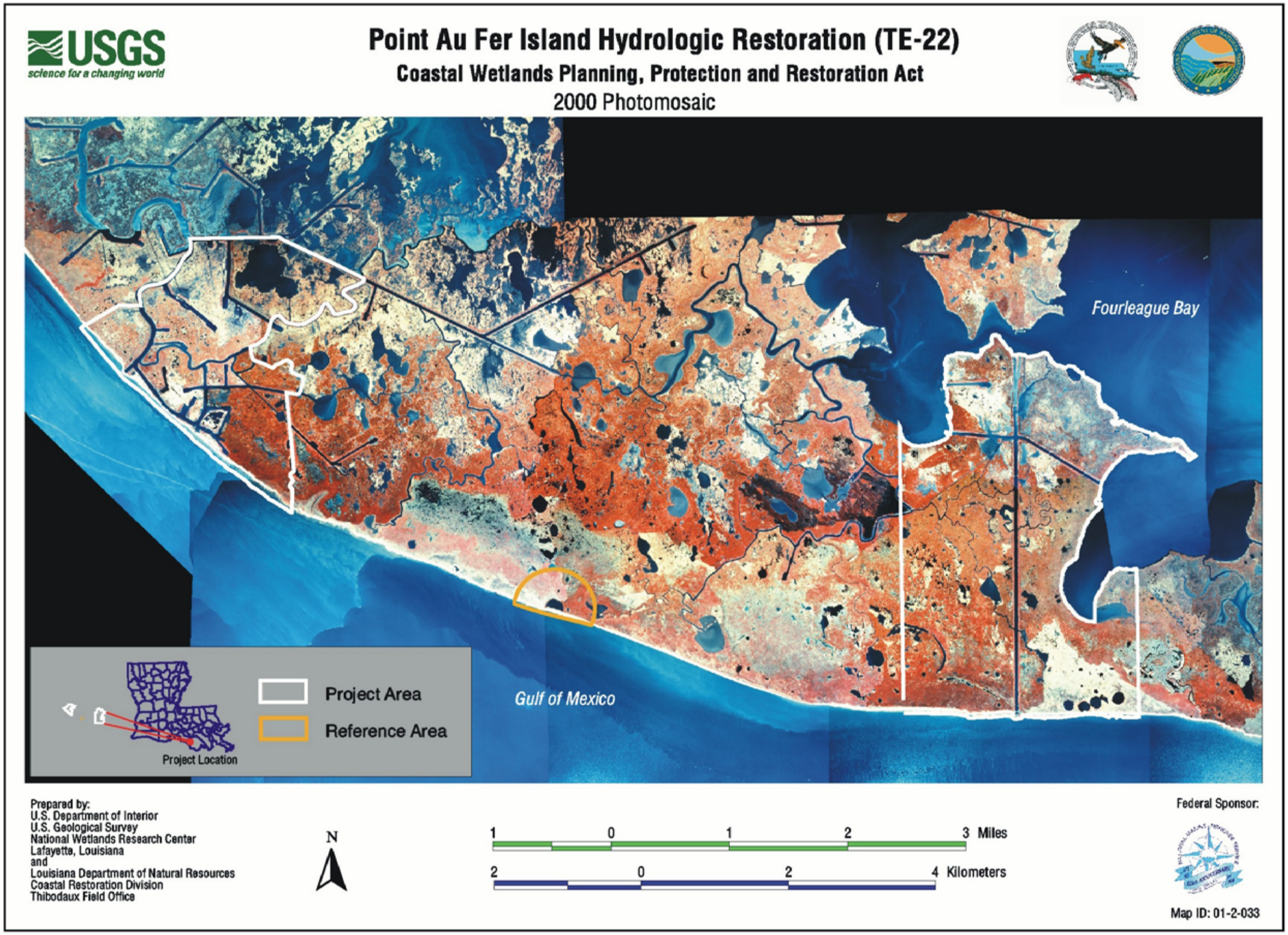

Figure 8C. 2000 photomosaic of the Point Au Fer Island Hydrologic Restoration (TE-22) project using 1:24,000 scale near-vertical color infrared aerial photography.

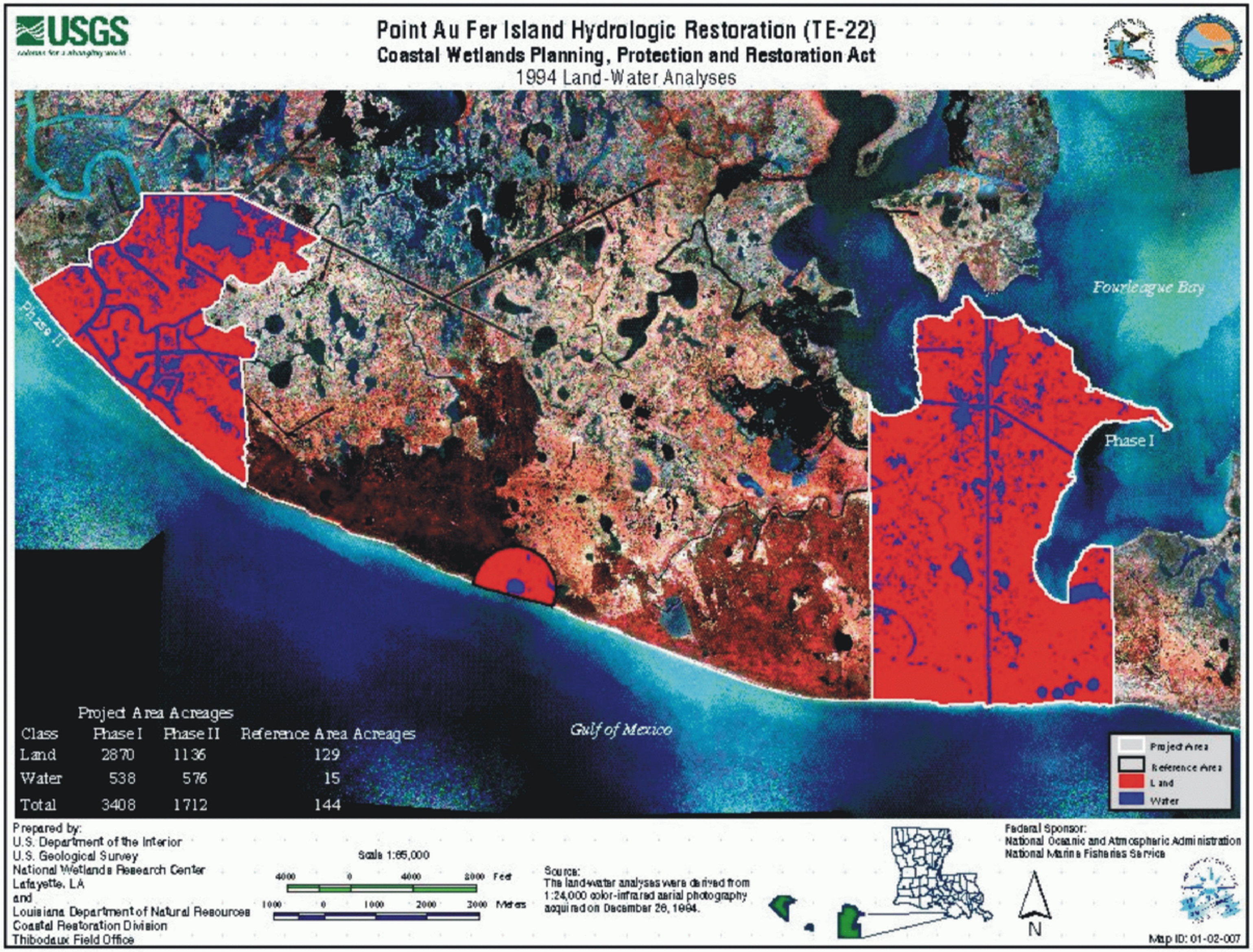

Figure 9A. 1994 classification of land and water for the Point Au Fer Island Hydrologic Restoration (TE-22) project.

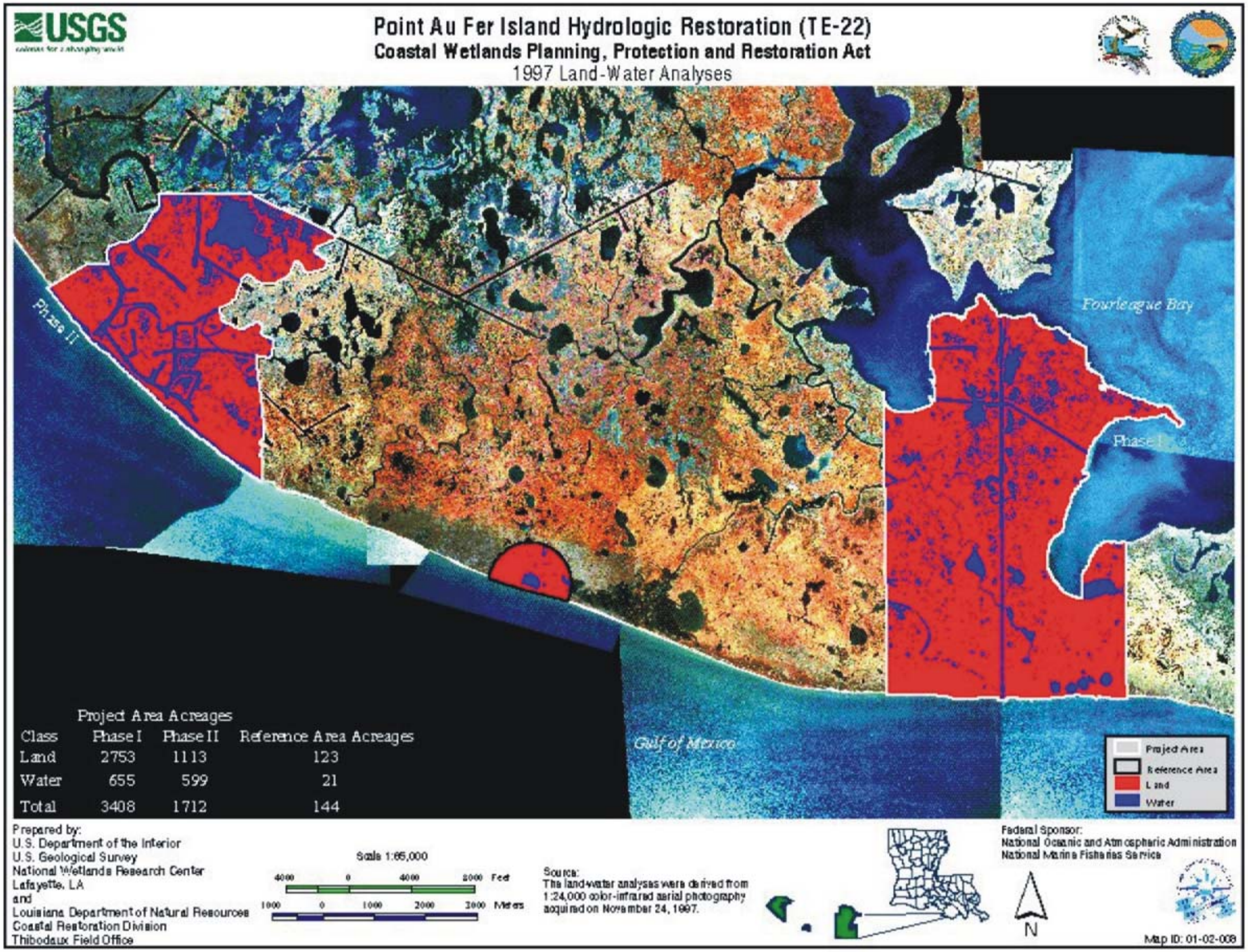

Figure 9B. 1997 classification of land and water for the Point Au Fer Island Hydrologic Restoration (TE-22) project.

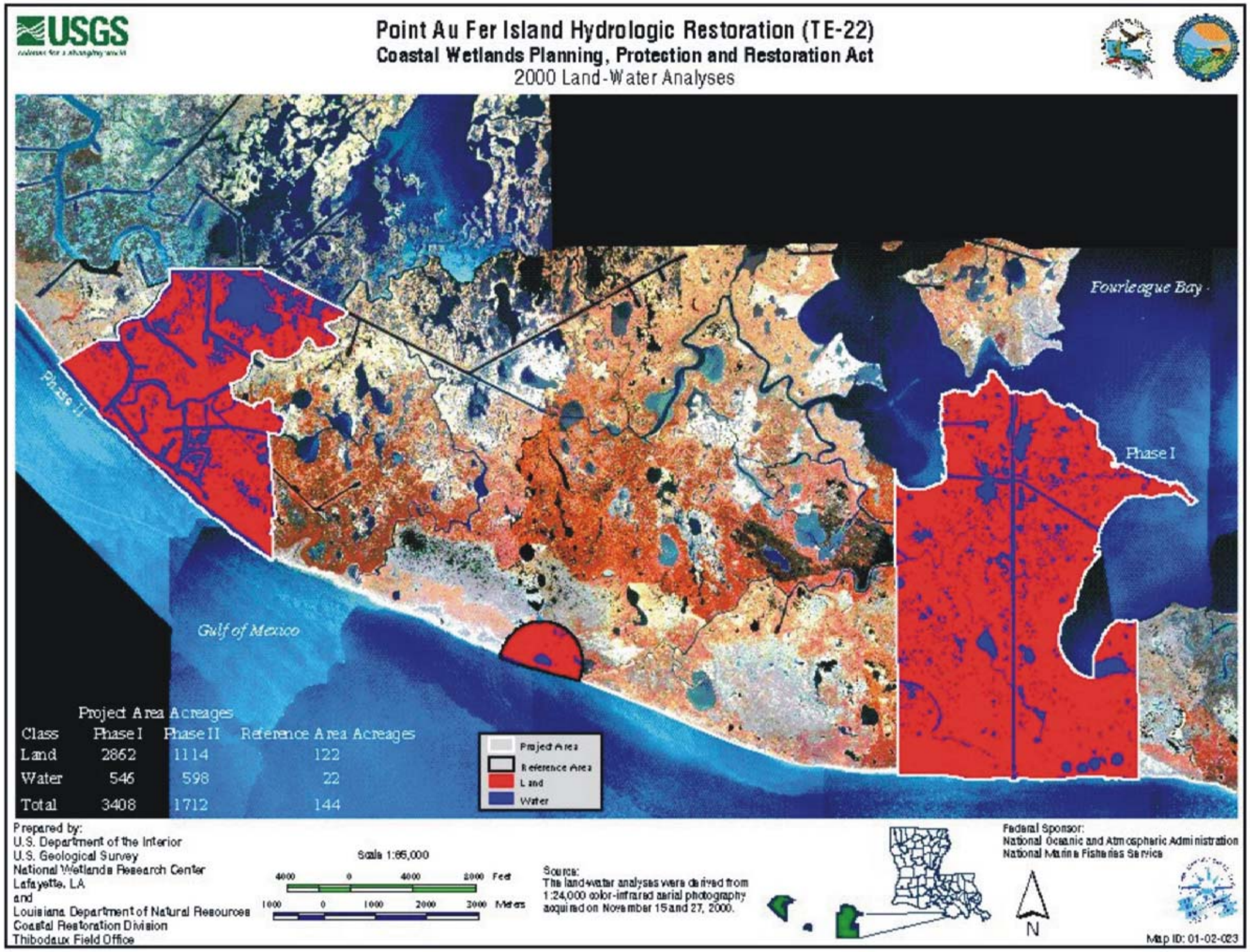

Figure 9C. 2000 classification of land and water for the Point Au Fer Island Hydrologic Restoration (TE-22) project.

<u>Canal Width</u>: To evaluate the second goal relative to the widening of canals in Phase I, we established a total of 24 shoreline marker stations adjacent to plugs #1, 3, 6, and 8 (6 stations per plug) on October 16 and 18, 1995, as per Steyer et al. (1995). Stations are spaced 100 ft (30.5 m) apart, and consist of four stakes inserted vertically into the ground: a home stake and 3 directional stakes. The home stake is positioned 6.56 to 9.84 ft (2 to 3 m) from the original shoreline, and directional stakes are exactly 3.28 ft (1 m) from the home stake. The center stake is, therefore, directly between the shoreline and the home stake, while the outer stakes are at a right angle to each other (45 degrees off the home stake toward the water)(figure 10).

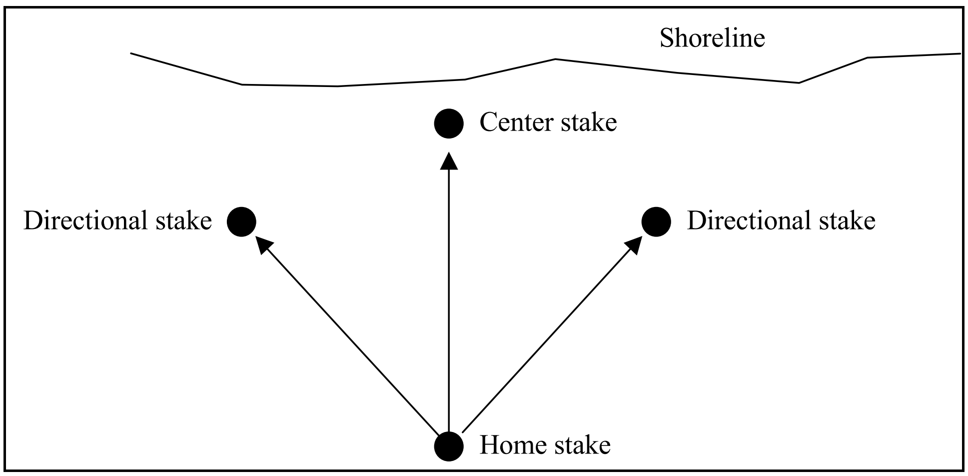

Figure 10. Example of shoreline position marker set-up.

LDNR/CRD measured shoreline position, defined as the edge of the live emergent vegetation (Steyer et al. 1995), relative to the center of each stations home stake on October 16 and 18, 1995, September 9, 1997, and April 19, 2000. Measurements were made along a straight line that passes through the home stake and a direction stake, therefore, yielding three measurements per station at each sampling period. Since the directional measurements are along a 45-degree angle, we convert it to a linear measure using the equation: *linear shoreline* = measured change * 0.7071.

Using the General Linear Model module of SAS (General Linear Model, SAS Institute Inc, 1990), we used analysis of variance to detect pre- and post-construction period differences in the rate of canal width change, using a significance level of *P*#0.05.

RESULTS

Land/water Analysis: In the Phase I project area, from pre-construction (December 26, 1994) to 6 months post-construction (November 24, 1997), land was converted to open water at a rate of 1.40% yr^{-1} (40.13 acre yr^{-1}/16.24 hectare yr^{-1}). However, during post-construction (November 24, 1997 to November 15, 2000), there was a 1.33% yr^{-1} increase (36.6 acre yr^{-1}/14.81 hectare yr^{-1}) in land area (table 1).

In Phase II, during the pre-construction period, land loss occurred at a rate of 0.7% yr^{-1} (7.9 acre yr^{-1}/ 3.2 hectare yr^{-1}). During the post-construction period, the Phase II area experienced a 0.03% increase in land (0.34 acre yr^{-1}/0.14 hectare yr^{-1}) (table 1). The reference area, located east of the rock shoreline at Phase II also experienced land-loss during the pre-construction period, but at a rate of 1.6% yr^{-1} (2.06 acre yr^{-1}/0.83 hectare yr^{-1}). Land-loss continued during the post-construction period, though it was minimal, and resulted in a loss rate of 0.3% yr^{-1} (0.34 acre yr^{-1}/0.14 hectare yr^{-1}) during the post-construction period (table 1).

Table 1. Acreage [*hectare*] and percent ( ) of land and water obtained through analysis of aerial photography for one pre-construction and two post-construction periods.

	Pre-Construction[1]		Post-Construction[2]					
Flight date	December 26, 1994		November 24, 1997		November 15 and 27, 2000		Land Change % yr^{-1}	
	Land	Water	Land	Water	Land	Water	1994 - 1997	1997 - 2000
Phase I	2,870 *[1,161]* (84)	538 *[218]* (16)	2,753 *[1,114]* (81)	655 *[265]* (19)	2,862 *[1,158]* (84)	546 *[221]* (16)	-1.4	+1.33
Phases II & III	1,136 *[460]* (66)	576 *[233]* (34)	1,113 *[450]* (65)	599 *[242]* (35)	1,114 *[451]* (65)	598 *[242]* (35)	-0.7	+0.03
Reference	129 *[52]* (90)	15 *[6]* (10)	123 *[50]* (85)	21 *[8]* (15)	122 *[49]* (85)	22 *[9]* (15)	-1.6	-0.3

[1]Pre-construction period: December 26, 1994 to November 24, 1997
[2]Post-construction period: November 24, 1997 to November 27, 2000

Shoreline position: During the pre-construction period from 1995 to 1997, the canals in Phase I eroded at a rate of 0.94 ft yr^{-1} (0.29 m yr^{-1}). During the post-construction period from 1997 to 2000, the canal banks eroded at a rate of 1.22 ft yr^{-1} (0.37 m yr^{-1}) (figure 11).

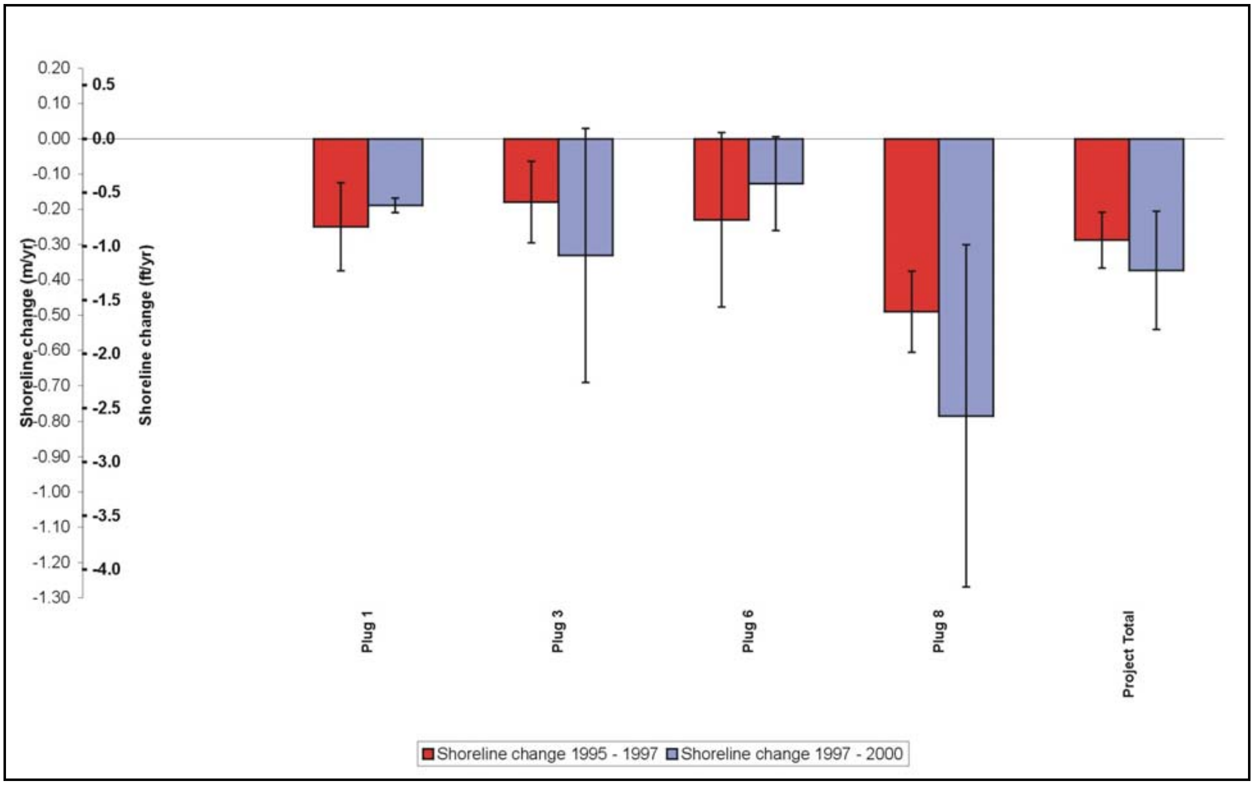

Figure 11. Average canal width change in Phase I of the Point Au Fer Island Hydrologic Restoration (TE-22) project, by plug and project average, as measured using shoreline position markers.

DISCUSSION

The results of the land/water analyses and shoreline position measurements are conflicting, and complicate the evaluation of goals 1, 2, and 3: reducing the rate of marsh loss (Phase I), reducing the rate of canal widening (Phase I), and maintaining or decreasing local shoreline erosion rates within Phase II, respectively.

Land/water analyses indicate that, during the pre-construction period, all project phases and the reference area experienced land loss well below that reported by Barras et al. (1994) for Terrebonne basin in their assessment of land loss in coastal Louisiana from 1978 to 1990 (6.5% loss yr^{-1}), but above those loss rates reported for the Atchafalaya basin during the same period (0.10% loss yr^{-1}). While Point Au Fer Island is included in the Terrebonne Basin boundary, we did not expect the equivalent losses of that basin reported above because of the islands location between both the Terrebonne and Atchafalaya Basins, and just 6 miles southeast of the mouth of the Atchafalaya River (which carries a heavy sediment load). Instead, Point Au Fer Islands loss rate of approximately 1.4% yr^{-1} from 1994 to 1997 seems reasonable given its geographic position. During the post-construction period Phases I and II experienced land gain at a rate that nearly equaled the previous 3-years loss rate, and the loss rate in the reference area was largely reduced. As a result of sediment inputs from the Atchafalaya River, the area around Point Au Fer (mainly North of the island) is building (Van Heerden et al. 1991, Roberts 1998), therefore, land loss rates will typically reflect that of the expanding Atchafalaya Basin. However, we posit that rebounds in loss rate of this magnitude did not occur. Instead, due to the drought southern Louisiana has experienced from late 1998 to 2000, there was a severe decrease in water level. As a result, large areas of mudflats were exposed, the distinction between land and water on aerial photography was difficult, and there exists a strong possibility that the calculated acreage of land was artificially inflated. The NWRC made every effort to minimize an over-exaggeration of land gain in low water areas, but until the project area is aerially photographed and analyzed again in 2006, it may be misleading to over-emphasize the trends presented above. Uncertainty about the accuracy of our results could have been greatly reduced if additional monitoring variables were incorporated from the onset of this project. Not only would they have added environmental data for analyses, but could have aided in determining the efficacy of canal plugs and rock armored shorelines as a means of protecting and preserving inland marsh. These additional components were excluded because of budgetary constraints.

The shoreline position measurements contradict the results of the post-construction land/water analyses. The loss rates of 0.94 ft yr^{-1} (0.29 m yr^{-1}) and 1.22 ft yr^{-1} (0.37 m yr^{-1}) from 1994 to 1997 and 1997 to 2000, respectively, indicate the continued widening of canals regardless of structural features built throughout Phase I. Though the authors are unsure of the original width of both the Transco and Hester canals, the average width of the pipeline canals in Phase I was approximately 130 feet (40 m; measured using ArcView® GIS software and 1998 DOQQ's). Using 130 ft (40 m) as an average, the annual increase in canal width is approximately 1.0% yr^{-1}, which is nearly half that found by Craig et al. (1979) who examined land loss throughout coastal Louisiana specifically as a result of canal impacts. They found an annual increase in canal width ranging from 2% to 4.6%, and that canal width doubling could occur in as few as 15 years, and as many as 34.6 years. Some cases have been even more extreme - Davis (1973) and Nichols (1958) found rates of canal expansion ranging from 4.6% to 14.8% in Bayou St. Denis, Humble Canal, Superior Canal, and Falgout Canal.

Craig et al. (1979) suggested the use of plugs at either end of a canal to reduce boat traffic and water flow, and consequently, the annual rate of canal widening. After the construction of plugs at various locations within the Hester and Transco canals, we found no significant change in the rate of canal widening. The goal of reducing canal widening may not have been met due to many of the structures state of disrepair (even immediately after construction). For example, plug #6 experienced deflections in the creosote timbers immediately following their placement in the canal. With every component of the plug constructed except the reef shell on the plug ends, the construction crew left the site and the water level behind the plug increased to a differential of nearly 2.0 ft (0.61 m) (Kendrick, unpublished), thereby causing the deflections. By the year 2000, there were four plugs in need of repair. Plug #4 (a shell plug) on the Gulf of Mexico side of the project was breached a few months after it was constructed as a component of Phase I. The plug was repaired during the Phase III construction period, but participants in fly-overs since construction have noted that the plug has again blown-out (Thibodeaux, pers. comm., 2001). Plug 3A, which is also shell, has sunk substantially and is easily driven over by small boats (Thibodeaux, pers. comm., 2001). Plugs #3 and #8 have breached around at least one side and are wide enough for small boats to enter the canal. The project area may be experiencing continued canal widening because the structures, when breached or constructed poorly, are not restricting small boat traffic and direct wave action from the adjacent bays and the Gulf of Mexico. Others suggest that land loss along canals is due to a restricted hydrologic regime (Swenson and Turner 1987, Turner et al. 1994b), alterations in soil chemistry (Mendelssohn et al. 1981, King et al. 1982, DeLaune et al. 1983), and the general adverse effects of continuous spoil banks on a marsh ecosystem (Abernethy and Gosselink 1988). The placement of shoreline position markers outside and away from the plugged area would have better enabled LDNR/CRD to determine if continued canal widening is the result of dilapidated structural features or those factors suggested by the above researchers.

CONCLUSIONS

At this point, predominantly due to a severe drought in Louisiana, the lack of additional and supporting ecological data, and numerous structural features in a state of disrepair, the project results regarding land loss are ambiguous. While we are unable to determine a trajectory toward or away from our project goals at this time, we are presented with an example of the importance of: 1) an experimental design and 2) a structured operations and maintenance plan. For example, multiple monitoring variables, reference areas for informative comparisons, and a statistically valid experimental design, would better enable the biological monitoring section to assess structure efficacy, determine the potential for meeting project goals, and contribute toward the design of new projects. In terms of operations and maintenance, plug #4 is a poignant example. There was a period of approximately two-years before the breached plug was repaired. Therefore, the intended benefit of the plug toward marsh protection and shoreline protection was not realized. Soon after its repair in 2000, plug #4 was again breached and at this time, plans have not been made to use an upgraded or alternate material (other than shell) for the repair or replacement of the structure. Again, the potential benefits are not being provided. To truly determine structure effectiveness and ensure their intended benefit, regular maintenance must be performed. We have learned, however, that while the exact mechanisms contributing to the structures failure are unknown, we should avoid areas of high energy when considering shell structures in the future. Projects, like Point Au Fer Hydrologic Restoration, that are not easily accessible make it difficult to perform general maintenance visits and structural repairs. This should be considered in future project design, operations and maintenance planning, and monitoring design.

If a project of this type is pursued in the future, greater attention should be paid to hydrologic conditions and soil properties, structure maintenance and long-term integrity, and those areas outside of the direct influence of project features (*i.e.,* - reference areas for comparisons).

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