MONITORING PLAN

PROJECT NO. TE-41 MANDALAY BANK PROTECTION (DEMO)

ORIGINAL DATE: July 30, 2002
REVISED: August 5, 2004

Project Description

The Mandalay Bank Protection Demonstration (TE-41) project consists of four low cost treatments designed to halt bank erosion and encourage sedimentation and vegetation growth along the Gulf Intracoastal Waterway. It is sponsored by the United States Fish and Wildlife Service (USFWS) and the Louisiana Department of Natural Resources/Coastal Restoration Division (LDNR/CRD) under the Coastal Wetlands Planning, Protection, and Restoration Act (CWPPRA, Public Law 101-646, Title III, Priority List IX).

The (TE-41) project is located along 3.4 mi (5.5 km) of the Gulf Intracoastal Waterway (GIWW). It is approximately 6 mi (9.7 km) southwest of Houma, Louisiana in the northeast portion of Terrebonne Parish. The project lies in the northern portion of the Penchant sub-basin in the Terrebonne hydrologic basin between Latitude 29°32'10" east Longitude 90°40'49" north, and Latitude 29°32'06" east Longitude 90°46'16" north (Figure 1).

The Terrebonne hydrologic basin experienced land loss rates of 9.3 sq mi yr^{-1} (15.0 sq km yr^{-1}) from 1956-78 and 10.2 sq mi yr^{-1} (16.4 sq km yr^{-1}) from 1978-1990. During this time, 61% of all coastal land loss occurred within the Terrebonne and Barataria basins when compared to the seven remaining Louisiana coastal hydrologic basins defined by the CWPPRA Task Force. Most of the Terrebonne Basin losses were interior marshes with some non-fresh land losses skirting the bays. (Barras et al. 1994). From 1944-1983 the GIWW shoreline in the project area has experienced land loss rates of approximately 13.22 ft y^{-1} (4.03 m y^{-1}) (May and Britsch 1987) (Figure 2, Table1).

Vegetative communities in the project area include fresh marsh, scrub/shrub, seasonally flooded bottomland forest, and open-water areas with aquatic vegetation. The two fresh marsh vegetation types; fresh bulltongue marsh and fresh maidencane marsh, have relatively high diversity. Fresh bulltongue marsh has an average salinity of 1.5±1.0 ppt. and is typically dominated by *Sagittaria lancifolia* (bulltongue) with *Panicum hemitomon* (maidencane) and *Eleocharis spp*. (spikerush).

Table 1. Approximate land loss rates within the TE-41 project area from 1944-1983. (May and Britsch 1987).

Location	Land loss (m yr^{-1})	Land loss (ft yr^{-1})
GIWW North Shore	3.32	10.89
GIWW South Shore	4.71	15.45
Average	4.015	13.17

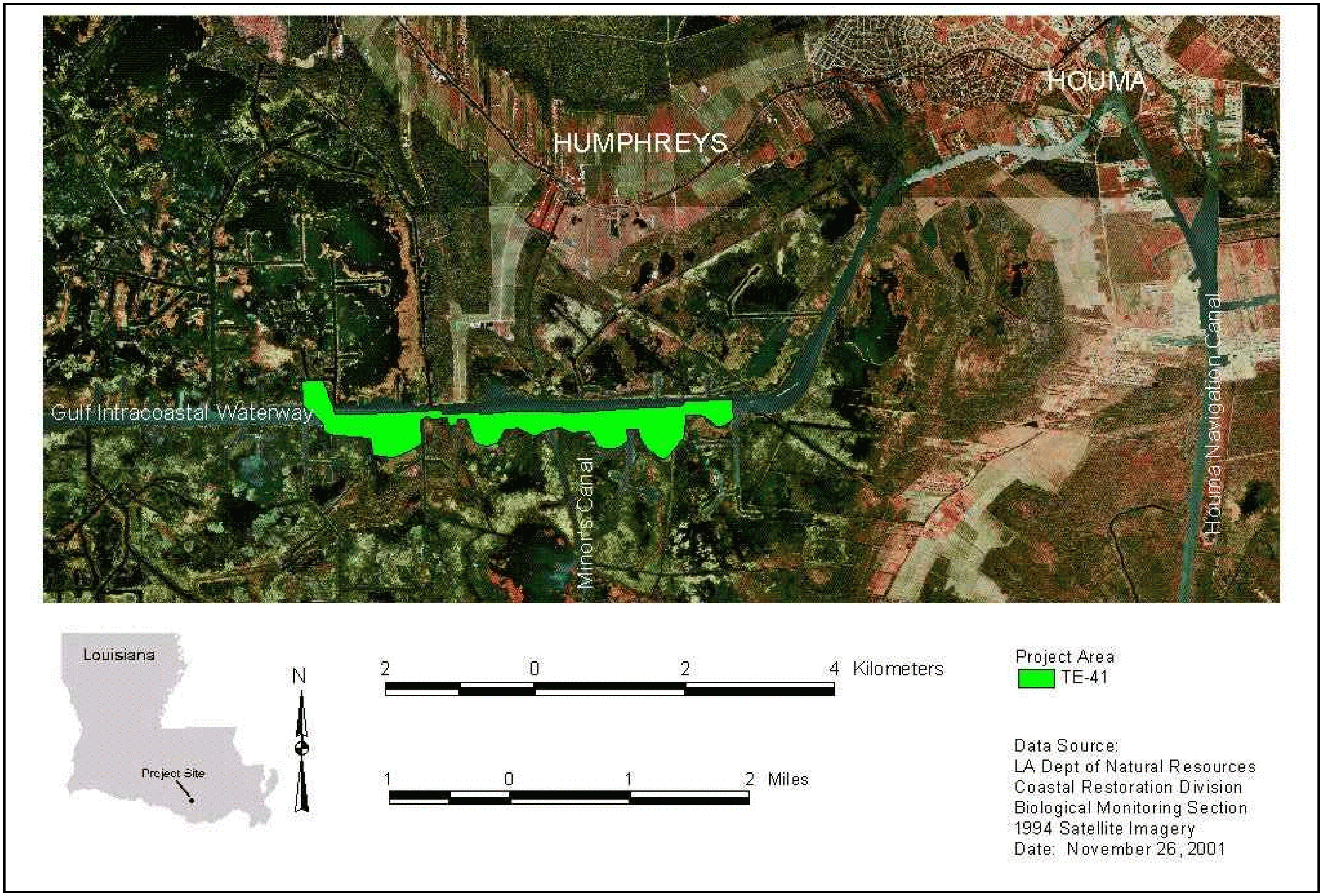

Figure 1. Location map of Mandalay Bank Protection Demonstration (TE-41) Project.

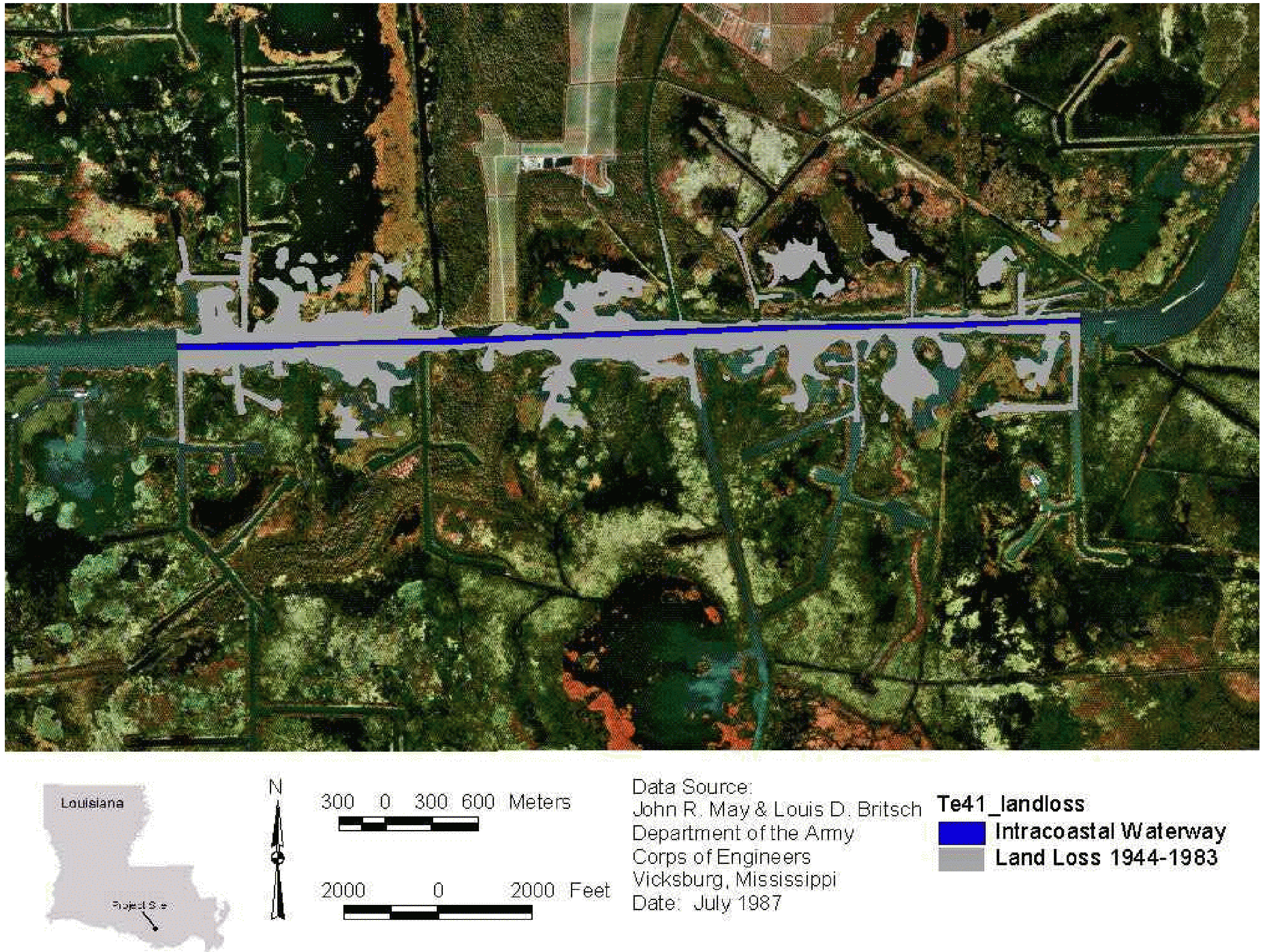

Figure 2. Land loss analysis map of the Mandalay Bank Protection Demonstration (TE-41) Project.

The average salinity of fresh maidencane marsh is 0.5±0.4 ppt. (Visser et al. 1996, 1999), and is dominated by *P. hemitomon* with *Eleocharis spp*. (spikerush) as a co-dominant. Scrub/shrub plant associations are best described as highly diverse types of wetland forests developing along elevated dredged spoil banks. Species include *Salix nigra* (black willow), *Acer rubrum* (red maple), and *Cephalanthus occidentalis* (buttonbush). Seasonally flooded bottomland forests are typically dominated by several *Quercus* spp. (oaks), *Fraxinus pennsylvanica* var. *lanceolata* (green ash), *Liquidambar styraciflua* (sweet gum), and other hardwood species. Aquatic vegetation includes *Lemna minor* and *Spirodella polyrhiza* (duckweeds), *Riccia* sp., and *Limnobium spongia* (common frog's bit) (Reed 1995). The submerged aquatic vegetation (SAV) *Vallisneria americana* (water celery) has been observed in many shallow water areas within the project (Segura 2001a).

The Louisiana Department of Environmental Quality (LDEQ) has collected salinity data for the stretch of the GIWW between the Bayou Boeuf Locks and Houma where the project lies. These data indicate salinities in the project area are generally fresh but may increase periodically depending on the Atchafalaya River stage, tides, and precipitation. Salinities tend to remain low during higher river stages (Segura 2001b).

There are nine soil types within the project (TE-41) area which are placed into five series classifications (Lytle et al. 1960a). They range from highly organic, continuously flooded soils at elevations level to the Gulf of Mexico to moderately organic plastic clays and mucky clays up to 10 feet in elevation above the Gulf. Land management practices on these soil types range from the intensive cultivation of row crops, to drained pastureland, to hunting and trapping only. Flora supported by these soil types all include fresh water to fresh water tolerant plant associations which range from bottomland hardwood forests to fresh marsh (Lytle et al. 1960b).

The Terrebonne hydrologic basin experiences the same humid subtropic climate as the rest of the northern Gulf of Mexico, which is characterized by relatively mild winters with a definite seasonal rainfall pattern. Average annual rainfall is approximately 150 cm (59.1 in). There is a large rainfall surplus during the fall, winter, and spring months when stormy frontal synoptic weather types predominate. A water deficit is likely during the hot summer months when maximum evaporation from the system occurs, however this can vary from year to year (Reed 1995). Tropical storms and hurricanes occur along the Gulf coast typically between June and November, creating drastic changes in the hydrologic regime in the surrounding basins. Mean annual air temperatures vary from 13°C (55.4°F) in January to 27.5°C (81.5°F) in July. The coldest nights bring on occasional freezes, but thawing is usually rapid after sunrise. Winds have an overall easterly component. They are predominantly south and southeasterly during the spring and summer, and north and northeasterly during the fall and winter (Conner and Day 1987). Average water temperatures range from 18°C (64°F) in February to 29°C (84°F) in August (Mendelssohn and Hester 1988).

The hydrology of the project area is closely tied to water levels in the Lower Atchafalaya River and to some extent, tides and winds associated with frontal passages. During moderate to high river stages, fresh water typically flows from the Lower Atchafalaya River northeastward through the Avoca Island Cutoff Channel into Bayou Chene and into the GIWW. The fresh water proceeds eastward through the project area toward Houma. At Houma, a large portion of the fresh water flows south to the Gulf of Mexico through the Houma Navigation Canal and a small amount continues east toward Larose. Strong southerly winds during high Atchafalaya River levels may exaggerate the eastward flow or even force water from the Verret Subbasin to the east. During low Atchafalaya River levels, flow directions in the GIWW through the project area may vary. Strong northeasterly winds during low river levels may sometimes halt or slow down the flow, or occasionally cause a westward flow in the GIWW (Paille 1997). Annual lowest and highest tidal ranges vary from 1.10 ft to 1.45 ft NGVD29 in the project area. Mean Low Water (MLW) is 0.70 ft NAVD88 and Mean High Water (MHW) is 1.05 ft NAVD88 (Coastal Engineering and Environmental Consultants, Inc. 2002).

The stretch of GIWW within the project area experiences a substantial volume of marine vessel traffic. The traffic is a mixture of small recreational vessels, large commercial and industrial type barges, supply ships, and crew boats. Data collected in 1997 and 1998 by the U. S. Army Corps of Engineers indicated an annual average of 53,839 vessels and barges (both east and west - bound) passed through the Bayou Boeuf Lock. This lock is approximately 28 river miles west of the Mandalay National Wildlife Refuge. Most of the traffic traveling through the lock is expected to pass through the refuge (Segura 2001b). The estimated mid-channel wave height in the GIWW generated by winds and large vessel wakes is approximately 3.0 ft (Coastal Engineering and Environmental Consultants, Inc. 2001). The wave height estimate is based upon observations and engineering calculations from preliminary design investigations. Frequent wave action along the waterway coupled with soft, unstable marsh sediments has resulted in several shoreline blowouts, bank erosion, and an overall widening of the channel. Adjacent freshwater marshes remain vulnerable to the damaging effects of erosion.

The Mandalay Bank Protection Demonstration (TE-41) project seeks to demonstrate the effectiveness of four low cost bank protection and stabilization treatments in a relatively high wave energy environment containing soft, highly organic soils. These nontraditional alternative treatments are being utilized in place of structures such as rip-rap stone which may be too heavy for the soil conditions encountered in these areas. Treatment designs are engineered for a 5 year project with a minimum life-span of twenty years (Coastal Engineering and Environmental Consultants, Inc. 2001).

Erosion of the shoreline within the project area has resulted in the formation of blowouts, or large areas of open water where chunks of adjacent marsh have eroded into the waterway forming small cove-like features. Other segments of shoreline still have low banklines which gently slope into shallow water (off-bank) of the waterway. These segments have not completely eroded away but remain vulnerable to the effects of large-vessel traffic and waves produced by high winds. Twelve treatment areas and three reference areas were selected along the south shoreline of the GIWW, while one reference area was selected on the north shoreline. Six of the treatment areas were selected for blowouts and six of the treatment areas were selected for off-bank shoreline segments.

Three locations where the banks had deep breaks were selected for armored earthen plugs to be installed in order to make the treatments effective. They are next to two of the blowout treatments and one of the off-bank treatments (Figure 3).

The project features include (Figure 3):

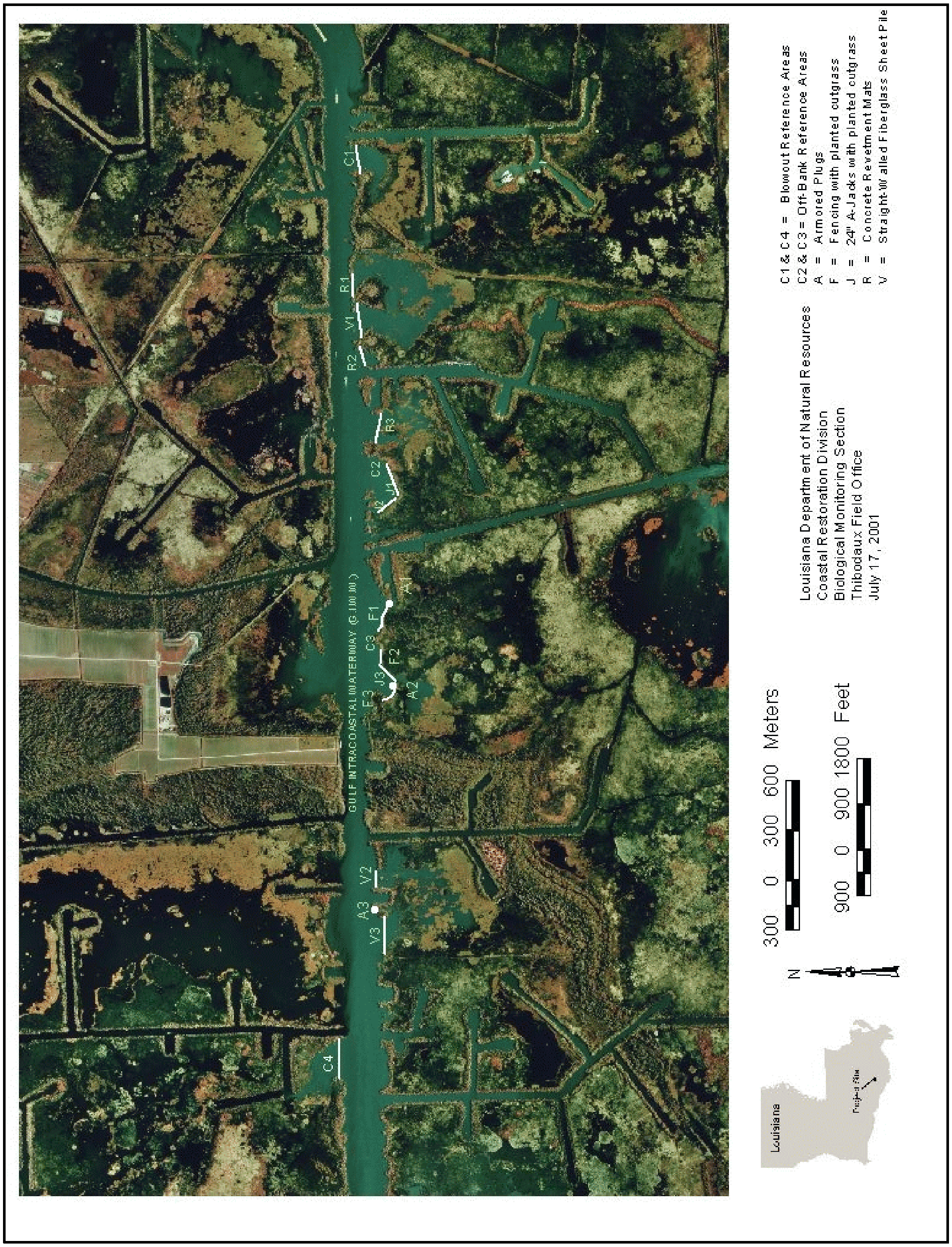

Figure 3. Location of treatments, plugs, and reference areas for Mandalay Bank Protection Demonstration (TE-41) Project.

Blowout Treatments:

1. Crews will construct approximately 1,196 ft (407 m) of submerged concrete revetment mats (Figure 4). Articulated concrete mats are draped over bundled perforated Corrugated Polyethylene Pipes (CPE) which are placed on top of a settlement plate on top of a geotextile fabric layer. This layered assembly is anchored to the water bottom and to shoreline banks through ropes woven into the concrete revetment mat. The revetment mat slows down the wave energy while allowing water exchange between the waterway and the surrounding marshes.

2. Crews will construct approximately 1,749 ft (601 m) of submerged straight-walled fiberglass sheet pile system (SWFSPS) (Figure 5). The sheet pile is vertically constructed parallel fiberglass panels. In-fill dredge material from the GIWW channel is placed between the sheet piles and galvanized rods are bolted to timber walers to provide lateral bracing. Wave energy and patterns would be dissipated. Larger waves would be able to top the sheet pile allowing for water and sediment to reach behind the structure and into the blowout. Initial vertical scouring is expected at the mudline followed by sedimentation.

Off-Bank Treatments:

3. Crews will construct approximately 1,241 ft (378.3 m) of 24 inch (0.61 m) high A-Jacks® concrete blocks in an interlocking double row will be placed on the channel side of *Zizaniopsis miliacea* (giant cutgrass) plantings (Figure 6). The blocks will be submerged and located in shallow water adjacent to eroding shoreline banks (off-bank). *Z. miliacea* was chosen for several reasons. It occurs in the area and field observation indicates it may hold the sediment together. It grows in flooded conditions and it has been used in the vegetative planting program at other locations. The A-Jacks® are expected to reduce wave energy and protect the plantings until they become established. A-Jacks® may act as a trap for sediment and organic matter.

4. Crews will construct approximately 1,194 ft (355 m) of staggered wooden fencing on the channel side of *Z. miliacea* plantings located in shallow water adjacent to eroding shoreline banks (off-bank) (Figure 7). Fencing will be constructed with treated timber. The structures will be similar to the angled timber fencing utilized on the Lake Salvador Shoreline Protection (BA-15) project, but on a smaller scale. Fencing protects the plantings from wave energy and it keeps floating mats of *Eichhornia crassipes* (water hyacinth) off of them until they are established. It also may act as a trap for sediment and organic matter.

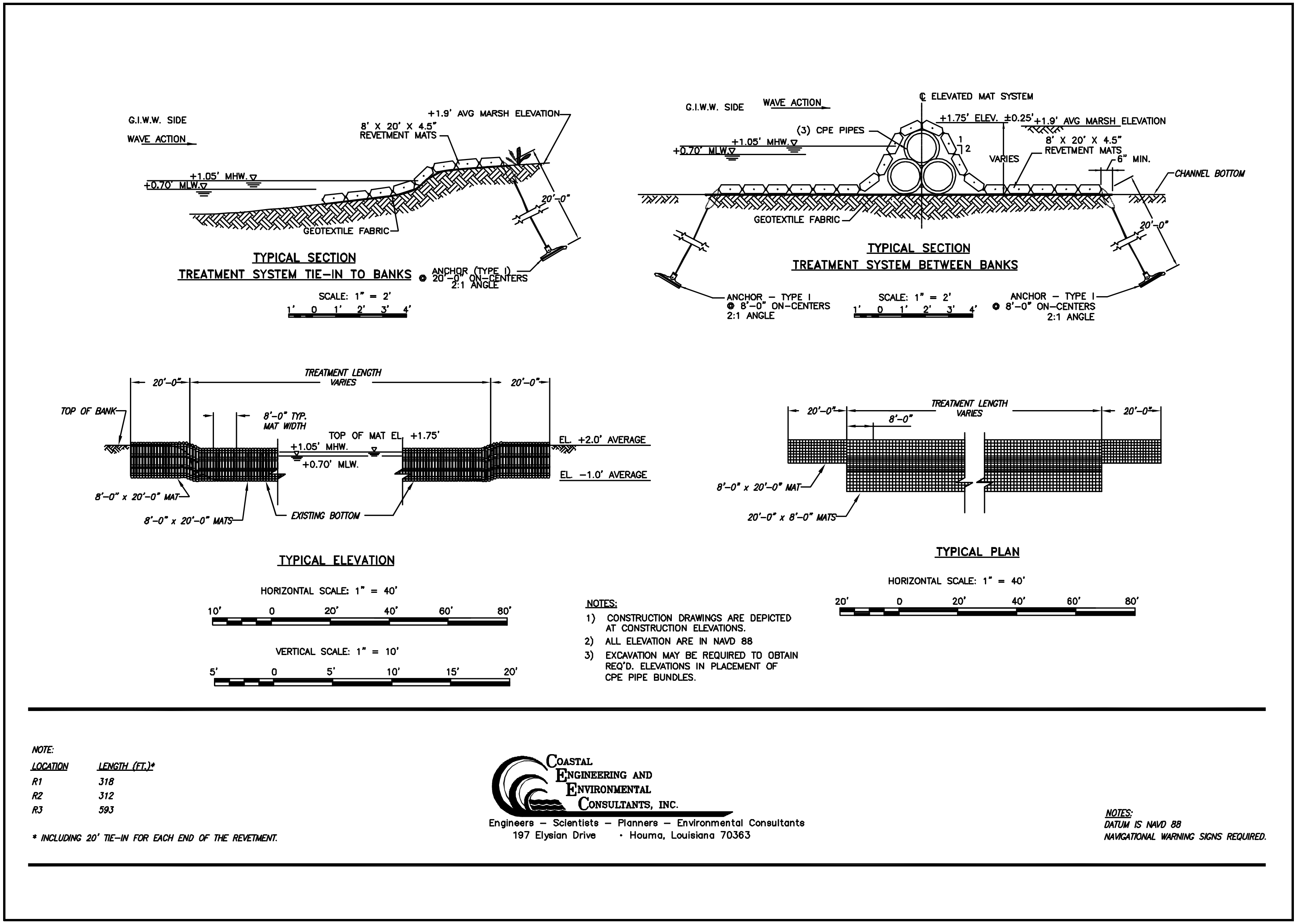

Figure 4. Typical design of the concrete revetment mats (treatment R) at Mandalay Bank Protection Demonstration (TE-41) Project (from CEEC 2001, not to scale).

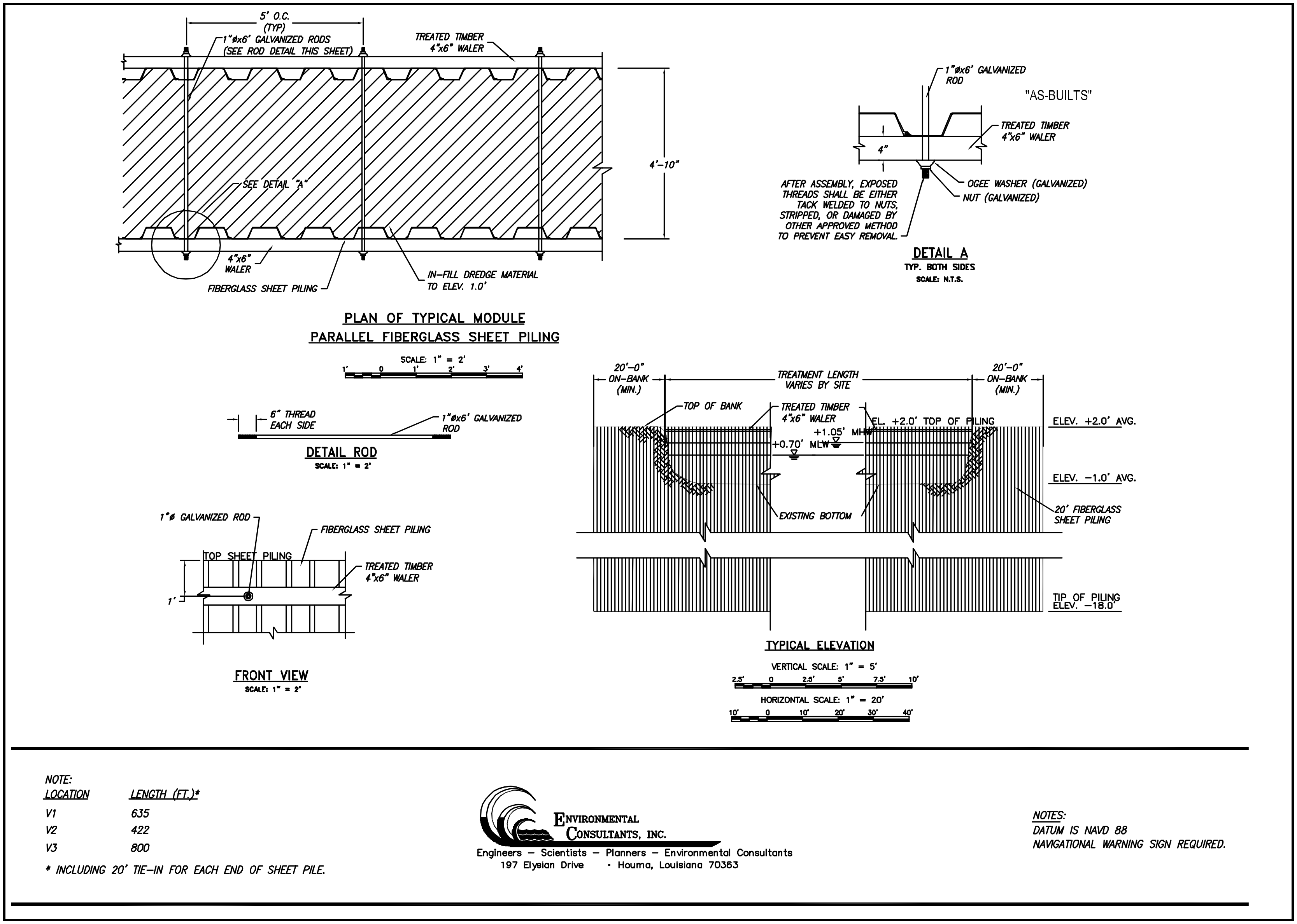

Figure 5. Typical design of parallel fiberglass sheet pile system (treatment V) at the Manadalay Bank Protection Demonstration (TE-41) Project (from CEEC 2001, not to scale).

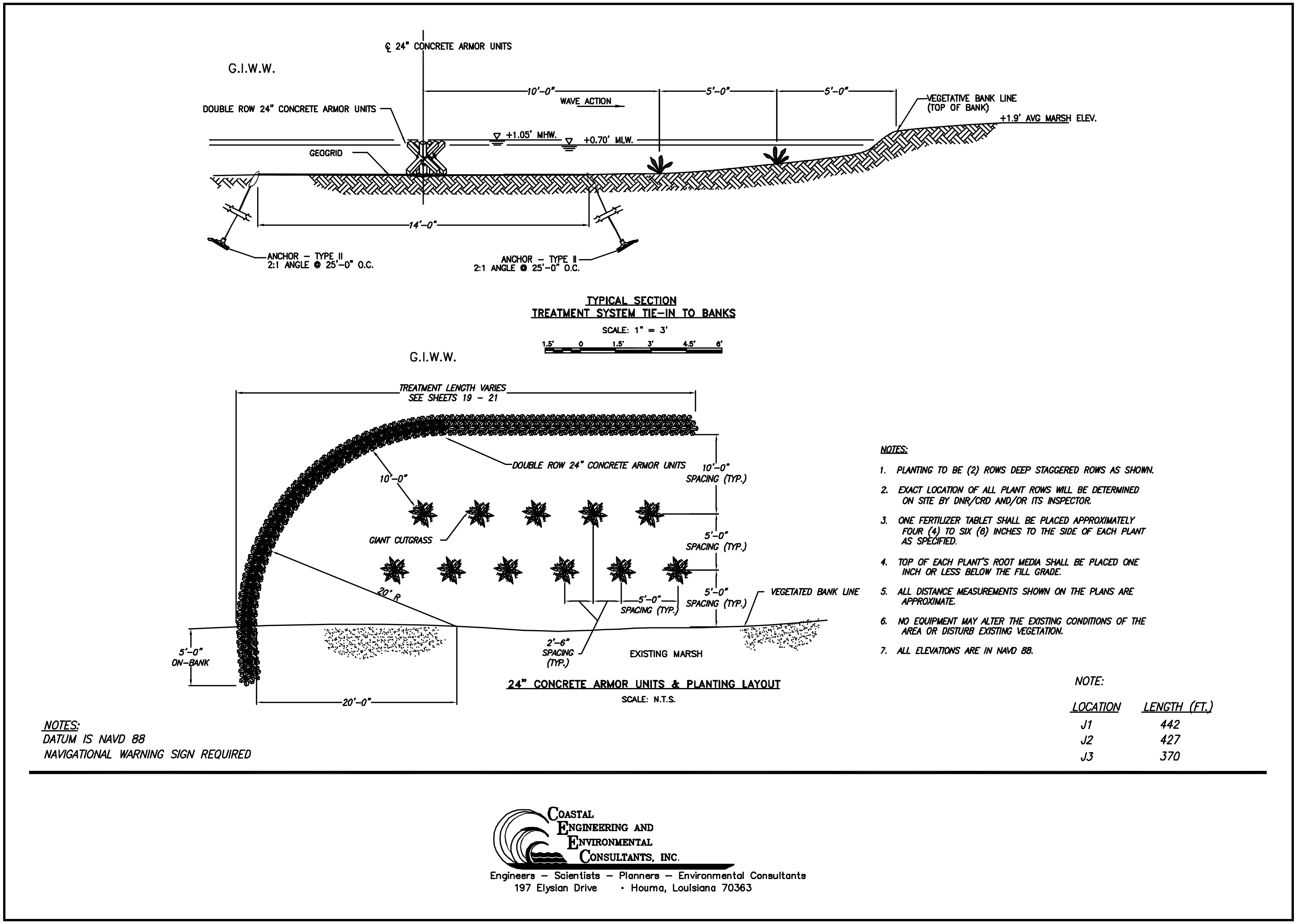

Figure 6. Typical section views of A-Jacks®with planting layout (treatment J) for (TE-41) Mandalay Bank Protection (Demo) Project (from CEEC 2001, not to scale).

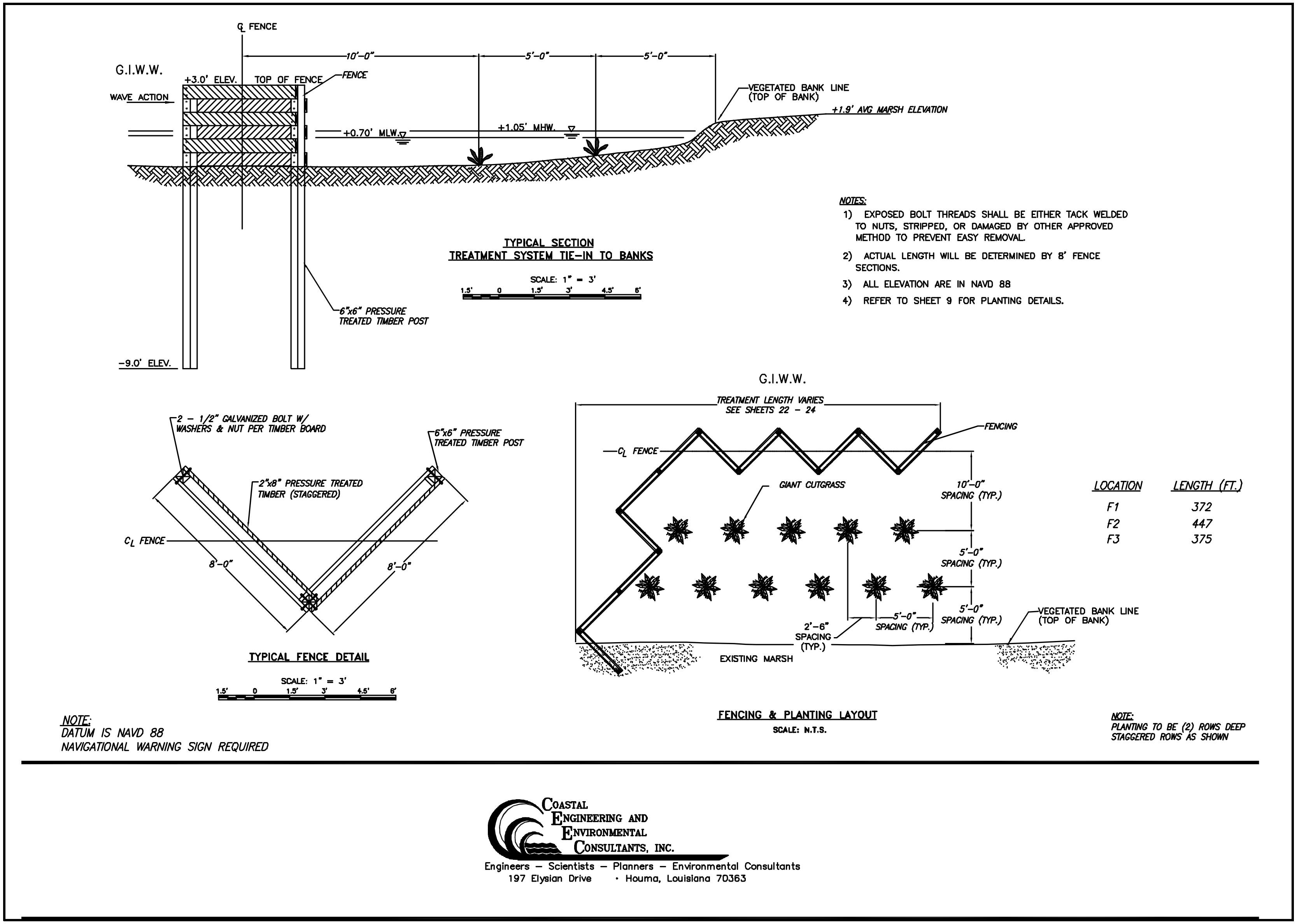

Figure 7. Typical section views of fencing and planting layout (treatment F) for (TE-41) Mandalay Bank Protection (Demo) Project (from CEEC 2001, not to scale).

Additional features are the construction of:

5. Crews will construct approximately 216 ft (66 m) of armored plugs (Figure 8). The armored plug is a layered structure consisting of a core of dredged fill material from the GIWW, with a geotextile fabric layer and a concrete revetment mat covering the core. The edges are anchored to the banks. The structure tops out at 1.0 ft. above MHW. The structure would be used across narrow openings between some of the treatments to prevent water movement from circumventing other features, negating their effects. Plugs are not be considered as a part of any treatment.

Project Objective

The overall objective of the project is to compare both the treatment as well as the cost effectiveness of two off-bank and two blowout treatments' ability to provide protection against shoreline erosion, promote sedimentation, and promote vegetation growth in selected areas along the GIWW.

Specific Goals

1. To stop shoreline erosion in specified areas along the south shores of the GIWW.

2. To increase elevation in shallow open water behind treatments along the GIWW.

3. To maintain/increase the frequency of occurrence of submersed aquatic vegetation (SAV) within shallow open water blowouts along the GIWW.

4. To increase mean cover of *Z. miliacea* to 50% or greater after five growing seasons in planted areas adjacent to eroding shorelines of the GIWW.

5. To increase mean cover of emergent vegetation within shallow open water blowouts along the GIWW.

6. To evaluate the cost effectiveness of different treatments in selected areas along the GIWW.

7. To evaluate the integrity of the structures associated with treatments in selected areas along the GIWW.

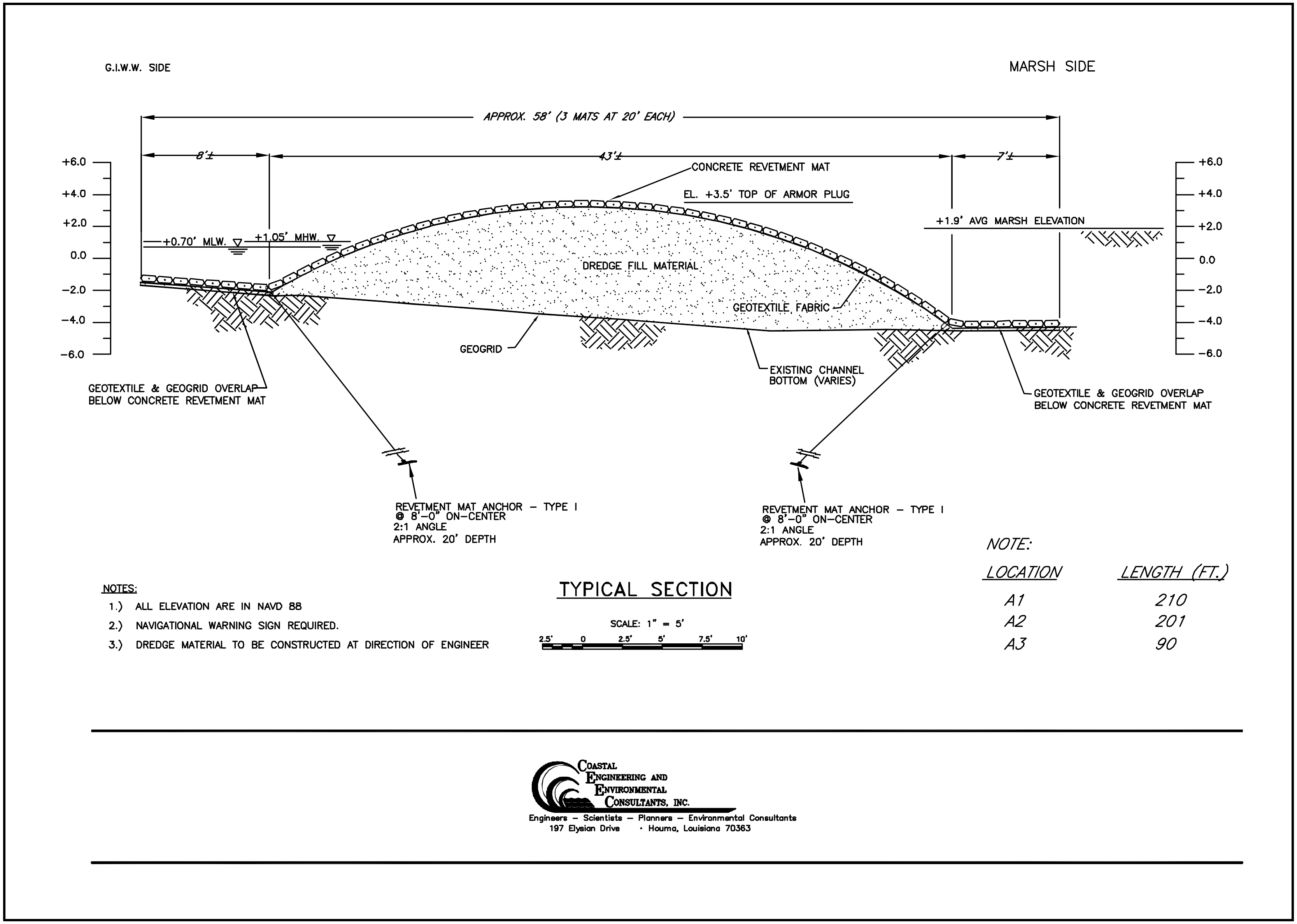

Figure 8. Typical section views of armored plug revetments (treatment A) for (TE-41) Mandalay Bank Protection (Demo) Project (from CEEC 2001, not to scale).

Treatment Assignments

A total of twelve treatment areas have been identified for project construction.

1. Six areas will be used for blowout treatments out of which,
   - (a) three will be used for Concrete Revetment Mats and,
   - (b) three will be used for submerged straight-walled fiberglass sheet pile system (SWFSPS).

2. Six areas will be used for off-bank treatments out of which,
   - (a) three will be used for Wooden Fencing with planted *Z. miliacea* and,
   - (b) three will be used for A-Jacks® with planted *Z. miliacea* .

Reference Shoreline

Four reference areas were identified along the shoreline which will be used to study the effectiveness of the treatments (Figure 3). Two reference areas (C1 and C4) will be used to study blowout treatments and two reference areas (C2 and C3) will be used to study off-bank treatments. Reference areas C1, C2, and C3 are on the south bank of the GIWW, while reference area C4 is on the north bank of the GIWW.

The two blowout reference areas were mandated as such and not included in the randomization process during blowout treatment assignations. C1 contained a cultural resources site which precluded construction of a treatment. No additional blowouts were available for selection close to the project on the south side of the GIWW, therefore C4 was chosen as a blowout reference. The two blowout references total approximately 1,300 ft (396.2 m). One reference is located on the western end of the project and one is located on the eastern end of the project (Figure 3).

The lengths of the off-bank reference areas and treatments were calculated before randomization took place. Total lengths were calculated in order to determine how many reference areas could be placed along each of the two shoreline segments targeted for off-bank treatments. The two off-bank reference areas total approximately 1,150 ft (350.5 m). One is located west of Minor’s canal, while one is located on the east side of the canal (Figure 3).

Monitoring Elements

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

1. Shoreline Survey — To document the rate of shoreline retreat or progradation in both blowout and off-bank treatments, shoreline position will be surveyed (outward edge of emergent vegetation) in all treatment and reference areas using methods described in Steyer et al. (1995). To determine shoreline position, three

transect lines per treatment area will be surveyed by a professional surveyor to a permanent benchmark established in the project area. The survey lines will coincide with vegetation plot transects and sedimentation elevation transects in each area. Shoreline position will be recorded pre-construction December of 2000, the fall of 2003 (as-built), post-construction in 2005 and 2008.

2. Elevation — To determine the elevation within shallow open water areas, surveys will be conducted along transects by professional surveyors. Elevation transects will be surveyed to a permanent benchmark established inside the project area. Three transects will be delineated in each treatment area and in each reference area and they will continue into the center of the channel. To document structural movement and integrity, the tops of all structures will be surveyed at the same points, during each elevation transect. Sediment elevations will be recorded pre-construction December of 2000. Sediment and structure elevations will be documented in the fall of 2003 (as-built), post-construction in 2005 and 2008.

3. % Survival — To determine the survival of planted *Z. miliacea* behind off-bank treatments, 18 permanent vegetation plots representing approximately 10% of the planted vegetation will be established among the off-bank treatments. Plots will contain 12 plants planted in two staggered rows. The rows will be spaced five feet apart with plants within each row spaced five feet apart. Percent survival will be determined in the fall of 2003 (as-built), and twice post- construction in fall 2005 and 2008.

4. Vegetation — To determine changes in % cover of emergent vegetation, plots will be randomly established along three line transects running north to south in each treatment and reference area. For blowout treatments, approximately four plots will be randomly placed along each transect. Three of the plots will be randomly placed within one of three zones based upon plot distance from the proposed structure (if a treatment plot) or channel (if a reference plot). A fourth plot per transect will be established on the marsh surface at a randomly chosen distance from the vegetated shoreline. Zones will be determined by dividing the longest transect in each treatment or reference area into three equidistant areas (Figure 9). For

off-bank treatment and reference areas, one plot per transect will be established in the water at a random distance (from the treatment or channel). Two additional plots will be placed along the transects on the marsh surface at a random distance from the vegetated shoreline. Total percent cover as well as individual species cover will be determined within the plots using a 6.6 ft x 6.6 ft (2 m x 2 m) square placed over the southeast corner post. Vegetation will be sampled once pre-construction in the fall of 2001, in the fall of 2003 (as-built), and post-construction in the fall of 2005 and 2008.

5. SAV — To determine the frequency of occurrence of SAV, open water areas inside blowout treatments and reference sites will be randomly sampled. Each blowout will be sampled at random points along transects using the rake method (Chabreck and Hoffpauir 1962; Nyman and Chabreck 1996). The number of random points and transects will be determined based upon the size and configuration of the blowout. Frequency of SAV occurrence will be determined for each area from the number of points at which SAV occurred and the total number of points sampled. SAV will be monitored once in the fall of 2001 (pre-construction), in the fall of 2003 (as-built), and post-construction in the fall of 2005 and 2008.

Anticipated Statistical Tests

Statistical tests will be used to evaluate goals 1 thru 5. Goals 6 and 7 will be evaluated through use of observational data and professional judgement.

Variables tested include:

a. shoreline position
b. sediment elevation
c. percent cover of planted vegetation
d. percent cover of naturally occurring emergent vegetation
e. SAV frequency of occurrence

1. All variables measured will be compared post-construction to determine differences between treatments and references.
2. Additionally, variables will be compared over time to determine treatment impacts pre- and post-construction.

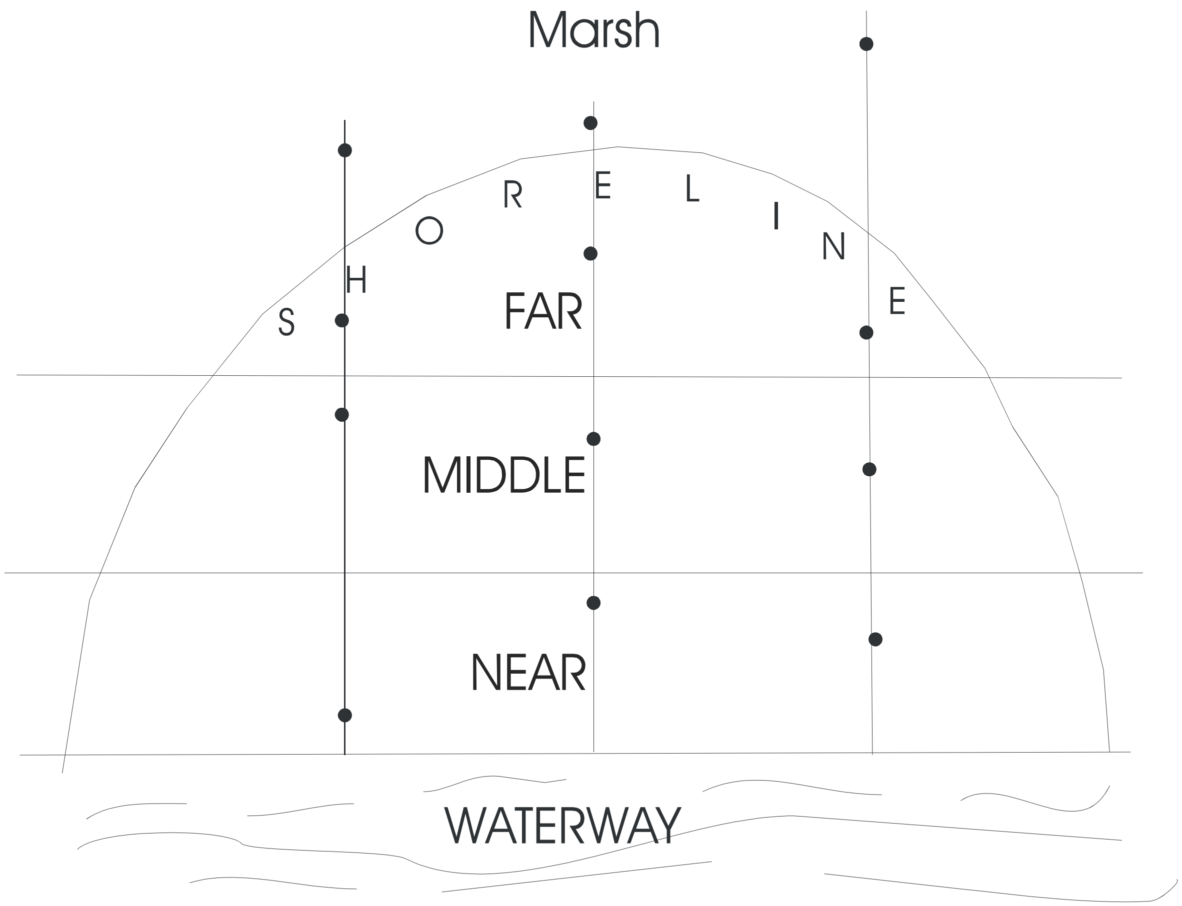

Figure 9. Typical blowout showing random vegetation plots placed along north-south transects within near, middle, far, and marsh zones for (TE-41) Mandalay Bank Protection (Demo) Project.

If treatments and references are not different then they will be considered not effective. If there are differences, then determinations of which treatment is most effective will be analyzed.

Notes:

1.	Implementation:	Start Construction:	April 25, 2003
		End Construction:	September 1, 2003
2.	USFWS Point of Contact:	Martha Segura	(337) 291-3100
3.	DNR Project Manager:	Ralph Libersat	(225) 342-1952
	DNR Project Supervisor:	Darin Lee	(985) 447-0991
	DNR Monitoring Manager:	Elaine Lear	(985) 447-0974

4. The five year monitoring plan development and implementation budget for this project is $105,190. Data and summary graphics will be available in 2003 and 2005. A comprehensive report will be available in 2009. These products will describe the status and effectiveness of the project. Mandalay National Wildlife Refuge personnel will report to the United States Fish and Wildlife Service and the Department of Natural Resources any changes in structure integrity they observe while in the area.

5. References:

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