartina alterniflora* plantings at 6 mo and 12 mo postplanting in none, low, medium, and high levels of *Phragmites australis* coverage.

Figure 7. Boston Canal/Vermilion Bay Shoreline Protection (T/V-09) 1998 GPS project shoreline survey.

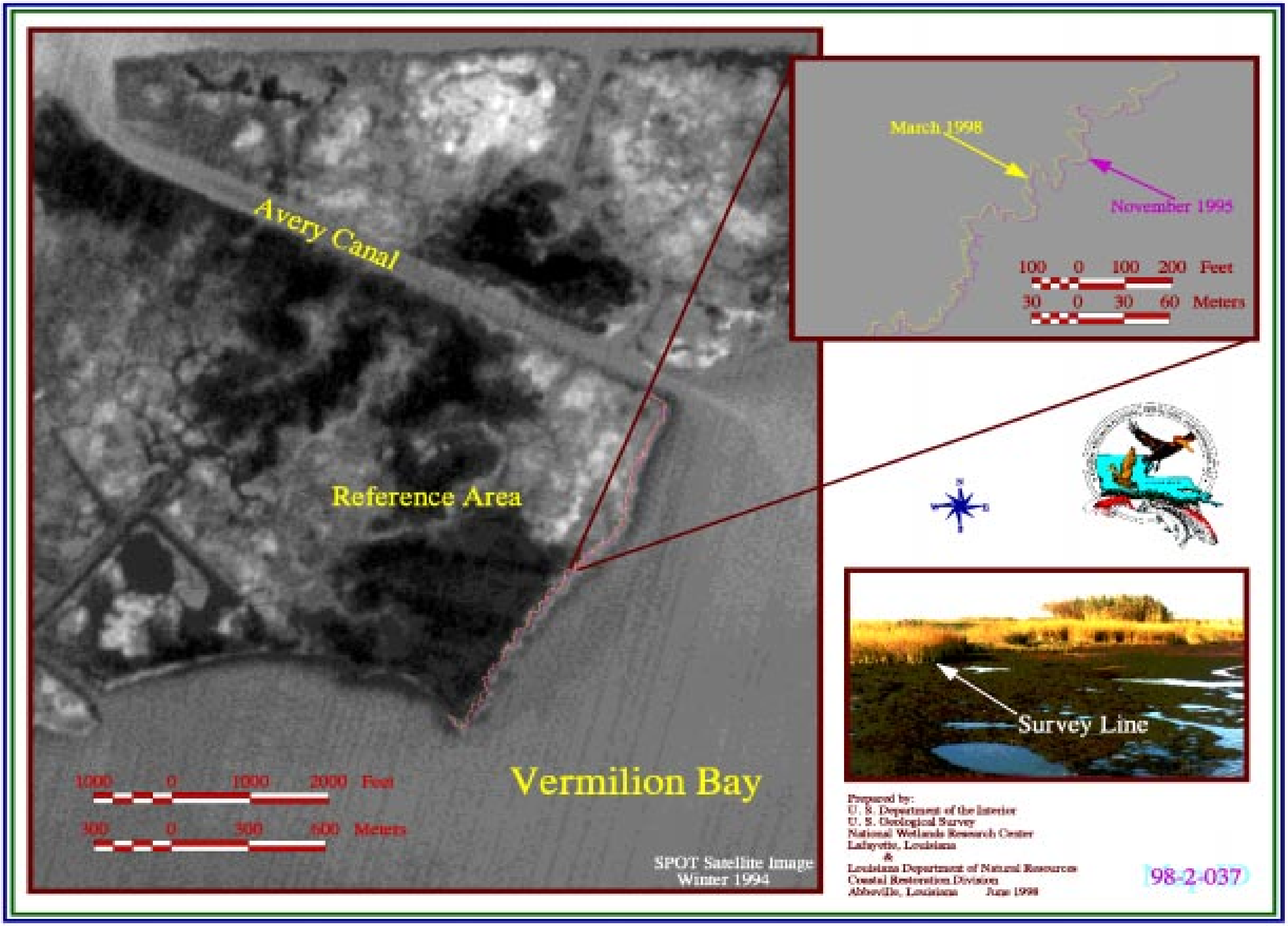

Figure 8. Boston Canal/Vermilion Bay Shoreline Protection (T/V-09) 1995 and 1998 GPS reference shoreline survey.

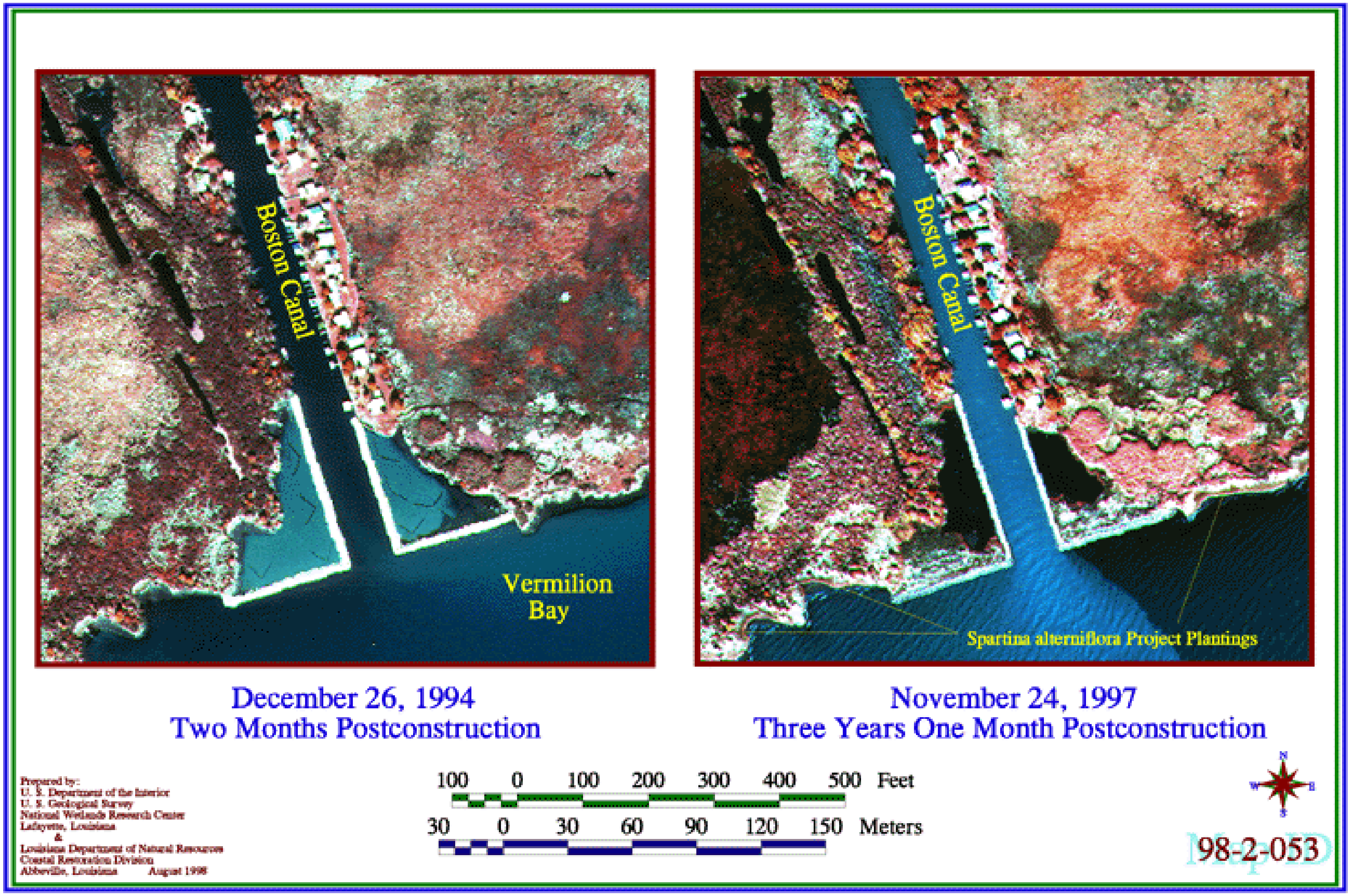

Figure 9. Boston Canal/Vermilion Bay Shoreline Protection (T/V-09) December 1994 and November 1997 sediment trapping and vegetation growth behind the rock breakwater at the entrance to Boston Canal.

Table 3. Land/Water analysis of the Boston Canal/Vermilion Bay Shoreline Protection (T/V-09) project and reference areas during the preconstruction (December 26, 1994) and postconstruction (November 24, 1997) time period and change over time.

	Water (Acres)	Land (Acres)
1994 Project	578.2	1708.7
1997 Project	521.0	1765.9
Project 1994 to 1997	**-57.2**	**+57.2**
1994 Reference	165.6	167.7
1997 Reference	169.8	163.5
Reference 1994 to 1997	**+4.2**	**-4.2**

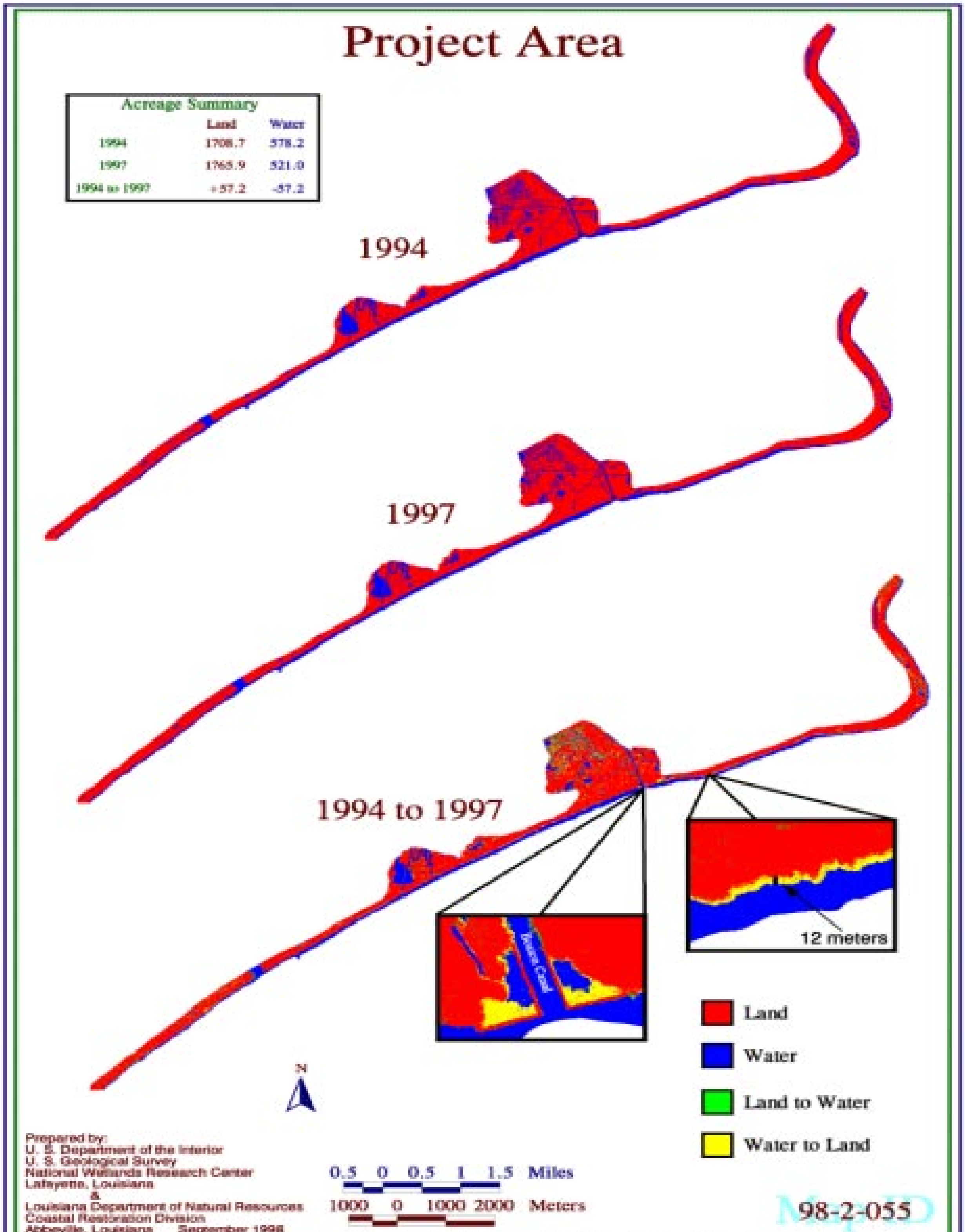

Figure 10. Boston Canal/Vermilion Bay Shoreline Protection (T/V-09) GIS Land/Water analysis of project area.

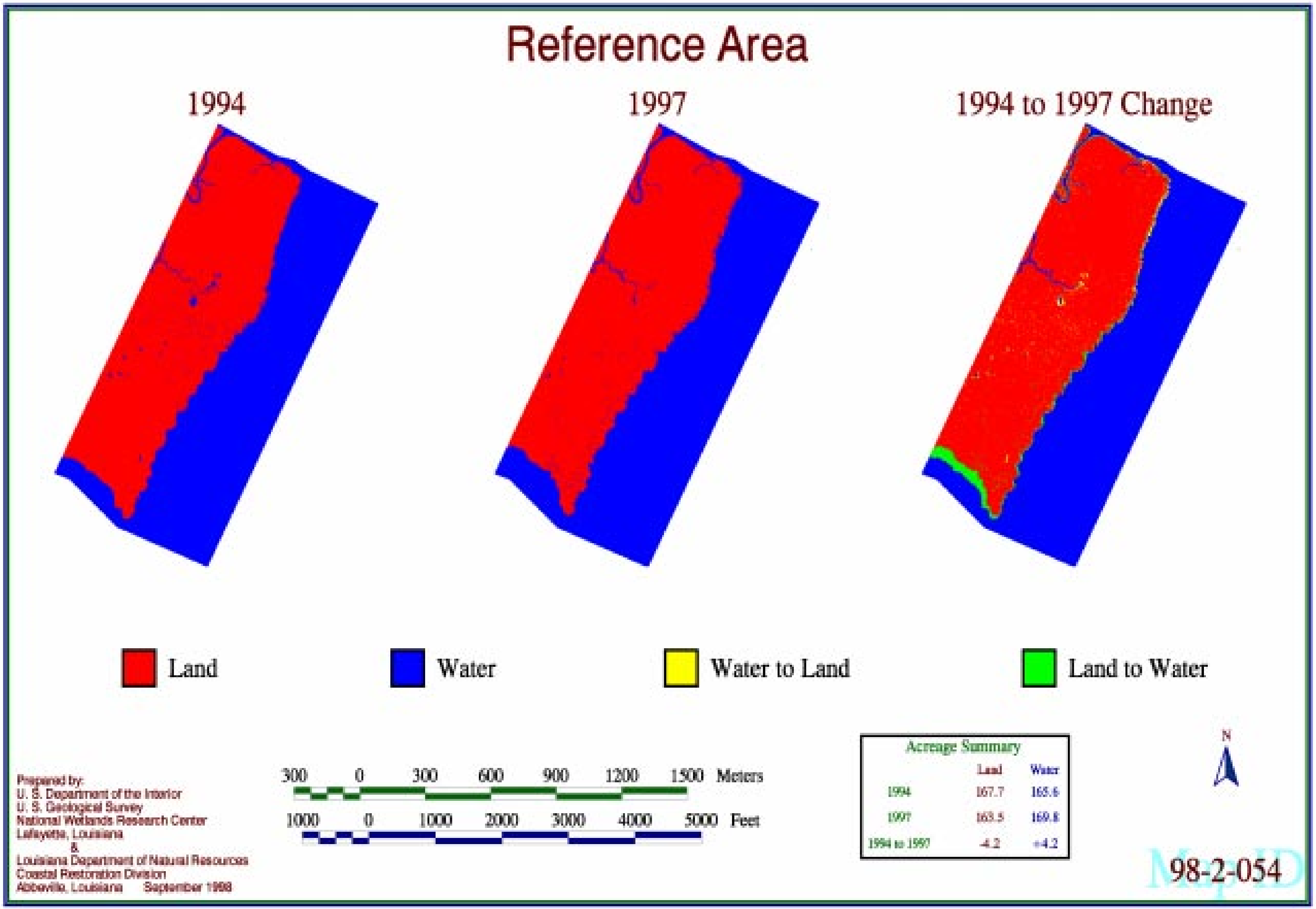

Figure 11. Boston Canal/Vermilion Bay Shoreline Protection (T/V-09) GIS Land/Water analysis of the reference area.

DISCUSSION

Observations to date suggest that the rock breakwaters have been effective in promoting sediment deposition and retaining this sediment at the mouth of Boston Canal (figure 12). Sediment laden waters appear to be overtopping the rock breakwater due to high water periods and boat traffic near the mouth of Boston Canal. Thus far, sedimentation is greatest in front of the sediment fences on the bay side. It appears that the fences closest to the bay are impeding the uniform distribution of sediments. Therefore, it is recommended that the sediment fences be removed to allow more uniform accumulation of sediment throughout the entire area behind the breakwater.

Results from similar projects corroborate the effectiveness of breakwater structures in dissipating wave energy and sediment trapping. In the Blind Lake project a rock dike was constructed adjacent to Blind Lake to prevent the GIWW from breaching into the lake. In addition to a rock dike, 400 *Zizaniopsis miliacea* (giant cutgrass) plants were installed on the bank behind the dike to accelerate the succession of vegetation and enhance the sedimentation process. Two and a half years after the completion of the project, there was an average elevational increase of 0.32 ft (0.10 m) behind the rock breakwater (Holbrook 1996). The Turtle Cove project rock gabion protected a narrow strip of land that separates Lake Pontchartrain from an area known as "the prairie." Based on a mean project area elevation from surveys taken during January 1996 and January 1997, the project area gained a mean of 0.25 ft (0.08 m) of elevation (Snedden 1998).

The high survival rates of *S. alterniflora* plantings recorded after one year indicate that this is an ideal species for establishment in this environment. Personal observation of the plantings in May 1998 indicate that the 1999 vegetation survey may reveal the original plants to be indistinguishable from each other due to tillering resulting in lateral spread of the plantings (figure 13). Their effectiveness in minimizing shoreline erosion will be determined after all subsequent shoreline surveys are conducted. The data indicates that *S. alterniflora* should not be installed in well established stands of *P. australis*. However, plants installed bayward of *P.australis* exhibited high rates of survival. This information may be used to modify future projects being constructed to prevent planting in environments where there may be little likelihood of survival.

GPS coordinates taken in the reference area in November 1995 indicate shoreline regression. Wave energy from Vermilion Bay may have contributed to the loss in the reference area. Because the project area did not have preconstruction differential GPS coordinates, it is recommended that one be performed in the future to document shoreline change.

GIS Land/Water analysis comparing preconstruction and postconstruction photography revealed shoreline regression in the reference area, whereas the project area showed a marked increase in the ratio of water to land. Difficulties associated with the interpretation of this photography included marsh burn, which could be interpreted as water, and wave white capping, which could be interpreted as shoreline. One of the heaviest shoreline erosion rates occurred on the west side of the shoreline at the intersection of Vermilion River Cutoff and Vermilion Bay.

(A) December 1994

(B) February 1998

Figure 12. Boston Canal/Vermilion Bay Shoreline Protection (T/V-09) photographs: (A) sediment deposition, December 1994; (B) vegetation behind rock breakwater; February 1998.

(A) July 1995

(B) March 1998

(C) March 1998

Figure 13. Boston Canal/Vermilion Bay Shoreline Protection (T/V-09) photographs: (A) *Spartina alterniflora* planting, July 1995; (B) tillering of *Spartina alterniflora*, March 1998; (C) three year growth of plantings, March 1998.

CONCLUSION

The project appears to be functioning properly in maintaining the integrity of approximately 466 ac (186 ha) of wetlands and stabilizing 14.3 mi (23 km) of the Vermilion Bay shoreline. Sediment build-up behind the dike on the east and west sides is continuing and vegetation has taken over the exposed mud flats. Elevational data show an increase in sedimentation behind the rock breakwater.

The high average percent survival of the *S. alterniflora* on the shoreline indicate that the plants have become established. Because survivorship and percent cover of *S. alterniflora* was lessened in established stands of *P. australis*, it is suggested that this planting situation be avoided.

The shoreline of the reference area has been experiencing a retreat of 5.17 ft/yr (1.58 m). A shoreline rate in the project area can not be determined until additional data is collected. However, information interpreted from GIS Land/Water analysis show an increase of 57.4 acres (23.2 ha) protected and or created.

Boston Canal/Vermilion Bay Shoreline Protection was designed to abate wind-driven wave erosion along Vermilion Bay and at the mouth of Boston Canal. Additionally, the goals being (1) to increase the deposition of sediment adjacent to sediment fences behind the breakwater, (2) establish *S. alterniflora* along the shoreline to decrease the rate of erosion and maintain the integrity of interior marsh, and (3) to decrease the rate of shoreline erosion by armoring the mouth of Boston Canal with rock breakwaters appear to have been met thus far. Data will be collected in the future according to the monitoring plan and will be used to evaluate the project effectiveness at that time.

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