



**State of Louisiana  
Department of Natural Resources  
Coastal Restoration Division**

**Monitoring Plan**

for

**Sweet Lake/Willow Lake Hydrologic  
Restoration**

State Project Number CS-11b  
Priority Project List 5

August 2003  
Cameron Parish

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**MONITORING PLAN**  
**PROJECT NO. CS-11B**  
**SWEET LAKE/WILLOW LAKE SHORELINE PROTECTION**

**ORIGINAL DATE: May 14, 1998**  
**REVISED DATE: August 14, 2003**

Preface

Pursuant to a CWPPRA Task Force decision on August 14, 2003 to adopt the Coastwide Reference Monitoring System (CRMS-*Wetlands*) for CWPPRA, updates were made to this Monitoring Plan to merge it with CRMS to provide more useful information for modeling efforts and future project planning while maintaining the monitoring mandates of the Breaux Act. The implementation plan included review of monitoring efforts on currently constructed projects for opportunities to 1) determine if current monitoring stations could be replaced by CRMS stations, 2) determine if monitoring could be reduced to evaluate only the primary objectives of each project and 3) determine whether monitoring should be reduced or stopped because project success had been demonstrated or unresolved issues compromised our ability to actually evaluate project effectiveness. The recommendations for modifying this Monitoring Plan are the result of a joint meeting with DNR, USGS, and the federal sponsor. Specifically, monitoring of planted vegetation and SAV was discontinued, and in lieu of post-construction aerial photography in 2009 and 2016, DGPS surveys of the shoreline will be conducted to document shoreline position and change. These recommendations have been incorporated into this revised Monitoring Plan and are described in the Monitoring Elements section.

Project Description

The Sweet Lake/Willow Lake shoreline protection project is composed of approximately 6,000 ac (2428 ha) of open water and freshwater wetlands surrounding Sweet Lake and Willow Lake in northeastern Cameron Parish (figure 1). The project area is bounded on the south and west by the Gulf Intracoastal Waterway (GIWW), and on the north and east by Pleistocene prairie formations along La. Hwy. 384 and La. Hwy. 27.

Three soil types occur in the project area (U. S. Department of Agriculture, Soil Conservation Service [USDA/SCS] 1995; USDA/Natural Resources Conservation Service [USDA/NRCS] 1997). Allemands muck, a very poorly drained organic soil found in freshwater marshes, makes up 90% of the area. The remaining 10% consists of frequently flooded Aquents Series (6.0%) and Udifluents Series (3.6%) soils that comprise the dredged spoil along the GIWW.

The plant community in the project area is fresh marsh consisting mainly of *Sagittaria lancifolia* (bulltongue), with lesser amounts of *Panicum hemitomon* (maiden cane), *Scirpus californicus* (California bullwhip), *Spartina patens* (marshhay cordgrass), *Typha* sp. (cattail), *Phragmites australis* (common reed), *Colocasia esculenta* (elephant ears), and *Alternanthera philoxeroides* (alligator weed). A canopy layer of *Sesbania drummondii* (rattlebox), *Salix nigra* (black willow), *Sapium sebiferum* (Chinese tallow tree), and *Cephalanthus occidentalis* (buttonbush) is present on



higher ground in the marsh and on the remains of ridges formed by old levees and spoil banks in the area. Shallow open water areas support a number of aquatic plants, with stands of *Nelumbo lutea* (American lotus) and *Potamogeton diversifolius* (common pondweed) being the most conspicuous. *Eichhornia crassipes* (water hyacinth) is also prevalent, with large floating mats often developing in open water areas by the summer and fall seasons.

In the early 1900's, Sweet Lake and Willow Lake were essentially land-locked lakes surrounded by coastal freshwater marsh on the northern edge of the Cameron-Creole estuary (USDA/NRCS 1997). The introduction of water and sediment into the project area was influenced mainly by precipitation, local drainage, and wind and tide generated water exchange extending across the Cameron-Creole estuary from Calcasieu Lake through overland flow and small, meandering bayous. Marsh elevation was maintained through vegetative biomass production which compensated for losses caused by subsidence and sea level rise (USDA/NRCS 1997).

When the GIWW was constructed in the early 1900's, its route lay just south of the southern shorelines of both lakes, but the high energy associated with the navigation channel has and continues to impact the lakes and surrounding marshes. Erosion of the banks of the GIWW, caused by the water level drawdown effect and wave wash from the wakes created by passing boats and barges (Good et al. 1995), along with the widening and deepening of the channel from its original dimensions of 40 ft ( 12.2 m) wide x 5 ft ( 1.5 m) deep to 125 ft (38 m) wide x 12 ft (3.7 m) deep in the 1940's (United States Army Corps of Engineers [USACE] 1978) and subsequent erosion of its banks, has resulted in the breaching of the narrow strip of marsh and spoil bank between the canal and the southern shoreline of both lakes.

These hydrological connections have led to increased mechanical erosion of the lake shorelines and the surrounding organic marsh soils, followed by the suspension and transport of organic and mineral sediments from the lakes and surrounding marshes into the deeper water of the GIWW channel, resulting in a significant loss of fresh marsh in the project area. Such “blowouts,” where direct connections between a channel and inland water body form, exposing fragile organic marsh soils to high energy and increased erosion, are a common problem along navigation channels in coastal Louisiana (Good et al. 1995).

Land loss studies by Britsch (1994) indicate that in 1956, approximately 39 percent of the project area was classified as open water, and 61 percent was classified as fresh emergent marsh. By 1993, approximately 74 percent of the project area was classified as open water, and only 26 percent as fresh emergent marsh, most of which was deteriorated and converting to open water (Britsch 1994).

Between 1952 and 1975, the average shoreline erosion rate was 3.8 ft/yr (1.2 m/yr) at Willow Lake and 2.6 ft/yr (0.8 m/yr) at Sweet Lake (Adams et al. 1978). Between 1978 and 1990, this rate increased to 11 ft/yr (3.4 m/yr) along the northern and eastern shorelines of Willow Lake, and averaged 22 ft/yr (6.7 m/yr) along the Sweet Lake shoreline (Brown & Root 1992). Erosion rates for the GIWW shoreline are not available for this area. A major concern today is that the remaining marshes surrounding Sweet Lake and Willow Lake will eventually erode away, creating one large open water body, which could exacerbate shoreline erosion of the adjacent south bank of the GIWW

and the Cameron-Creole estuary marshes to the south (Louisiana Coastal Wetlands Conservation and Restoration Task Force [LCWCRTF] 1993).

The Sweet Lake/Willow Lake project plan includes structural and nonstructural measures designed to close off breaches of the north spoil bank of the GIWW into the lakes, provide shoreline protection along the GIWW adjacent to the lakes and along the north shoreline of Sweet Lake, and increase the acreage of emergent and submerged marsh in the project area as listed below.

1. Rock embankment along the north bank of the GIWW, 4,000 linear ft (1,219 m) adjacent to Willow Lake and 14,200 linear ft (4,329 m) adjacent to Sweet Lake, to partially close off the lakes to the GIWW.
2. Vegetative plantings of *S. californicus* along 24,300 linear ft (7,408 m) of the north shoreline of Sweet Lake to reduce shoreline erosion and attempt to capture suspended sediments. (See note 4.)
3. Construct 25,500 linear ft (7,774 m) of earthen terraces with two rows of vegetative plantings of *S. californicus*, one row on each side of the terraces), in an open-water area of deteriorated marsh north of Sweet Lake, to reduce further marsh deterioration caused by wind-driven wave erosion, and to protect and enhance the growth of submerged aquatic vegetation (SAV). (See note 5.)

#### Project Objectives

1. Protect emergent marsh in the project area by reducing shoreline erosion.
2. Increase the acreage of emergent and submerged aquatic vegetation (SAV) within the project area.

#### Specific Goals

The following goals will contribute to the evaluation of the above objectives:

1. Reduce the erosion rate along the Sweet Lake shoreline adjacent to the vegetative plantings of *S. californicus*.
2. Decrease the rate of marsh loss in the terracing/vegetative planting section of the project area.
3. Increase the coverage of emergent wetland vegetation and submerged aquatic vegetation (SAV) in the shallow open water areas in the terracing/vegetative planting section of the project.

## Reference Area

The importance of using appropriate reference areas cannot be overemphasized. Monitoring of both the project and reference areas provides a means to achieve statistically valid comparisons, and is therefore, the most effective way to evaluate project success. The main criteria for selecting reference areas are similarities in soil type, vegetation community, and hydrology.

The north shoreline of Willow Lake, and the open water ponds in the broken marsh northeast of Willow Lake (figure 1) were selected as the best reference areas available for the Sweet Lake/Willow Lake project. The predominant soil type in both the project and reference areas is Allemands muck (USDA/SCS 1995). The plant community in the proposed reference areas is essentially the same as the previously described fresh marsh found in the project area. All of these areas have experienced a similar loss of freshwater marsh due to boat-wake induced shoreline erosion along the GIWW, wind-driven wave erosion of lake and marsh shorelines, and the deterioration and erosion of the remaining emergent marsh.

The objectives of the Sweet/Willow Lake project are to protect emergent marsh in the project area by reducing shoreline erosion and to increase the acreage of emergent and SAV within the project area. Reference area 1, the unplanted north shoreline of Willow Lake (figure 1), will be monitored concurrently with the planted north shoreline of Sweet Lake (figure 1) to determine if shoreline erosion is reduced and if emergent marsh is protected by the plantings. Emergent vegetation and SAV will be monitored in the terracing/planting area north of Sweet Lake and the open water ponds in reference area 2 to determine the effect of the terracing and plantings on their relative abundance.

In addition, CRMS will provide a pool of reference sites within the same basin and across the coast to evaluate project effects. At a minimum, every project will benefit from basin-level satellite imagery and land:water analysis every 3 years, and supplemental vegetation data collected through the periodic Chabreck and Linscombe surveys. Other CRMS parameters which may serve as reference include Surface Elevation Table (SET) data, accretion (measured with feldspar), hourly water level and salinity, and vegetation sampling. A number of CRMS stations are available for each habitat type within each hydrologic basin to supplement project-specific reference area limitations.

## Monitoring Limitations

Consideration was given to monitoring shoreline erosion along the GIWW, behind the Sweet Lake/Willow Lake rock dike. However, comparisons of bank erosion behind the rock dike and other sections of the GIWW shoreline are not possible, primarily because the rock dike was constructed in open water where the original canal bank and the south shoreline of the lakes are gone. Also there is no additional large open water body contiguous with the channel that has similar site conditions and can be used as a reference area.

Consideration was also given to monitoring erosion along the shoreline surrounding the terracing/planting section of the project area. However, a reference area where the shoreline

protection effects from terracing/planting could be separated from the shoreline protection effects of the rock dike and the shoreline plantings is likewise unavailable.

### Monitoring Elements

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

1. **Aerial Photography** To document land and open water areas, and marsh loss/gain rates in the terracing/planting section of the project area and the terracing reference area, near-vertical, color-infrared aerial photography (1:12,000 scale) will be obtained in 1998 prior to construction. The photography will be processed by National Wetlands Research Center (NWRC) personnel using standard operating procedures documented in Steyer et al. (1995) for determining land-to-water ratios and corresponding acreage through GIS analysis. In addition, the length of the shoreline of Sweet Lake adjacent to the vegetation plantings will be determined using the most current aerial photography available at the time of construction. Shoreline length will be used to estimate marsh loss/gains along the Sweet Lake shoreline over time using shoreline erosion rates determined through Global Position System (GPS) shoreline surveys, as described below.

Photography originally scheduled for 2009 and 2016 was eliminated. Changes in land and water areas will be monitored through CRMS satellite imagery and shoreline change will be monitored through GPS shoreline surveys.

2. **Shoreline Change** To document shoreline movement along the Sweet Lake shoreline, GPS surveys of unobstructed sections of shoreline adjacent to the *S. californicus* plantings will be conducted at the vegetative edge of the bank to document the position of the shoreline in 1998 (pre-construction) and post-construction in 2004, 2009, and 2016. A similar survey will be conducted concurrently along a 1-mi (1.6 km) long section of the north shoreline of Willow Lake in reference area 1 (figure 1) for use as a reference. A survey monument established in the vicinity of the rock dike for construction purposes will be used to establish a GPS control point at the beginning and end of each day of surveying. GPS readings taken at this control point will be used as an accuracy check and for determining error associated with each GPS shoreline survey. GPS shoreline positions will be mapped and used to measure shoreline movement over the life of the project.

3. **Vegetation Plantings** The survival and general condition of the *S. californicus* plantings along the Sweet Lake shoreline will be documented by monitoring a 5% subsample of the plantings randomly selected from areas where GPS surveys will be conducted. Each sampling plot will consist of 16 plantings. The location will be marked with a labeled post. Within each sampling plot, survival will be determined as a percentage of the number of live plants to the number planted (percent survival = no. plants/no. planted x 100), after Mendelssohn and Hester (1988) and Mendelssohn et al. (1991). Survival will be monitored at 1 month postplanting in 2001 and in 2002. These data will be used to determine if the plantings have an effect on the Sweet Lake shoreline erosion rate, as compared with rates similarly estimated along Willow Lake shoreline in reference area 1, as described above. In order to determine planting success, and to estimate the amount (acreage) of emergent vegetation that becomes established on the terraces, random sampling plots will be established to include a 3% subsample of the *S. californicus* plantings on the terraces constructed in the open water area north of Sweet Lake. Plots will be randomly selected by numbering the plantings and randomly selecting plots based on these numbers. Each plot will include 16 plants, and consist of a rectangular section of terrace with eight plantings along each long side of the terrace section. The area of each plot will be determined by measuring the length and width of the terrace for each plot after construction is complete. Ocular estimates of percent canopy cover will be recorded for each plot. The percent cover for each plot will be broken down into the percent cover provided by the *S. californicus* plantings, by other wetland species, and by upland species. The terracing plantings will also be monitored postplanting in 2000.

Based on the CRMS review, monitoring of planted vegetation (originally scheduled for 2004, 2009, and 2016 both along the shoreline and on the terraces) was discontinued after 2002 (3-years post-planting).

4. **Submerged Aquatic Vegetation (SAV)** The rake method (Chabreck and Hoffpauir 1962; Nyman and Chabreck 1996) will be used to document changes in the relative frequency of SAV in the project and reference areas. Transects will be established in the shallow open water area north of Sweet Lake where the terraces and plantings will be installed. For comparison and use as a reference, transects will be similarly established in an open water area in the marsh northeast of Willow Lake. Open water areas will be sampled for presence or absence of SAV at 25 to 100 random points along each transect line, depending on the size of the



water body. Species composition and relative frequency of occurrence (frequency = number of occurrences/number of samples taken x 100) will be determined. Because extensive colonies of *Eichhornia crassipes* are likely to be present in the open water areas during the fall season, SAV will be monitored during the spring (April or May) in 2000 pre- construction.

Based on the CRMS review, SAV sampling originally scheduled for 2004, 2009, and 2016 was cancelled.

### Anticipated Statistical Analyses and Hypotheses

The following hypotheses correspond with the monitoring elements and will be used to evaluate the accomplishment of the project goals.

1. Aerial Photography. Descriptive and summary statistics on historical data (for 1956, 1978, 1988, and for any subsequent years) and data from aerial photography collected pre- and post-construction will be used, along with GIS interpretations of these data sets, to evaluate marsh to open water ratios and changes in the rate of marsh loss/gain in the terracing/planting section of the project area and the terracing reference area.

*Goal:* Decrease the rate of emergent marsh loss in the project area.

2. Shoreline Change. Descriptive and summary statistics will be used to compare measured rates of shoreline movement along the Sweet Lake shoreline adjacent to *S. californicus* plantings the project and reference area shoreline along Willow Lake between successive years. In addition, historical data sets will be used for statistical analyses of the long-term movement of these shorelines along the GIWW. Two sets of hypotheses will be tested to determine if the following project goal has been met.

*Goal:* Decrease the shoreline erosion rate along the Sweet Lake shoreline.

*Hypothesis:*

H<sub>0</sub>: Shoreline retreat rate along the project area at time point i will not be significantly less than the shoreline retreat rate along the reference area at time point i (where i = 1, 2, 3).  
i = 1 3 yr. 2004  
i = 2 3 yr. 2009  
i = 3 3 yr. 2016

H<sub>a</sub>: Shoreline retreat rate along the project area at time point i will be significantly less than the shoreline retreat rate along the reference area at time point i.

*Hypothesis:*

H<sub>0</sub>: Shoreline retreat rate along the project area at time point *i* will not be significantly less than the shoreline retreat rate along the project area in previous years (where *i* = 1, 2, 3).

H<sub>a</sub>: Shoreline retreat rate along the project area at time point *i* will be significantly less than the shoreline retreat rate along the project area in previous years.

3. Vegetation Plantings. The primary method of analysis for vegetation plantings will be to determine differences in mean vegetation cover as evaluated by an analysis of variance (ANOVA) that will consider both spatial and temporal variation and interaction. The ANOVA model used will be a BACI (Before-After-Control-Impact) type model, which will determine if there are detectable impacts in the project area after construction, (e.g., an increase in vegetation cover) in the project area after construction. A repeated measure design will be used in the ANOVA model. Multiple comparisons will be used to compare individual means across different treatment levels. All original data will be analyzed and transformed (if necessary) to meet the assumption of ANOVA (e.g., normality). When the H<sub>0</sub> is not rejected, the possibility of negative effects will be examined.

*Goal:* Increase the vegetative cover in the terracing/planting section of the project area (north of Sweet Lake).

*Hypothesis:*

H<sub>0</sub>: Vegetative cover within the project area after construction at time point *i* + 1 will not be significantly greater than vegetative cover within the project area after construction at time point *i* (where *i* = 1, 2).

*i* = 1 3 yr. 2000

*i* = 2 3 yr. 2002

H<sub>a</sub>: Vegetative cover within the project area after construction at time point *i* + 1 will be significantly greater than vegetative cover within the project area after construction at time point *i*.

4. Submerged Aquatic Vegetation (SAV). Nonparametric tests will be used to compare the frequency of occurrence of SAV within a given sampling period and over all sampling dates. Within a given sampling period, the Wilcoxon–Mann–Whitney Test will be used to test the hypothesis that there is no difference in the mean frequency of SAV in the project area and the mean frequency of SAV in the reference area, after Siegel and Castellan (1988:128! 37).

Over all sample dates, Repeated Measures Analyses will be used to compare the mean frequency of SAV between the project area and reference area (Steele and Torrie

1980:377! 437). These data are likely to require transformation because percentage data with ranges between 0 and 20 or between 80 and 100 often follow the Poisson distribution (Steele and Torrie 1980:234! 38). The square root plus 0.5 and the arcsin transformations are the most likely to correct heterogeneity of error associated with percentage data. Two sets of hypotheses will be tested to determine if the following project goal has been met.

*Goal:* Increase the mean frequency of occurrence of SAV in the terracing/planting section of the project area.

*Hypothesis:*

H<sub>0</sub>: Mean frequency of occurrence of SAV within the terracing/planting section of the project area after construction at time point *i* will not be significantly greater than the mean frequency of occurrence of SAV in the reference area after construction at time point *i* (where *i* = 1).  
*i* = 1 3 yr. 2000

H<sub>a</sub>: Mean frequency of occurrence of SAV within the terracing/planting section of the project area at any time point *i* will be significantly greater than the mean frequency of occurrence of SAV in the reference area after construction at time point *i*.

*Hypothesis:*

H<sub>0</sub>: Mean frequency of occurrence of SAV within the terracing/planting section of the project area after construction at time point *i* will not be significantly greater than the mean frequency of occurrence of SAV in the project area in previous years (where *i* = 1).  
*i* = 1 3 yr. 2000

H<sub>a</sub>: Mean frequency of occurrence of SAV within the terracing/planting section of the project area after construction at time point *i* will be significantly greater than the mean frequency of occurrence of SAV in the project area in previous years.

## Notes

1. The project will be constructed in two phases as follows:

Rock embankment:	Construction Start Date:	December 2, 1999
	Construction End Date:	January 27, 2000
Sweet Lake open water terraces:	Construction End Date:	November 1, 2001
Sweet Lake shoreline terraces:	Construction End Date:	September 2002
Willow Lake shoreline terraces:	Construction End Date:	September 2002
  
2. NRCS Monitoring Manager: Marty Floyd (318) 473-7690
  
3. DNR Project Manager: Melvin Guidry (337) 482-0680  
DNR Monitoring Manager: Mike Miller (337) 482-0662
  
4. The twenty year monitoring plan development and implementation budget for this project is \$161,249. Pursuant to the CRMS review, it was authorized by the Task Force to maintain \$126,419 with the project, and utilize \$34,830 to support CRMS. A progress report will be available in 2000. Periodic comprehensive reports on coastal restoration efforts in the Calcasieu-Sabine hydrologic basin will describe the status and effectiveness of the project as well as cumulative effects of restoration projects in the basin.
  
5. In May 1997, *Scirpus californicus* was planted along 4,000 linear ft of the northwest shoreline of Sweet Lake through the LDNR/NRCS/SWCC Vegetative Planting. The plantings were monitored under this program in July 1997, at which time survival was estimated to be approximately 90 to 95 percent. Therefore, this section of shoreline will not be planted or monitored as part of the C/S-11b project.
  
6. The terracing configuration illustrated in figure 1 is subject to modification during the design phase of this component to accommodate several existing buried pipelines that cross the construction site, and to allow for access routes required to mobilize and operate the necessary construction equipment.
  
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