State of Louisiana
Department of Natural Resources
Coastal Restoration Division and
Coastal Engineering Division

2004 Operations, Maintenance, and Monitoring Report

for

BRADY CANAL HYDROLOGIC RESTORATION

State Project Number TE-28
Priority Project List 3

May 2004
Terrebonne Parish

Prepared by:

Todd Folse, Biological Monitoring Section[1]
and
Brian Babin, Operations and Maintenance Field Engineer[2]

LDNR/Coastal Restoration Division[1]
LDNR/Coastal Engineering Division[2]
Thibodaux Field Office
1440 Tiger Dr., Suit B
Thibodaux, LA 70301

Suggested Citation:

Folse, T. and B. Babin. 2004. *2004 Operations, Maintenance, and Monitoring Report for Brady Canal Hydrologic Restoration (TE-28)*, Louisiana Department of Natural Resources, Coastal Restoration Division, Thibodaux, Louisiana. 39pp.

2004 Operations, Maintenance, and Monitoring Report
For
Brady Canal Hydrologic Restoration (TE-28)

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I. Introduction

The Brady Canal Hydrologic Restoration Project consists of 7,653-ac (3,097-ha) located in the Terrebonne Basin, within the Bayou Penchant-Lake Penchant watershed. The project is bounded by Bayou Penchant, Brady Canal, and Little Carencro Bayou to the north, Bayou de Cade and Turtle Bayou to the south, Superior Canal to the east, and Little Carencro Bayou and Voss Canal to the west (Figure 1).

The project area is bisected by the Mauvais Bois Ridge, which results in different hydrologic regimes to the north and south of the ridge. The northern section of the project area still receives freshwater and sediments which is provided through overbank flow from Bayou Penchant, Little Carencro Bayou, and Brady Canal. The Mauvais Bois Ridge forms a barrier to reduce the outflow of freshwater. Freshwater and sediment retention has diminished in the southern portion of the project area due to unimpeded throughflow and tidal exchange combined with a decrease in freshwater and sediment.

Land loss data show that during the period from 1932 to 1990, about 1,818-ac (736-ha) of land were converted to open water in the Brady Canal Hydrologic Restoration project area. Approximately 52% of the loss occurred over a 16 year period between 1958 and 1974. The average loss between 1932 and 1958 was approximately 18-ac (7.3-ha) per year while the average loss of 31-ac (12.5-ha) per year occurred between 1983 to 1990.

The increase of land loss in the project area was a result of major changes: (1) the hydrology of the Penchant Basin, both natural and human induced, was altered, (2) the natural levee ridge of Bayou de Cade had eroded below marsh elevation along the southern end of the project area, (3) higher salinity waters from the south began infiltrating the lower saline environment, (4) the tidal exchange at the southern end of the project area began to increase, and (5) there was a reduction in freshwater and sediment retention.

The original project proposal involved the installation and maintenance of canal plugs along with the repair, construction, and maintenance of levees, the construction and maintenance of different types of weirs, the construction and maintenance of a rock plug, the construction and maintenance of rock, earthen, and/or rock and earthen embankments as well as the construction and maintenance of stabilized channel cross-sections. The structures are designed to reduce adverse tidal effects in the project area as well as to better utilize available freshwater and sediment.

A subsequent project, Penchant Basin Plan (TE-34), was authorized encompassing the entire Penchant Basin which included the Brady Canal Hydrologic Restoration project. Due to the proposed features of the TE-34 project, two construction features for the TE-28 project were not constructed. The features included the northern most structure and the overflow banks along Brady Canal in the northern section of the project.

Construction of the Brady Canal Hydrologic Restoration Project began in August 1999 and was accepted on July 10, 2000. During this period, the following features were constructed: three fixed crest weirs with variable crest section(s), a fixed crest weir with barge bay, a fixed crest weir, two rock armored channel liners, a rock plug, and three different embankment types (rock armored earthen embankment, rock dike, and earthen embankment) (Figure 1).

Breaches along Bayou de Cade east of Jug Lake to Turtle Bayou were not closed during construction. In August of 2003, the Louisiana Department of Natural Resources (LDNR)–Coastal Engineering Division's (CED) Operation and Maintenance (O&M) Field Engineering section from the Thibodaux Field Office accepted the completion of a contract that closed the breaches along Bayou de Cade. These breaches were closed using rock rip-rap. Under this same contract, small breaches along Turtle Bayou and Superior Canal were closed using either earthen material or rock rip-rap.

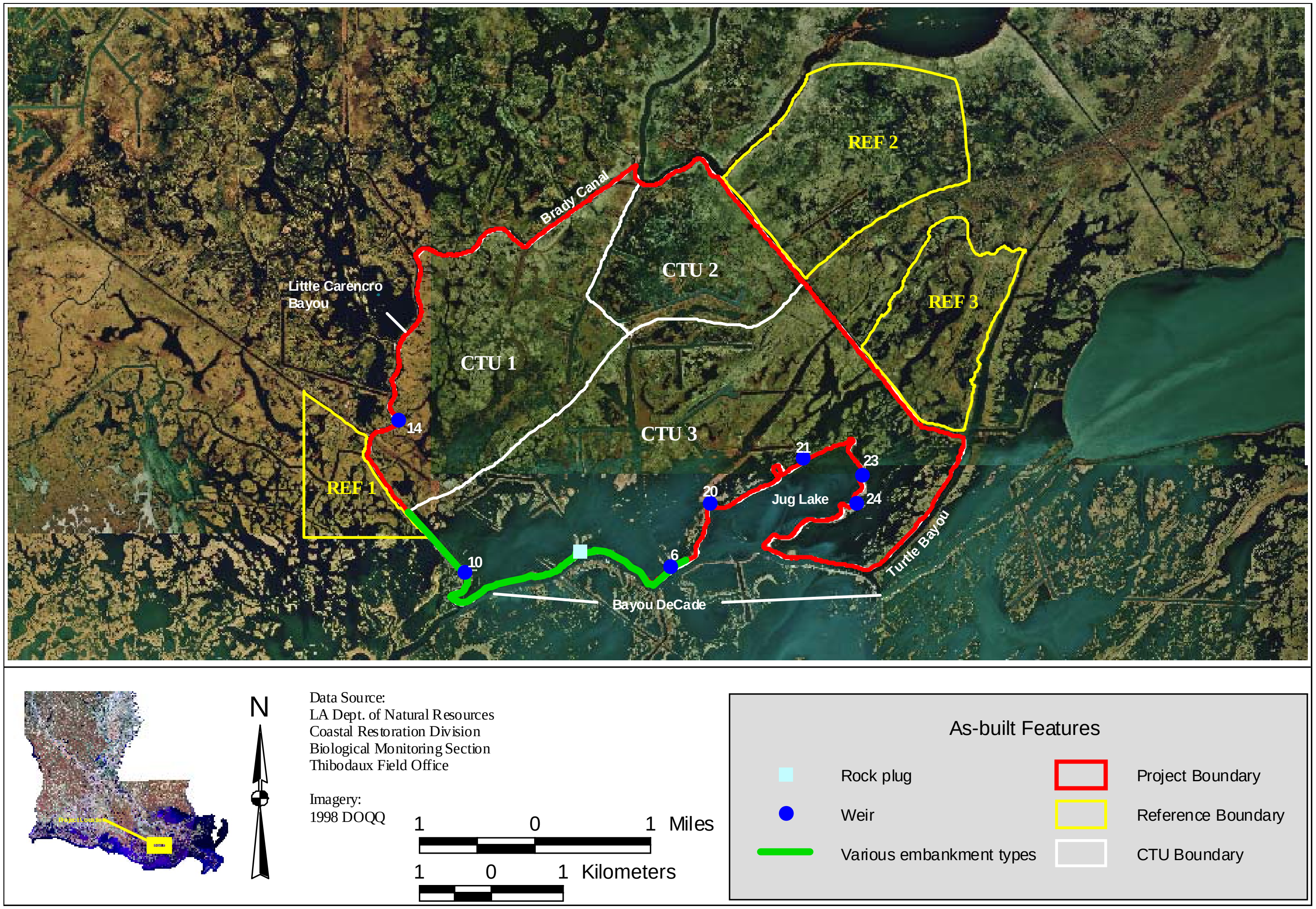

Figure 1. Brady Canal Hydrologic Restoration (TE-28) project boundary and features.

II. Maintenance Activity

a. Project Feature Inspection Procedures

The purpose of the 2004 Annual Inspection of the Brady Canal Hydrologic Restoration Project (TE-28) is to evaluate the constructed project features, to identify any deficiencies, and prepare a report detailing the condition of project features and recommended corrective actions, if needed. Should it be determined that corrective actions are needed, LDNR shall provide, within the inspection report, a detailed cost estimate for engineering, design, supervision, inspection, construction, contingencies, and an assessment of the urgency of such repairs (LDNR/CRD and Pyburn & Odom, Inc. 2002).

An inspection of the Brady Canal Hydrologic Restoration Project (TE-28) was held on February 17, 2004 under partly cloudy skies and mild temperatures. In attendance was Brian Babin and Shane Triche from LDNR, Brad Sticker and Dale Garber representing United States Department of Agriculture – Natural Resources Conservation Service (NRCS), Evance Adams with Burlington Resources and Lloyd Triche with Apache Corporation. All parties met at the Falgout Canal Marina in Theriot, La. The annual inspection began at approximately 9:30 a.m. on the east side of the project area near Turtle Bayou and ended at 1:30 p.m. on the west end of the project area at Little Carencro Bayou and Brady Canal.

The field inspection included a complete visual inspection of all project features. Staff gauge readings and existing temporary benchmarks were used to determine approximate elevations of water, rock weirs, earthen embankments, steel bulkhead structures and other project features. Hand held GPS units were used to mark low areas of rock dikes and earthen embankments which may require corrective actions or re-evaluation on future site visits.

b. Inspection Results

<u>Structure No.6 – Fixed crest weir with barge bay</u>

The overall physical condition of Structure No.6 appeared to be very good with slight erosion noted along the earthen wing-wall on the west side of the structure. It was determined that the erosion along the wing-wall was not serious and no corrective action will be taken other than re-evaluating the condition of the earthen wing-wall on future site visits. Navigational aids, warning signs and timber pile clusters were found to be in very good condition.

Structure No.7 – Rock Plug

The physical condition of Structure No.7 was very good with no noticeable signs of settlement along the length of the rock plug. The timber piles and warning signs were in good condition. No maintenance is planned for Structure No.7 in 2004.

Structure No.10 – Stabilization rock armored channel liner

The physical condition of Structure No.10 appeared to be very good with no noticeable settlement of the rock armor. The timber piles supports and signage were in very good condition. No maintenance is required as a result of the annual inspection.

Structure No.14 – Fixed crest weir with variable crest section

Upon a visual inspection of Structure No.14, we noticed that there was slight erosion on the earthen wing-walls of the structure. The erosion along the wing-walls is not significant enough to warrant maintenance at this time. However, it is recommended that erosion along the wing-walls be re-evaluated on future site visits. All signs and supports were in good condition.

Structure No.20 – Stabilization rock armored channel liner

Rock rip-rap channel liner appeared to be in very good physical condition with no noticeable settlement along the length of the structure. No maintenance is required at this time. All signs and timber supports were in good condition.

Structure No.21 – Fixed crest weir with three (3) variable crest sections

The variable crest weir structure appeared to be in very good physical condition. The earthen wing-walls were recently refurbished by the Apache Corporation under the in-kind services clause of the cost-share agreement. All signs and timber supports were in good condition. No maintenance is required.

Structure No.23 – Fixed crest weir with two (2) variable crest sections

The variable crest weir structure appeared to be in good physical condition with only slight erosion noted along the wing-walls of the structure. The earthen wing-walls will not require maintenance this year and should only be re-evaluated on future site visits. All signs and supports were in good condition.

Structure No.24 – Fixed crest weir

Upon visual inspection of Structure No.24, we noticed significant erosion along the earthen wing-walls. Although significant erosion was noted, the wing-walls are not breached and will not require maintenance at this time. However, it is recommended that the wing-walls be re-evaluated on future site visits. Water elevation at Structure No.24, at the time of the inspection, was approximately 0.7’ NAVD 88. All signs and supports were in good condition.

Photographs of the erosion around these structures are located in Appendix B of Babin (2004).

Earthen Embankments

The inspection of earthen embankments consisted of a visual inspection of recently repaired breaches performed under the 2003 Brady Canal Breach Repair Project and the Levee Refurbishment Project along Jug Lake which was completed in 2003, as well as an inspection of existing embankments and overflow banks making up the boundary of the Brady Canal Hydrologic Restoration Project. Below are the results of the earthen embankment inspections:

2003 Brady Canal Breach Repair Project

Breach 7 – Breach 7 was located along an existing oilfield canal off of Superior Canal. Due to the depth of the opening in the levee, rock rip-rap was used to close the breach. The rock riprap plug appeared to be in very good condition with no noticeable settlement. It was estimated from water level reading from a staff gauge set by Pyburn & Odom in 2003 at the intersection of Turtle Bayou and Bayou de Cade (water level: 0.0’) and that the rock plug was presently at an elevation of +3.5’ NAVD 88. No maintenance required.

Breach 8 – Breach 8 was approximately 200’ long located along Superior Canal adjacent to an existing pipeline right-of-way. This breach was repaired using dredge material from Superior Canal. The earthen embankment in this area was in good condition with thick vegetation present. No maintenance required.

Breach 9 – Breach 9 was approximately 250’ long located along Superior Canal near the bend. This breach was repaired using dredge material from Superior Canal. The earthen embankment in this area was in very good condition with no noticeable erosion or settlement. No maintenance required.

Breach 5 and 6 – Breach 5 and 6 consisted of a low area along the earthen berm of Turtle Bayou from the mouth of Superior Canal 1500’ southward.

This low area was refurbished using dredge material from Turtle Bayou. The overall physical condition of the refurbished levee in this area was in good condition. However, we did notice a slight cut bank along the entire length of the levee. The erosion along the cut bank is considered minimal and no maintenance will be required.

Breach 1 thru 4 - Breach 1 thru 4 consisted of a low lying bank along Bayou de Cade with large openings in the levee exposing the interior marsh. Due to the elevation of the existing bank line and the size of the openings in the levee, a rock dike was constructed along the length of Bayou de Cade from Turtle Bayou to Jug Lake. At the time of the inspection, the rock dike was in fair condition with several low areas along the length of the structure. We feel that the rock dike is not settling and the low areas are due to the fact that the design elevation of the rock dike was not achieved during construction. The rock dike appeared to be in fair condition and no maintenance will be required.

A map showing the locations of breaches repaired under the 2003 Brady Canal Breach Repair Project is located in Appendix A of Babin (2004). Also, Project Completion Report and As-built Drawings are available upon request.

Levee Refurbishment Project along Jug Lake

As a result of past inspections with representatives of LDNR, NRCS and the landowners, it was obvious that the existing levee along the west bank of Jug Lake was deteriorating at an alarming rate and would require immediate repairs. The landowner, Apache Corporation, agreed to contract the maintenance work using in-kind service credits authorized in the Brady Canal Cost Share Agreement. The contractor selected Berry Brothers General Contractors to perform the repairs. At the time of the inspection, the levee refurbishment appeared to be in good condition with thick vegetative cover. We did note significant cut banks along the front face of the levee. Due to extensive wave action in Jug Lake, this was expected. We feel that the refurbished earthen section is stabilized and no maintenance is required.

Existing Earthen Embankments and Overflow Banks

During the visual inspection of all earthen embankments and overflow banks which make up the boundary of the Brady Canal Hydrologic Restoration Project, we identified several locations which are considered to be low and at a high risk of potential breaching. We also located two (2) small breaches along Little Carencro Bayou. A decision was made by LDNR and NRCS agreed that the undertaking of such a project to repair two (2) small breaches would not be economically feasible. Therefore, it was determined that these areas would be closely monitored on future site visits to ensure that the breaches have not worsened. A map showing these areas is found in Appendix E of Babin (2004).

Rock Armored Embankments

Rock armored embankments along the north bank of Bayou de Cade and Voss Canal appear to be in good condition. However, the rock dike, without earthen embankments, along Voss Canal appeared to be experiencing moderate settling. We will continue to monitor this area in the future.

In-Kind Service Credits

Under Article II of the Brady Canal Cost Share Agreement, the landowners, Burlington Resources and Apache Corporation were granted in-kind service credits to repair existing earthen embankments within the project area. Below is a description of work and cost associated with the maintenance performed by Burlington and Apache:

In-kind Service Credits - Burlington Resources: In February 2003, Burlington Resources was granted in-kind service credits for the repair of two (2) large breaches along Little Carencro Bayou resulting from Hurricane Lili. The maintenance project consisted of the repair of a 133 ft. and 268 ft. breach in the existing overflow bank along Little Carencro Bayou. The maintenance project was completed on March, 15, 2003.

In-kind Service Credits - Apache Corporation: On September 3, 2003, Apache Corporation requested in-kind service credits for the removal of an existing dilapidated water control structure and refurbishment of approximately 3,100 linear ft. of earthen embankment along the west bank of Jug Lake estimated to cost approximately $35,000. Apache completed approximately 5,050 linear ft. of levee refurbishment and removed the existing structure along Jug Lake on October 31, 2003. Shaw Coastal, Inc. was tasked through LDNR to perform an as-built survey of the refurbished levee. This work was completed in November 2003.

In-kind Service Credits - Apache Corporation: As a result of Hurricane Lili, existing levee embankments along Turtle Bayou, Superior Canal and the west bank of Jug Lake were breached. Apache repaired these breached locations and were granted in-kind credits as reimbursement.

Brady Canal Breach Repair Project – LDNR: As a result of the 2002 Annual Inspection, a plan of action was prepared to repair deficiencies discovered during the inspection. LDNR tasked Pyburn & Odom, MCA to perform surveying, engineering and design and project oversight services to complete the maintenance project. This maintenance project included the installation of approximately 9,667 tons of broken stone riprap, 2,325 linear feet of earthen breach repair, and replacement of a timber pile on dolphin at structure no.6. Construction of the breach repair project was completed on August 13, 2003. A map showing the locations which were repaired under this construction contract are located in Babin (2004).

c. Maintenance Recommendations

With the exception of slight erosion along the spill slope of structures 6, 14, 23 and 24, two (2) small breaches located along Carencro Bayou, and the length of rock dike along Voss Canal which has settled slightly, the project features inspected are in good condition and no maintenance is required as a result of the 2004 Annual Inspection. However, it is recommended that the locations identified above be re-evaluated on future site visits to ensure that deficiencies are not impacting the performance of these structures.

This annual inspection was an evaluation of the physical integrity of the constructed project features and does not represent an analysis of the overall effectiveness of the project. Should monitoring data collected in the field show that the deficiencies outlined in the inspections results of this report are having an adverse affect on the performance of the project, the conclusions and recommendations concerning maintenance objectives may change.

III. Operation Activity

a. Operation Plan

The Operation, Maintenance and Rehabilitation Plan for the Brady Canal Hydrologic Restoration Project (TE-28) was jointly prepared and approved by the Louisiana Department of Natural Resources (LDNR), the Natural Resources Conservation Service (NRCS), Apache Corporation (formerly Laterre Co. Ltd.) and Burlington Resources. The intention of the Operation, Maintenance and Rehabilitation Plan for the Brady Canal Hydrologic Restoration Project (TE-28) is to maintain the constructed project features in a condition that will generally provide the anticipated benefits that the project was based on (LDNR/CRD and Pyburn & Odom, Inc. 2002). A cost share agreement was implemented and executed on June 17, 1998 between the government agencies and landowners involved, outlining the responsibilities and obligations of each party. The Brady Canal Project has a 20 year economic life which began in July 2000 at completion of the construction phase of the project. As a result of periodic field inspections since the completion of the project, several maintenance projects were identified and completed under the guidelines of the cost share agreement and O&M Plan. Below is a summary of completed maintenance projects undertaken since July 2000:

b. Actual Operations

Within the Brady Canal Project, structures no. 14, 21, and 23 are variable crest weirs and require active operations. The basic philosophy for operation of these project structures is to allow fresh water from the north to move into the project area and block southerly water fluctuations by keeping these structures as high as possible. During emergency and storm events, the stop logs in the variable crest weir structures should be removed to allow water out of the project area. Generally, during the fall (September 1) of each year, all stop logs shall be placed at a maximum elevation and during the spring (March 15) of each year, lower or remove stop logs to the natural channel bottom. This operation schedule may change once the Penchant Basin Project comes on-line and cuts in the southern portion of the project are repaired. Therefore, the operation of the variable crest weir structures shall be observed and revised as needed (LDNR/CRD and Pyburn & Odom, Inc. 2002).

The Brad Canal Project area is divided into Conservation Treatment Unit (CTU) #1, CTU #2 and CTU #3. Operation plans and procedures for CTU #1 are designed to stabilize water fluctuations. Operation plans and procedures for CTU #2 and CTU #3 are designed to expose mud flats for seed germination and planting. Once vegetative plantings are established, operation and procedures for CTU #3 are designed to gradually increase water levels to maintain and enhance vegetative growth (LDNR/CRD and Pyburn & Odom, Inc. 2002). Below is a description of the Operation and Water Management Schedule and Special Safety Provisions regarding operations of water control structures within the Brady Canal Project:

<u>Operation and Water Management Schedule</u>

CTU #1 — Structure No.14: Fall (September 1) of each year, set structures to maximum elevation. Spring (March 15) of each year, lower or remove stop logs to natural channel bottom.

CTU #3 — Structure No.21 and No.23: Fall (September 1) of each year, set structures to maximum elevation. Spring (March 15) of each year, lower or remove stop logs to natural channel bottom.

In accordance with the Operation and Water Management Schedule above, structures 14, 21, & 23 were adjusted twice a year (March and September) beginning in April 2002. Details of each operation period are documented in an Operations Report which can be obtained from LDNR – Thibodaux Field Office.

<u>Safety Provisions</u>

Storms: Immediately following heavy rain storms or storm tidal surges, all weirs shall be opened, to provide normal gravity drainage for the area as well as to protect the integrity of the levee system surrounding the project area.

Monitoring Activity

a. Monitoring Goals

The objective of the Brady Canal Hydrologic Restoration Project is two-fold: (1) to maintain and enhance existing marshes in the project area by reducing the rate of tidal exchange and (2) to improve the retention of introduced freshwater and sediment.

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

1. Decrease the rate of marsh loss.
2. Maintain or increase the abundance of plant species typical of a freshwater and intermediate marsh.
3. Decrease variability in water level within the project area.
4. Decrease variability in salinities in the southern portion of the project.
5. Increase vertical accretion within the project area.
6. Increase the frequency of occurrence of submerged aquatic vegetation (SAV) within the project area.

b. Monitoring Elements

Habitat Mapping

To document vegetated and non-vegetated areas, color infrared aerial photography (1:12,000 scale with ground controls) will be obtained. The photography will be photointerpreted, scanned, mosaicked, georectified, and analyzed by National Wetlands Research Center (NWRC) personnel according to the standard operating procedure described in Steyer et al. (1995). The photography was obtained in 1998 (pre-construction) and in 2002 (post-construction), and will be obtained in 2008 and 2017 (post-construction).

Salinity

To monitor salinities one continuous recorder is located in each CTU and reference area (Figure 2). One additional recorder is located outside the project area on Bayou Penchant where Brady Canal begins near a water control structure. Discrete salinities are measured monthly at five sites within each CTU and reference area. Salinity data has been collected from 1996-2000 (pre-construction) and from 2000-2003 (post-construction), and will continue through 2004.

Water Level

To monitor water level variability, one continuous recorder is located within each CTU and one recorder is located in each reference area (Figure 2). One additional recorder is located outside the project area on Bayou Penchant near a water control structure. Mean daily water level variability and duration and frequency of flooding will be compared between pre-construction and post-construction and also between project and reference areas. Water level data was collected from 1997-2000 (pre-construction) and 2000-2003 (post-construction), and will be collected through 2004.

Emergent Vegetation

Species richness and relative abundance are evaluated in the project and reference areas using the Braun-Blanquet method (Mueller-Dombois and Ellenberg 1974). Five stations were chosen within each CTU and reference area and replicate samples are collected at each station (Figure 3). Relative abundance will be documented in permanent plots to allow revisiting over time. Sites were sampled once in 1996 (pre-construction), 1999 (as-built), and in 2002 (post-construction) and will be sampled in 2004, 2006, 2009, 2012, and 2015 (post-construction).

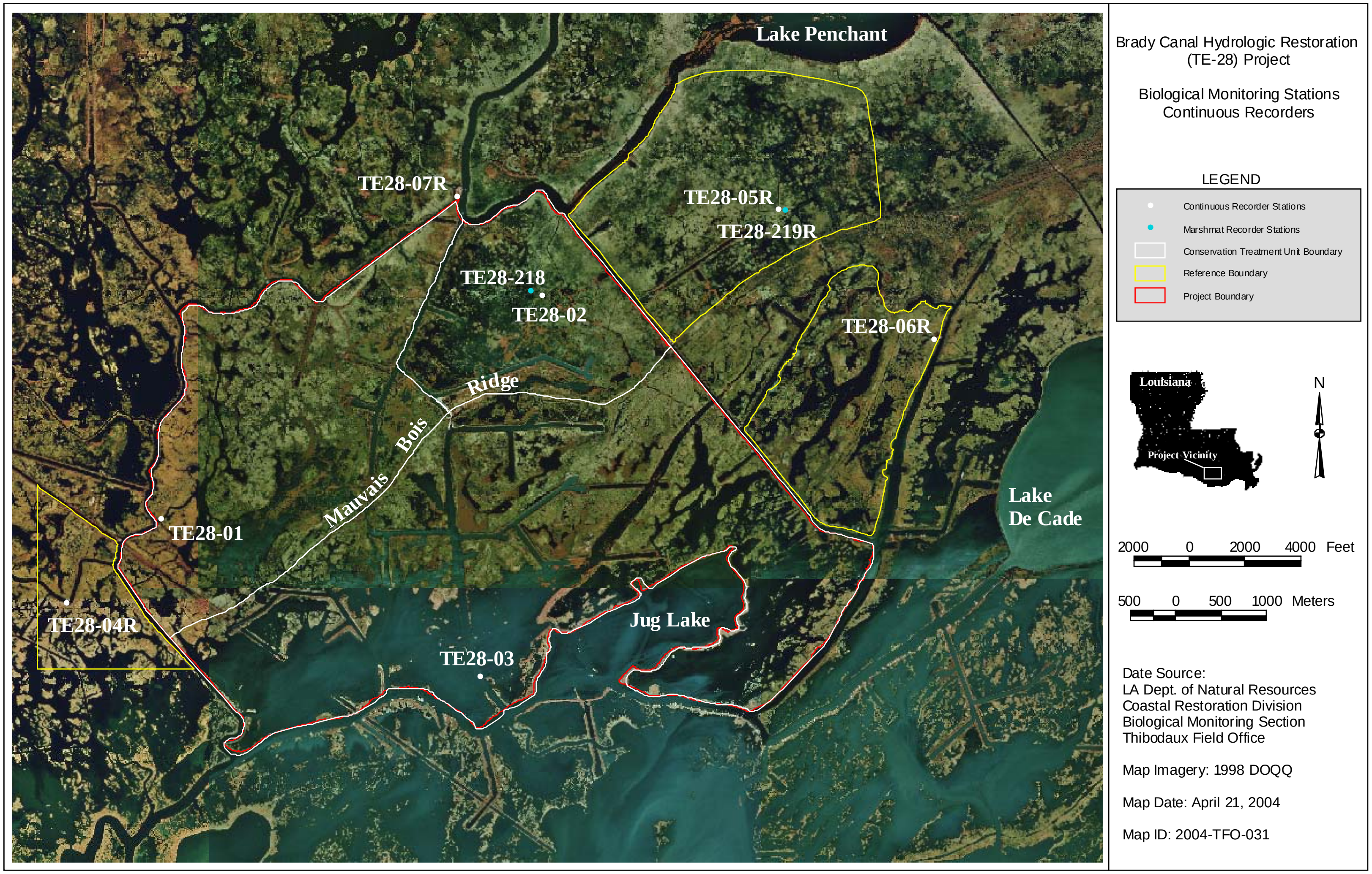

Figure 2: Location of continuous salinity and water level recorders in the Brady Canal Hydrologic Restoration (TE-28) project.

Accretion

Vertical accretion is determined in triplicate at each of the five representative stations within each CTU and reference area using techniques described in Steyer et al. (1995). The location of vertical accretion sites corresponds with the location of vegetation sampling sites (Figure 4). Sites were sampled in 1997/1998 (pre-construction), and in 2000/2001 (post-construction), and will be sampled in 2004, 2006, 2009, 2012, and 2015 (post-construction).

Marsh Mat Movement

To monitor marsh mat movement, one continuous recorder is located within CTU #2 and one recorder located in the paired reference area #2 (Figure 2). Mean daily water level variability and duration and frequency of flooding of floating marshes are determined for pre-construction vs. post-construction comparisons and also project vs. reference comparisons. Marsh mat movement data were collected from 1998-2000 (pre-construction) and 2000-2003 (post-construction) and will be collected through 2004 (post-construction).

Submerged Aquatic Vegetation (SAV)

The frequency of occurrence of SAV was compared between project and reference areas. Within the project (by CTU) and reference areas (Figure 5), 5 ponds were sampled during the Fall (October or November) in 1996 and 1999 (pre-construction) and in 2002 (post-construction) and will be sampled in 2006, 2012, and 2015 (post-construction). Methods described in Nyman and Chabreck (in press) will be used to determine the frequency of occurrence of SAV. Within each pond sampled, the presence/absence of SAV is determined at a minimum of 20 random points. Frequency of occurrence is determined for each pond from the number of points at which SAV occurred and the total number of points sampled. When SAV occurs at a point, the species occurring will be listed.

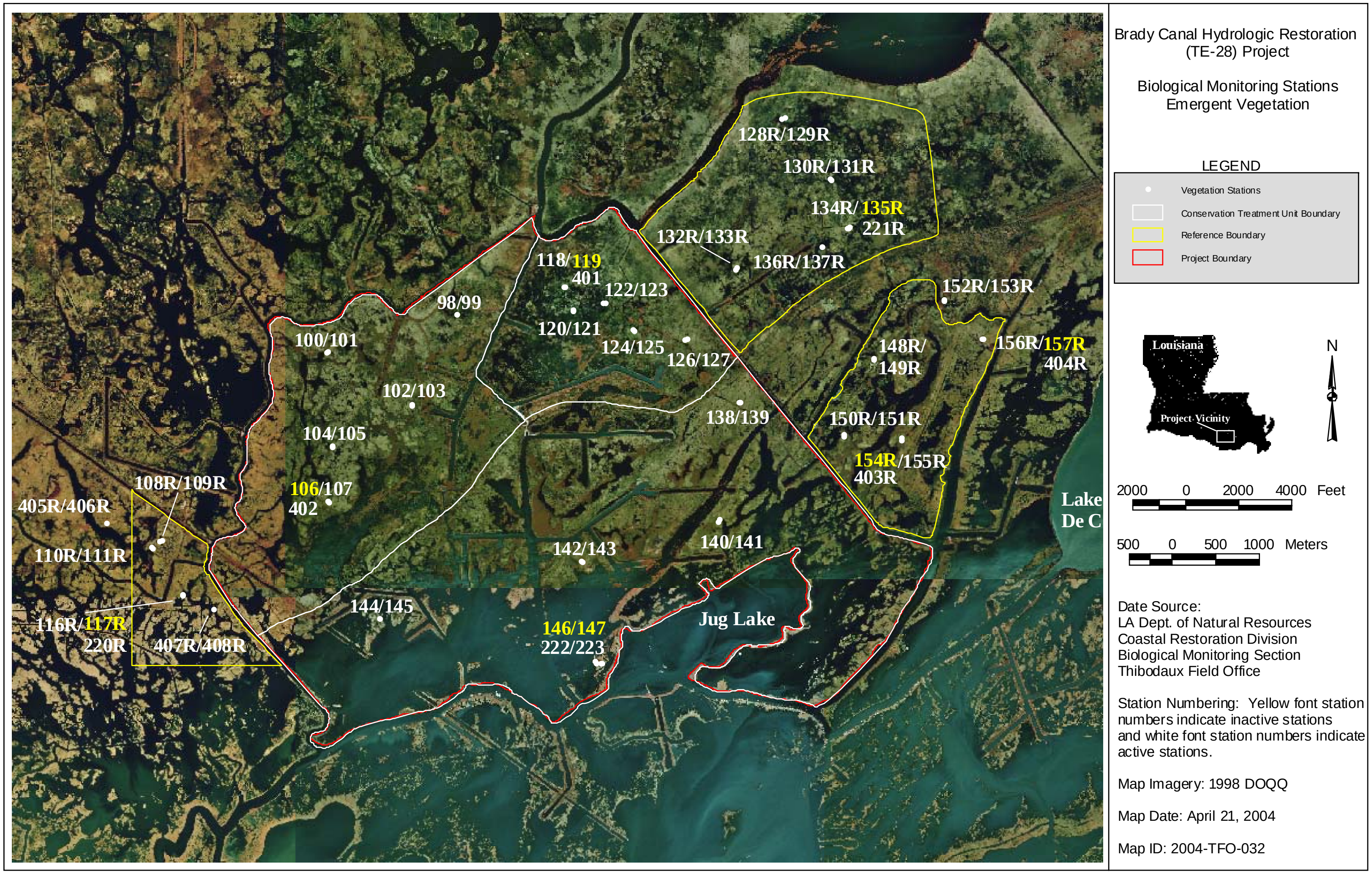

Figure 3: Location of emergent vegetation stations for the Brady Canal Hydrologic Restoration (TE-28) project.

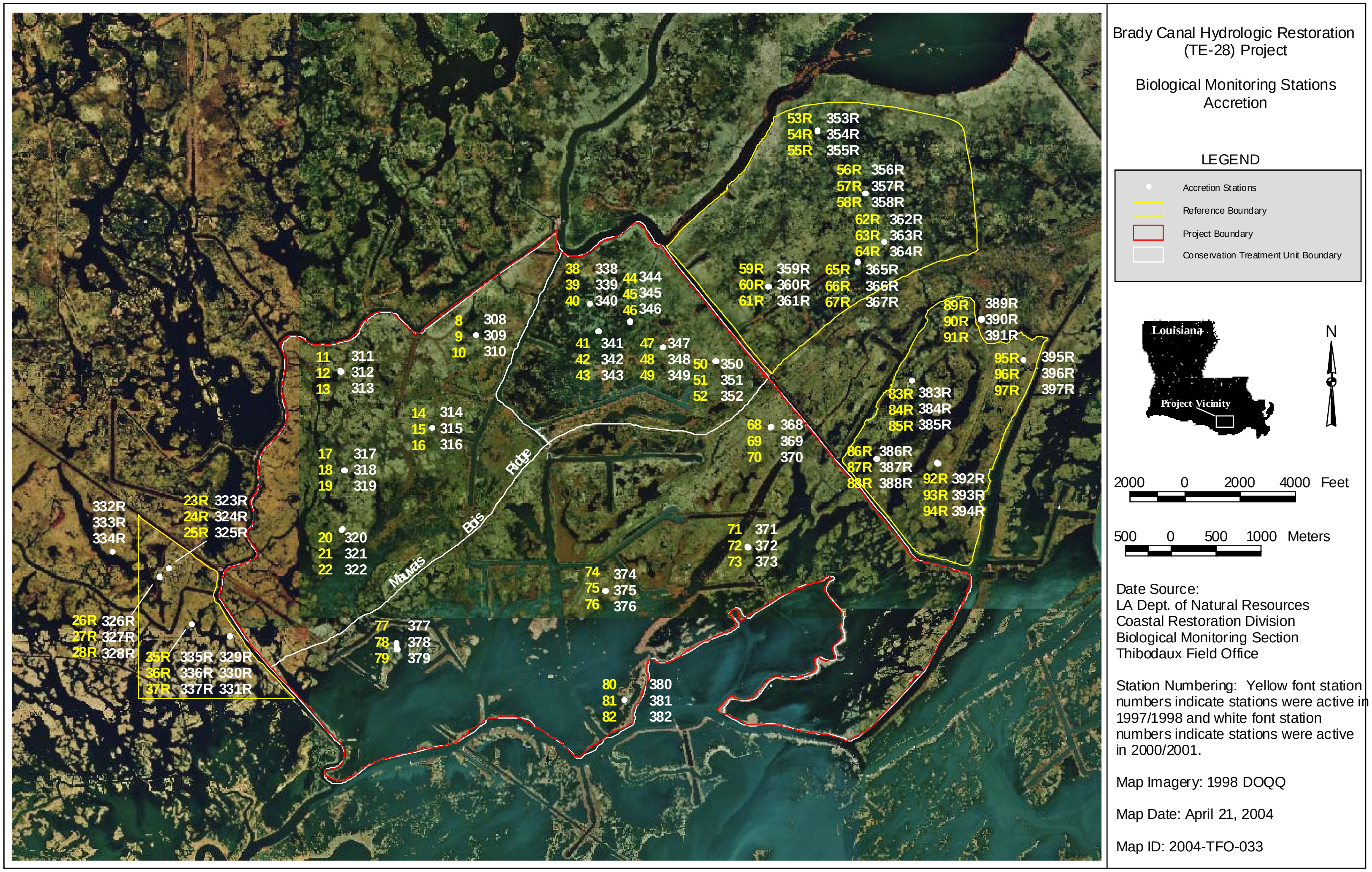

Figure 4: Location of accretion stations for the Brady Canal Hydrologic Restoration (TE-28) project.

Figure 5: Location of submerged aquatic vegetation stations for the Brady Canal Hydrologic Restoration (TE-28) project.

IV. Monitoring Activity (continued)

c. Preliminary Monitoring Results and Discussion

Habitat Mapping

Habitat mapping has not been initiated on the 1998 and 2002 aerial photography; consequently, any conclusions concerning the rate of marsh loss would be speculation. However, observations during the monthly field trips in 2003 showed the marsh had begun its recovery process from the impacts of Hurricane Lili in October 2002. The marsh loss associated with the hurricane is still evident, but additional impacts have not continued from ground observations.

Salinity

Mean weekly salinity concentrations at each continuous recorder station were used in a General Linear Model (GLM) with a Tukey-Kramer least square test for significance ($p<0.05$). Hourly readings were used to obtain the mean weekly salinity readings. Mean weekly readings were used to reduce the effects of diurnal tides that occur in the project area. Often times, tidal cycles span more than one day; consequently, analyzing data on a daily basis does not account for the tidal cycle. The data were analyzed two ways because of a drought that coincided with the beginning of construction and lasted eleven months after the completion of the project. The most severe portion of the drought occurred after the completion of the project; therefore, one analysis occurred with the data from the drought and the second analysis removed the drought data into its own category. This enabled a comparison of how the drought affected the area as well as allowing an unbiased analysis between the pre- and post-construction data. The dates for each analysis include pre-construction (1997 – August 1, 1999) and post-construction (July 11, 2000 – October 23, 2003) or pre-construction (1997 – August 1, 1999), drought (August 2, 1999 – June 5, 2001), and post-construction (June 6, 2001 – October 28, 2003). The Palmer Drought Severity Index and the U.S. Drought Monitor were consulted in the determination of the dates which the area was experiencing drought conditions. The area experienced the most severe portion of the drought during the post-construction phase.

Figure 6 shows the mean weekly salinity concentrations at each continuous recorder station have increased except for station TE28-07R between the pre- and post-construction data; however, only station TE28-06R has shown a significant ($p<0.05$) increase. Examining the figure also shows that the post-construction period experienced a higher degree of variability indicated by the standard deviation bars. When the interactions between all the stations and the time periods were analyzed, the results showed a significant increase in the salinity between the pre-construction (0.67ppt) and the post-construction (1.04ppt) time periods. This indicates that the entire region where the continuous recorders are located is increasing in salinity. Although the differences may be statistically significant, the biological response may not reflect the significance since the classification for both periods are within the brackish oligohaline category (0.5 – 5.0ppt).

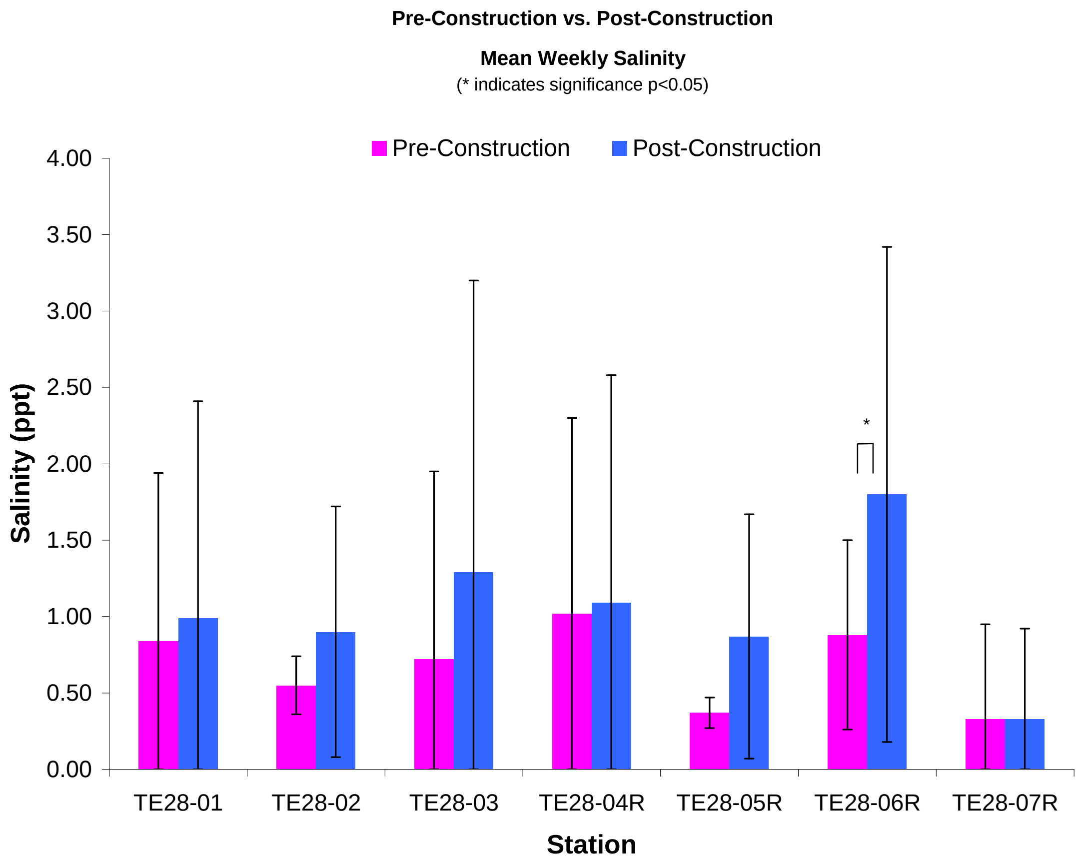

Figure 6: Mean weekly salinity ± standard deviation have shown an increase at all stations associated with the Brady Canal Hydrologic Restoration (TE-28) project; however, only station TE28-06R has had a significant increase.

Mean weekly salinity measurements were also calculated by separating the period of the drought. A GLM with a Tukey-Kramer least square test for significance was performed on the data which was separated into pre-construction, drought, and post-construction. Mean weekly salinity measurements during the drought were compared to the data collected prior to construction (pre-construction) and after construction (post-construction). The portion of the post-construction data that experience the drought was removed and placed in the drought category to examine the data without the influence of the drought. Once the mean weekly salinities were calculated, a GLM was performed to determine if the data were significantly different ($p<0.05$). For each station, significance was determined between pre- and post-construction, pre-construction and drought, and post-construction and drought categories. Several stations were significantly different between the pre-construction and drought and post-construction and drought, but no stations were significantly different between the pre- and post-construction periods when the drought data were removed. Therefore, the drought had a significant influence on the area; however, the project did not show a statistical significance between the pre- and post-construction data. Figure 7 shows the specific results of the GLM test with respect to the weekly means.

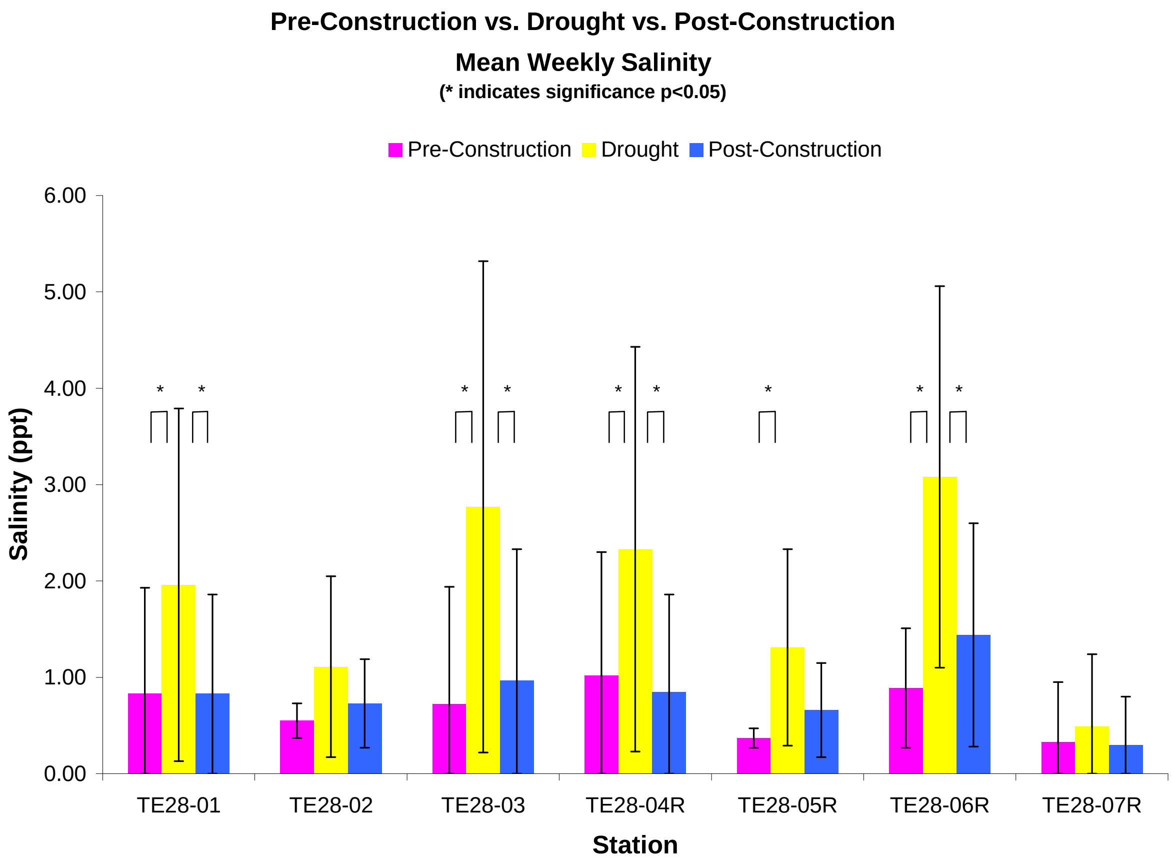

Figure 7: Mean weekly salinity ± standard deviation showing the effects of the drought as recorded at each continuous recorder in the Brady Canal Hydrologic Restoration (TE-28) project.

Even though the drought data have been removed from the post-construction data, the continuous recorders in the project area show an increase in the mean weekly salinity readings as well as an increase in the standard deviation. The increase may not be statistically or biologically significant; however, any time salinity begins to rise in an area concerns are warranted.

To test for variability, hourly salinity changes between each hour of recorded data were calculated. Analysis results from the pre- verses post-construction data set showed six of the seven stations were significantly different with each station showing a rise in the amount of change. The only station not showing a difference was TE28-07R. Analyzing the data with the drought category revealed three of the seven stations having a significant difference between the pre- and post-construction time periods (Figure 8). Every station showed a significant difference between pre-construction verses drought and post-construction verses drought except for TE28-05R. With the increase in the mean hourly change, the standard deviation also increased for each station during the post-construction period. GLM results of the interactions between the project's southern most stations (TE28-01 and TE28-04R; TE28-

03 and TE28-06R) revealed there were significant differences with the reference stations always being lower than the project stations. This indicates the project is different from the surrounding areas.

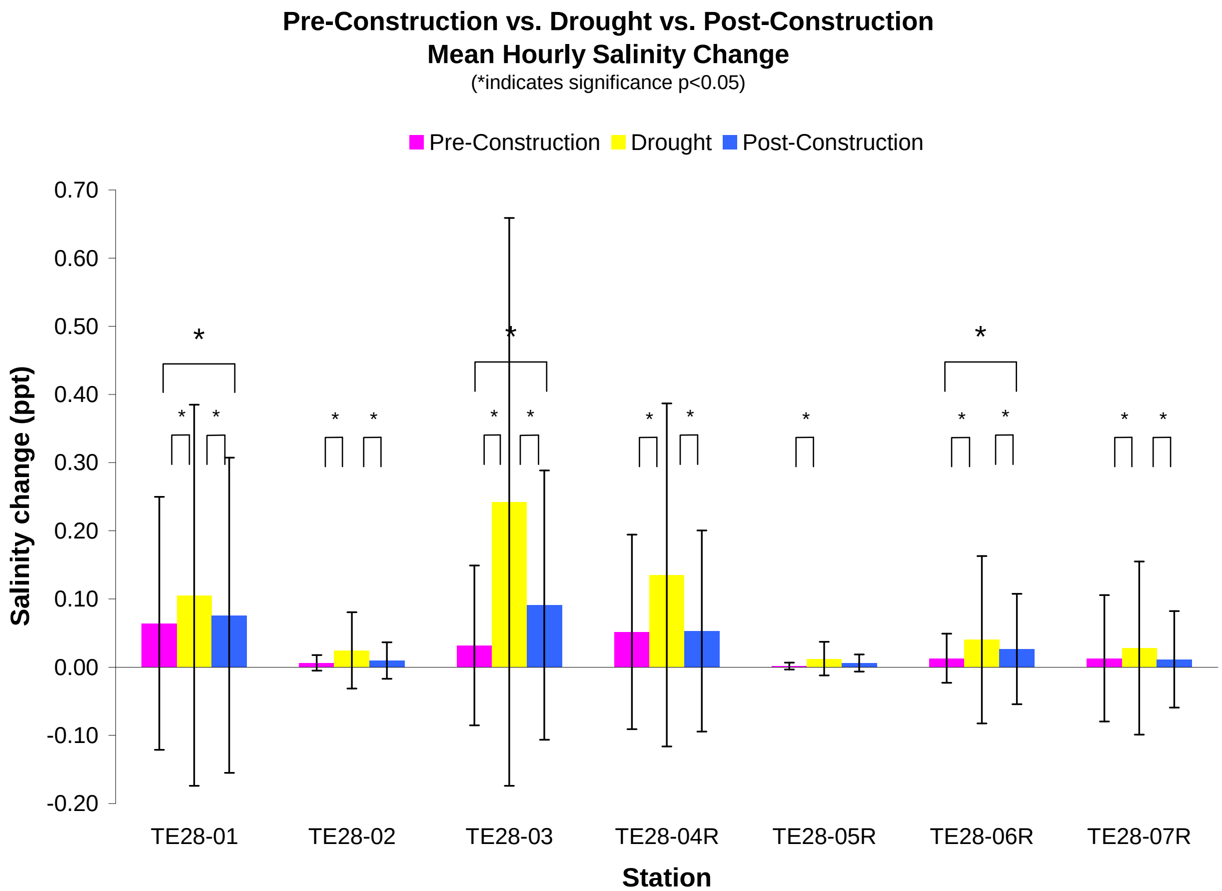

Figure 8: Mean hourly salinity change ± standard deviation at all continuous recorders associated with the Brady Canal Hydrologic Restoration (TE-28) project during pre-construction (March 1997 – August 1, 1999), drought (August 2, 1999 – June 5, 2001), and post-construction (June 6, 2001 – October 2003) periods.

Because station TE28-01 showed a significant increase in the mean hourly salinity change (Figure 8), the data for this station and its paired reference station were analyzed for operational structure affects. This station is located in the interior of the marsh where a variable crested weir was constructed as a part of the project feature. This structure is numbered site 14 in figure 1. Since the operation of the structure did not begin until April 2002, the data used for this analysis began with the first structure manipulation (April 11, 2002) and stopped with the latest available data (October 28, 2003) that has been processed for accuracy. Briefly, the operations plan for this structure calls for stop logs to be removed in March and added in September. For detailed structure operations refer to the operations activity section of this document. Results indicate that there is a statistical significance ($p<0.05$) between the stations, stop log position, and the interaction between the stations and stop log position (Figure 9). The overall mean salinity (Figure 6) has increased near the structure, but the mean salinity has remained the same when removing the data for the drought period (Figure 7).

Using a GLM, tests were performed between the structure and reference area, the positions of the stop logs, and the interaction between the structure and stop logs. The results (Figure 9) show significance between all three. Since the results have shown a significant difference between the structure and reference area and the position of the stop logs as well as the interaction between the structure and the stop logs, we can conclude that the structure does not effect the hourly salinity change.

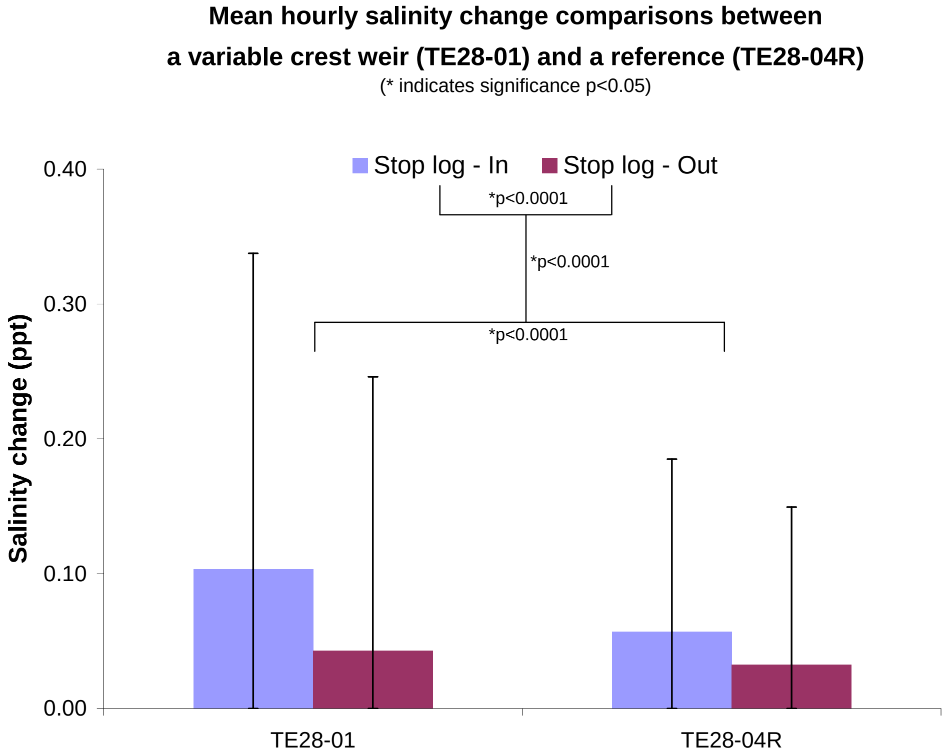

Figure 9: Mean salinity change comparison ± standard deviation between a continuous recorder station located near a variable crest weir structure inside the marsh (TE28-01) and a continuous recorder located in a bayou (TE28-04R) in the near vicinity of the structure but are not affected by the structure. Stop logs – in (September 15, 2002 – March 18, 2003 and September 10, 2003 – October 28, 2003) and stop logs – out (April 11, 2002 – September 15, 2002 and March 18, 2003 – September 10, 2003) were used to determine the affects of the weir on the variability of the salinity.

Water Level

Mean weekly water elevations (NAVD 88, ft) at each continuous recorder station were used in a GLM with a Tukey-Kramer least square test for significance ($p<0.05$). Mean weekly values were used to account for the diurnal tidal change that occurs in coastal Louisiana. Often times a tidal cycle may span two days and affect the daily means; thus, data were analyzed by weekly means. The weekly means were analyzed two ways: (1) pre-construction (without the construction period) verses post-construction and (2) pre-construction, drought, and post-construction.

Figure 10 shows all four reference stations and one project station (TE28-01) having a decrease in mean water levels after the completion of the project features. A test for significance among the pre- and post-construction weekly means resulted in only one station (TE28-05R) being statistically significant ($p<0.05$). Combining the water elevations within the project and reference areas and comparing the pre- and post-construction water levels reveal the water elevation in the project area did not change (1.27 ft, NAVD 88) while the reference area decreased (1.27 to 1.21 ft, NAVD 88).

With respect to the drought data, the water level was lower at all stations throughout the area and statistically significant between pre-construction verses drought and post-construction verses drought data except at station TE28-03. Test between the pre- and post-construction data with the drought data removed showed no statistical significance at any station; however, the mean water levels had increased at two project stations and one reference station (figure 11).

Hourly water level changes were calculated at each station (Figure 12). A comparison of pre- verses post-construction, pre-construction verses drought, and post-construction verses drought data shows a significant difference at six of the seven stations. Of the seven stations, only one station (TE28-01) showed a significant decrease in the mean hourly water level change.

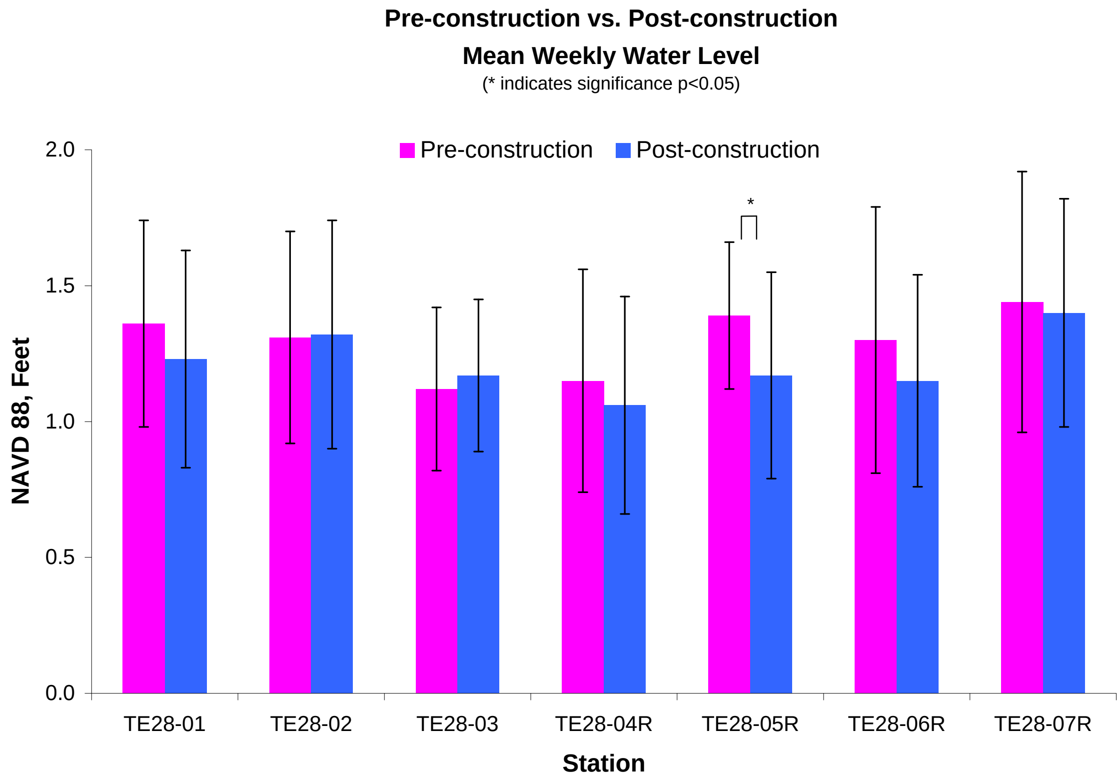

Figure 10: Mean weekly water level ± standard deviation at each of the continuous recorder stations associated with the Brady Canal Hydrologic Restoration (TE-28) project during pre-construction (March 1997 – August 1999) and post-construction (July 2000 – October 2003) periods.

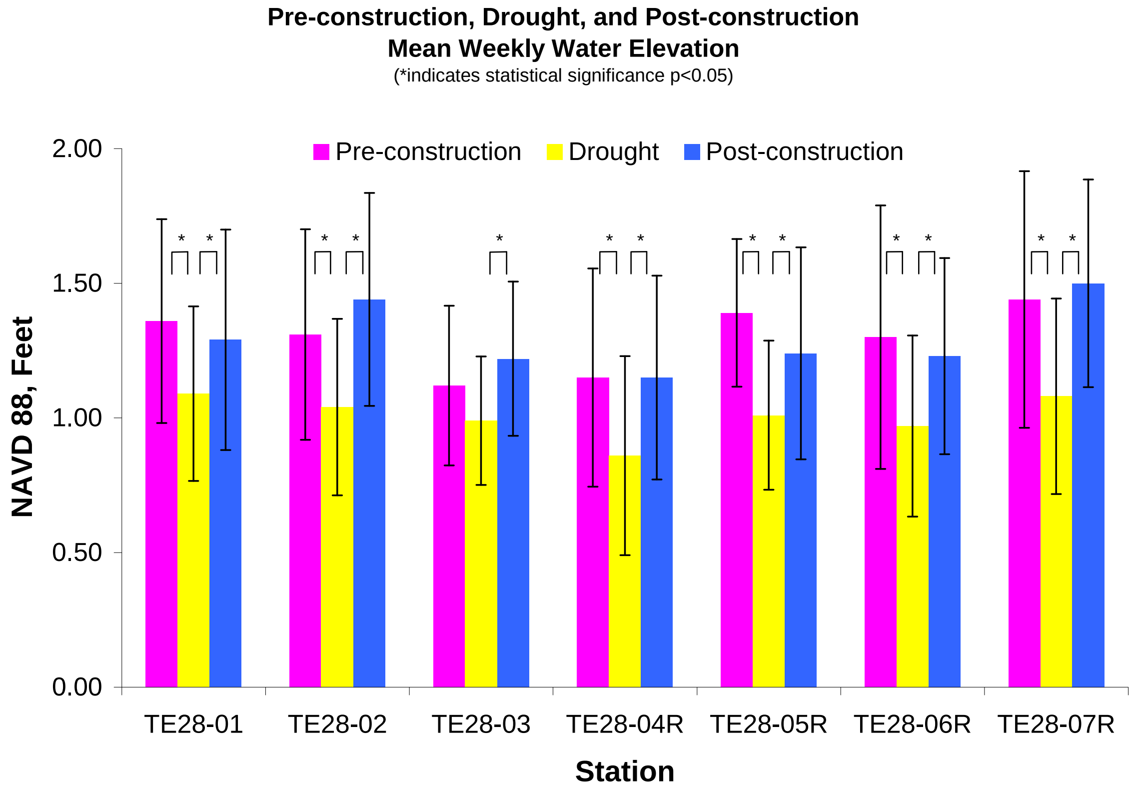

Figure 11: Mean weekly water elevation at each continuous recorder station with respect to pre-construction (1997 – August 1, 1999), the drought (August 1, 1999 – June 5, 2001), and post-construction (June 5, 2001 – October 28, 2003) at the Brady Canal Hydrologic Restoration (TE-28) project.

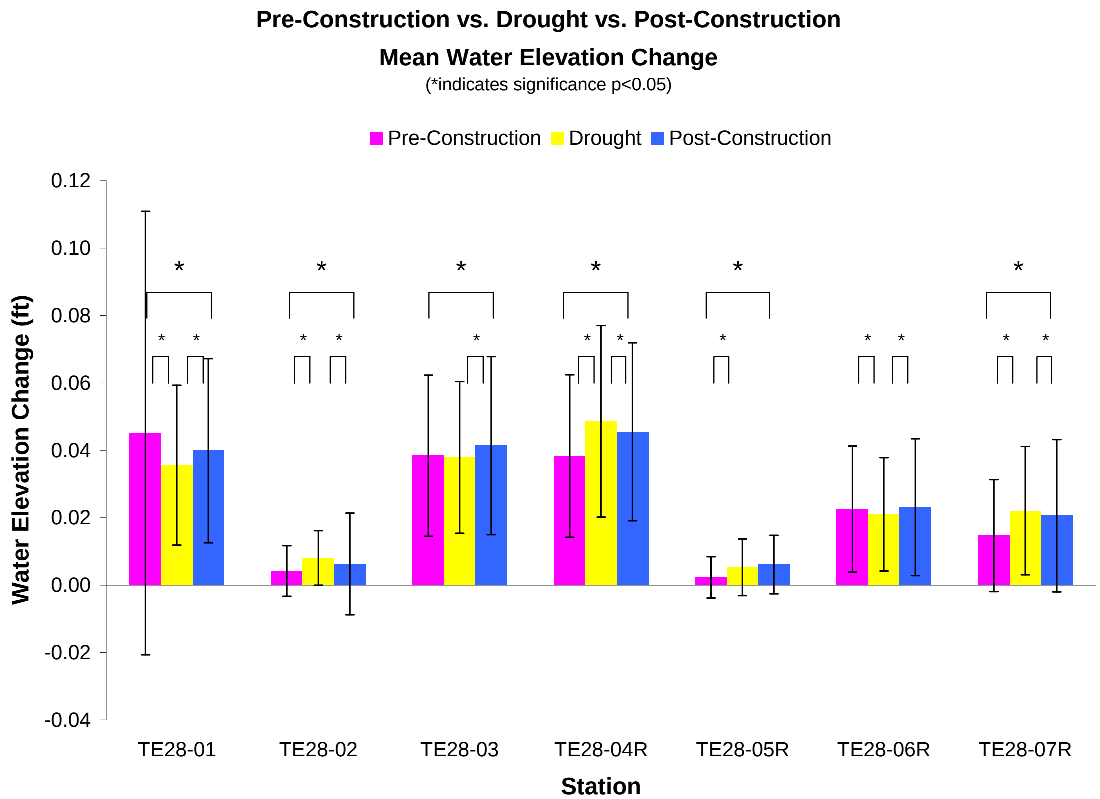

Figure 12: Mean hourly water level change ± standard deviation at each of the continuous recorder stations associated with the Brady Canal Hydrologic Restoration (TE-28) project during pre-construction (March 1997 – July 2000) and post-construction (July 2000 – October 2003) periods.

Using the water level change data, the data for stations TE28-01 and TE28-04R were analyzed even further to investigate the effects of the variable crest weir structure near TE28-01 on the water level change. The data were separated by "stop logs in" and "stop logs out." Since the structure was not operated until April 2002, all data prior to this date were not used in the analysis. The results showed a significant difference between the two stations and the stop log position; however, there was no significant difference between the interaction of the stop log and stations (figure 13). Consequently, the project feature(s) have not affected the variability of the water level at this particular station.

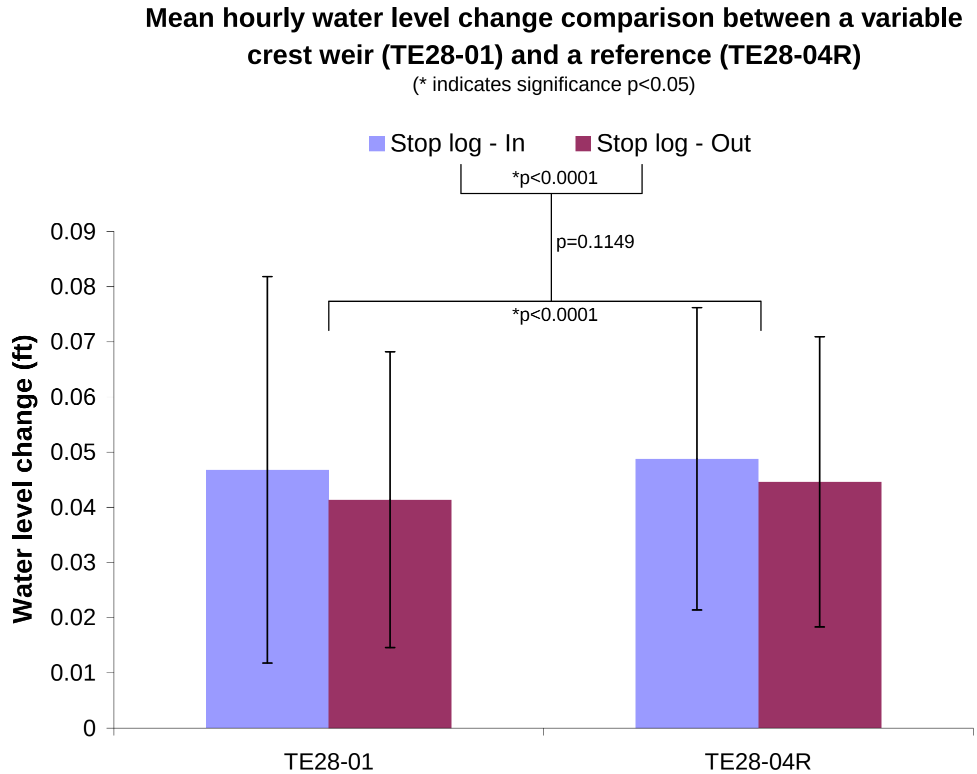

Figure 13: Mean water level change ± standard deviation comparison between a continuous recorder located near a variable crest weir structure inside the marsh (TE28-01) and a continuous recorder located in a bayou (TE28-04R) in the near vicinity of the structure but not affected by the structure. Data used for this analysis included stop logs – in (September 15, 2002 – March 18, 2003, and September 10, 2003 – October 28, 2003) and stop logs – out (April 11, 2002 – September 15, 2002 and March 18, 2003 – September 10, 2003) to determine the affects of the weir on the variability of the water levels.

Emergent Vegetation

The abundance of plant species has decreased from the pre-construction period to the post-construction period throughout the project and reference areas. Although statistical tests were not performed to show significance, regardless of the analysis, the conclusion would be that the 2002 sampling period occurred after the passing of Tropical Storm Isidore and Hurricane Lili which both had impacts to the project area. Figures 14-16 show the five (5) species with the highest relative mean cover common to all areas for years 1996 (pre-construction), 1999 (post-construction), and 2002 (post-construction).

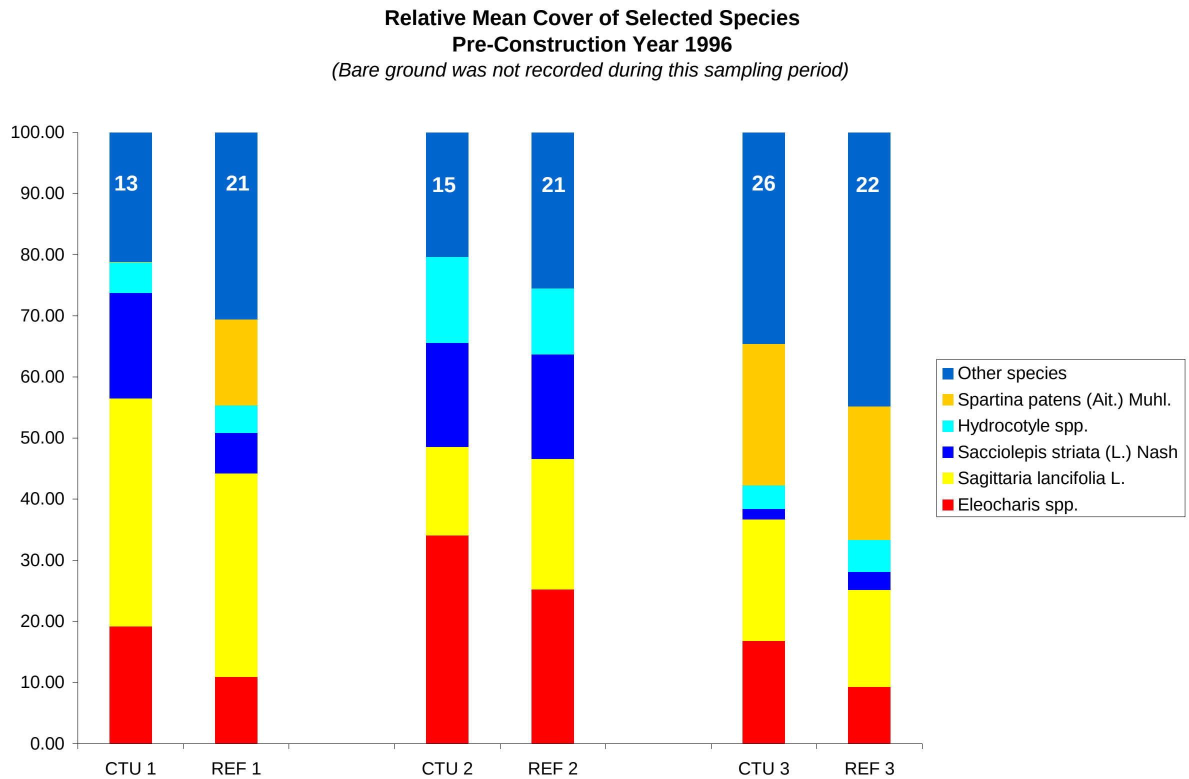

Figure 14: The relative mean cover of five selected emergent vegetation species at the Brady Canal Hydrologic Restoration (TE-28) project during the September 1996 pre-construction sampling period.

Within the other species category for the 1996 pre-construction sampling period, there were three other species that were present in an area with over ten percent relative mean cover; however, they were only present in one or two of the six areas. In reference area #1 *Vigna luteola* had a relative mean cover of 11.56. In CTU #3, *Vigna luteola* had a relative mean cover of 12.49. In reference area #3, *Polygonum hydropiperoides* had a relative mean cover of 19.92.

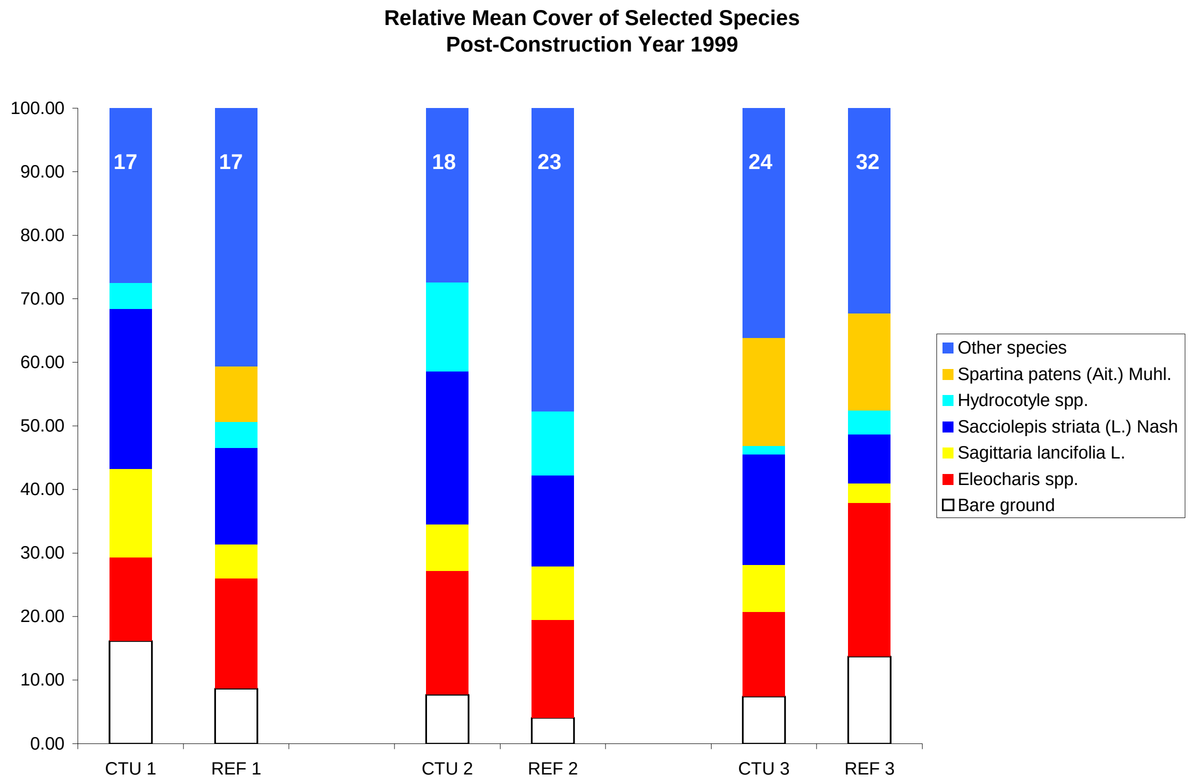

Figure 15: The relative mean cover of five selected emergent vegetation species at the Brady Canal Hydrologic Restoration (TE-28) project during the September 1999 post-construction sampling period.

Within the other species category for the 1999 post-construction sampling period, there were two other species that were present in an area with over ten percent relative mean cover; however, they were only present in two out of the six. In reference area #1 and CTU #3, *Schoenoplectus pungens* had a relative mean cover of 10.84 and 11.08, respectfully. In CTU #2 and reference area #2, *Leersia hexandra* had a relative mean cover of 10.28 and 21.52, respectfully.

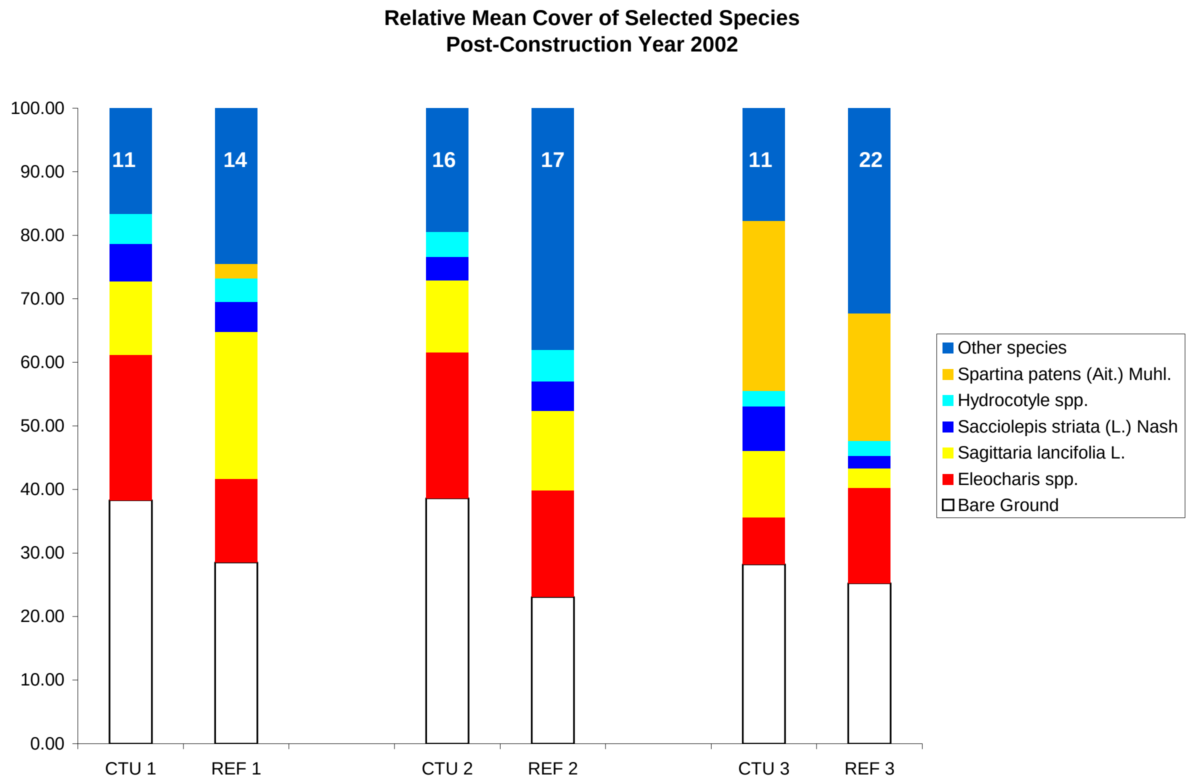

Figure 16: The relative mean cover of five selected emergent vegetation species at the Brady Canal Hydrologic Restoration (TE-28) project during the October 2002 post-construction sampling period.

Only two species had greater than ten percent relative mean cover in two different areas of the reference area in 2002. *Schoenoplectus americanus* had a relative mean cover of 11.02 in reference area #3, and *Leersia hexandra* had a relative mean cover of 14.24 in reference area #2.

In 1996, bare ground was not recorded as an individual category; therefore, the figure for the 1996 data collection period does not provide a relative mean cover. In 2002, the relative cover for bare ground more than doubled from the 1999 sampling period. This is a reflection of the two tropical systems that affected the project area. During monthly field trips prior to the tropical systems, field personnel can attest to the fact that the vegetation had covered more ground than what was observed during the data collection efforts for vegetation. Prior to the data collection efforts field personnel can attest that the percent bare ground was more in the line of the 1999 data collection period.

Accretion

Figure 17 shows that the rate of vertical accretion within the project area has decreased significantly ($p<0.05$) from the pre-construction sampling to the post-construction sampling. The decrease in accretion can be attributed to environmental conditions that the project and reference areas experienced during the sampling period. The post-construction sampling period occurred during a severe drought that lowered water levels (Figure 11) and increased salinities (Figure 7) throughout the area. Because of these conditions the marsh experienced little or no flooding which would have deposited mineral sediment on the surface. More importantly, it is believed that freshwater floating marshes, such as those in the project area, depend heavily on the production of biomass to sustain their ability to increase vertically. During this period, the lack of marsh flooding and increase in salinity concentrations may have reduced the productivity of the plants thereby reducing the marshes ability to vertically accrete. During the sampling period, the marker horizon (feldspar) was still visible on the surface 9-12 months after plot establishment.

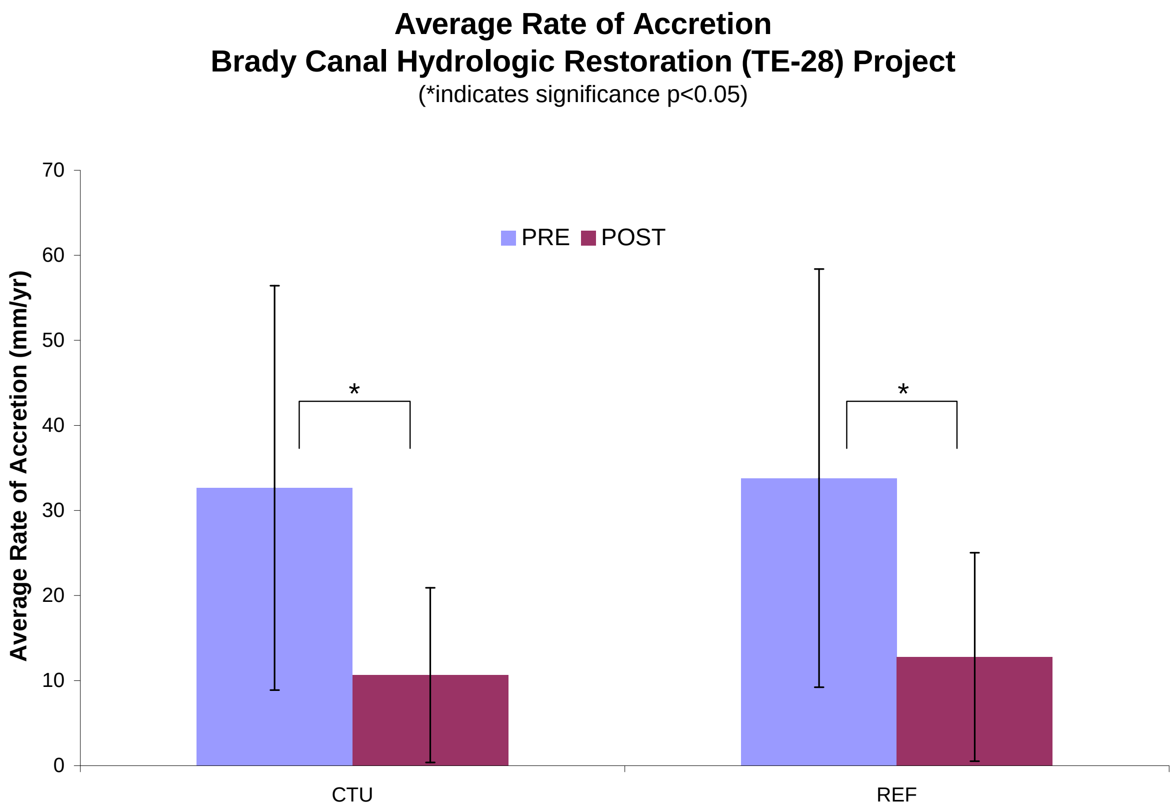

Figure 17: Average rate of accretion ± standard deviation showing significance between pre- and post-construction time periods in the conservation treatment unit (CTU) and reference area (REF).

Marsh Mat Movement

The vertical movement of the floating marsh was included in the monitoring elements to observe possible changes when the project was accepted by the Coastal Wetlands Planning Protection and Restoration Act task force. The project's initial purpose was to introduce more freshwater into the marshes in the northern portion of the project by lowering the bank elevation along the canals and bayous as well as modifying the structure where Brady Canal and Bayou Penchant meet. For simplicity, the project was constructed, but these features were not part of the final construction; however, monitoring of the floating marshes continued.

Figures 18 and 19 show the mean daily water and marsh surface elevations in CTU #2 and reference area #2. These graphs show the vertical movement of the water and marsh surface as well as the depth and duration of flooding. In January 2002, a decision was made to remove the marsh mat equipment at station TE28-219R which is the reference site since the marsh was not showing a comparable response to the changing water levels. Attempts were made to re-locate the instrumentation; however, a site was not found.

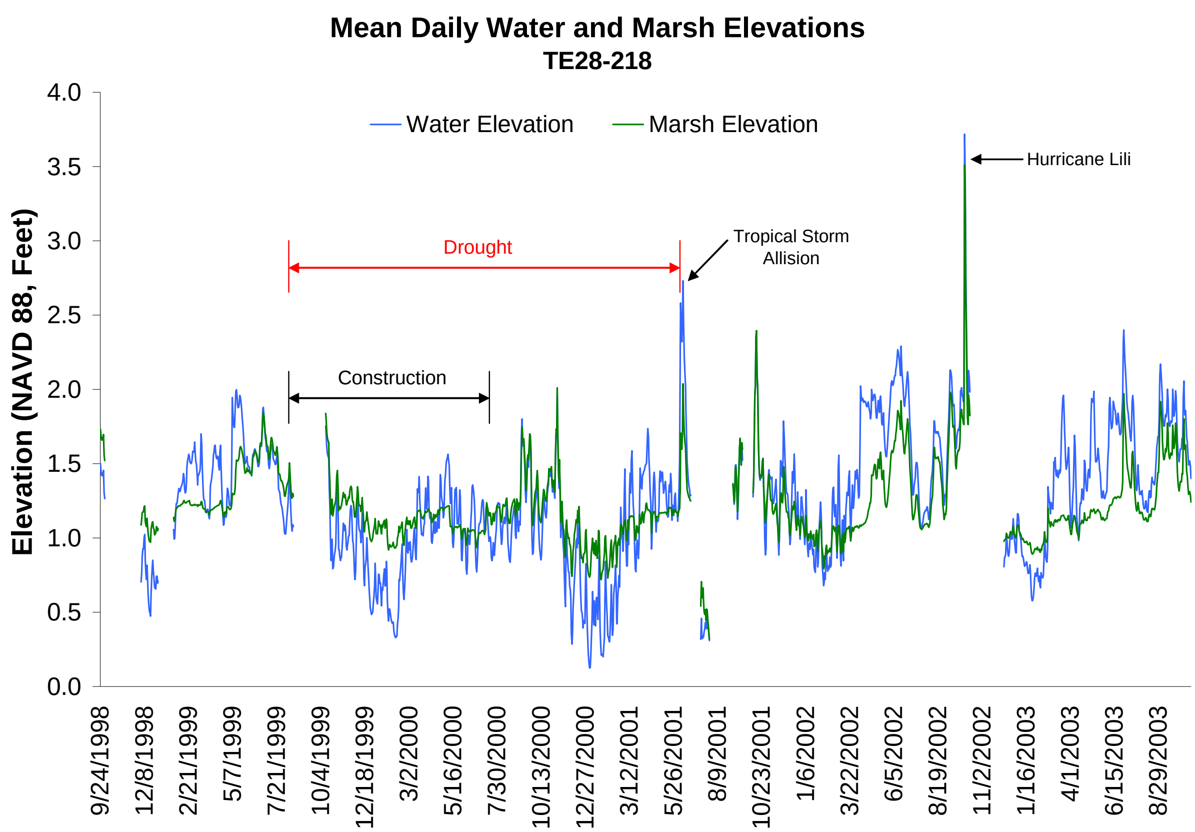

Figure 18: Mean daily water and marsh elevations in conservation treatment unit two at the Brady Canal Hydrologic Restoration (TE-28) project.

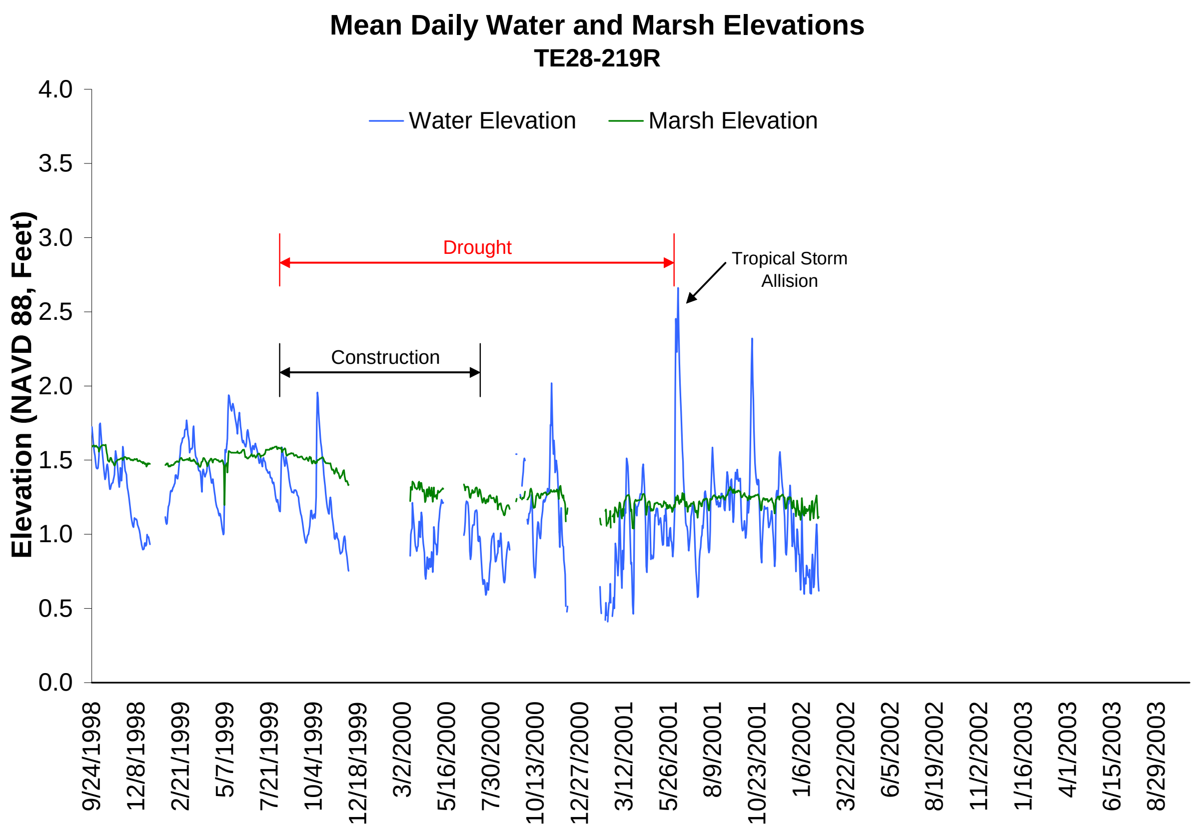

Figure 19: Mean daily water and marsh elevations in reference area two at the Brady Canal Hydrologic Restoration (TE-28) project.

Submerged Aquatic Vegetation

The frequency of occurrence of submerged aquatic vegetation within the project area has decreased from the pre-construction sampling period to the post-construction sampling (figure 20). Although it has decreased significantly, this decrease can be explained by the passing of Hurricane Lili prior to the post-construction sampling. This hurricane passed just weeks before the scheduled sampling period and affected the submerged aquatic vegetation as well as the emergent vegetation. During the pre-construction sampling period, the dominant species included *Ceratophyllum demersum*, *Najas guadalupensis*, *Nuphar lutea*, and *Nymphaea mexicana*. During the post-construction sampling period, the dominant species included *Ceratophyllum demersum* and *Nymphaea mexicana*.

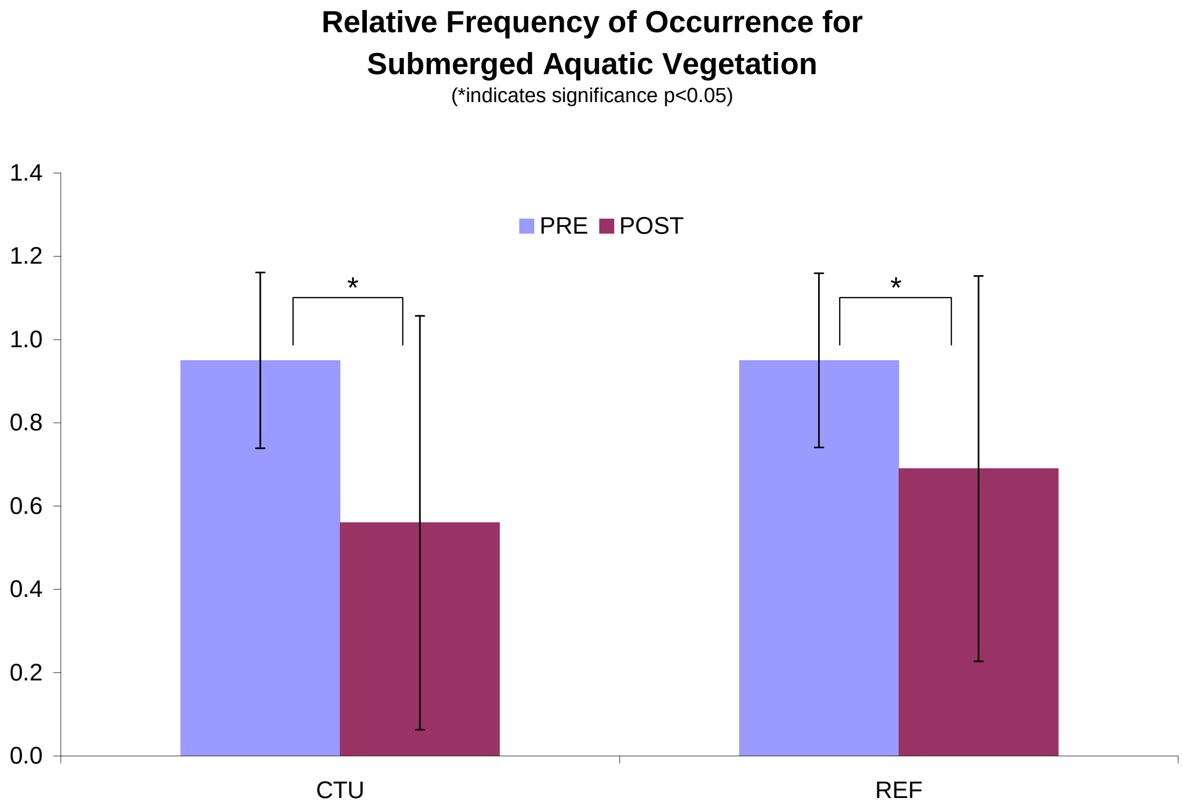

Figure 20: Relative frequency of occurrence for submerged aquatic vegetation ± standard deviation significance between the pre- and post-construction time periods in the conservation treatment unit (CTU) and reference area (REF).

V. Conclusions

a. Project Effectiveness

In general, the entire area has experienced an increase in the mean weekly salinity after the project was completed; however, a severe drought was experienced in south Louisiana which significantly increased the mean weekly salinity in the southern portion of the project area. Some stations during the drought did not experience a significant increase; however, the overall mean weekly salinity levels did increase. By removing the climatic affects of the drought condition from the data set, the data indicates that there is no statistical significance between the data collected before and after construction of the project features. Biologically, the mean weekly salinity readings have not increased enough to cause a dramatic change; however, the project and reference areas boarder on the edge of being classified as fresh (<0.5ppt) and oligohaline (0.5-5ppt).

The two stations in the southern portion of the project have shown a significant increase in the mean hourly salinity change between the pre- and post-construction periods when excluding the drought period data. Moreover, only one (TE28-06R) of the paired reference stations has shown a significant increase between the pre- and post-construction periods. The other reference station (TE28-04R) showed no change between the two time periods. Since station TE28-01 showed a significant increase, the data was analyzed to determine if the structure no. 14 was having an effect on the salinity change; however, the analysis revealed the structure was not having an effect with respect to the hourly salinity change. Explaining how the hourly salinity change has increased may be difficult since the hydrologic connection between structure no. 14 and the interior marsh seems to have been drastically reduced. Field observations after Hurricane Lili revealed large pieces of floating marsh were moved into the channel between structure no. 14 and the interior marsh ponds. Field observations during the spring and summer months have revealed thick rafts of water hyacinths (*Eichhornia crassipes*) growing in the open water areas between the structure and floating marsh that is blocking the channel. During the late summer, the water hyacinths are chemically sprayed by waterfowl lessees to gain access to the interior marsh ponds. These decomposing water hyacinths are settling to the bottom of the channel and possibly reducing the capacity of the channel.

The mean weekly water elevation has decreased at one of the three project stations; however, the reference stations have all shown a decrease in the mean weekly water elevation. The increase has occurred in the area where the embankments of Bayou Decade have been re-established. This could be an affect of the project since the water has only a few structures where the water can exchange. Prior to the construction of the embankment, the water would exchange along the entire southern end of the project. Once the project was completed, the water exchange only occurs through the structures.

A goal of the project was to decrease the water level variability in the project area. The mean hourly water level change has increased at the same two stations within the project as the mean weekly water elevation; however, the reference areas surrounding the project have shown increases at three of the four stations. With the increase of the mean hourly water level change in the reference areas, it is not conclusive if the water level change increased in the project as a result of the project construction features. The investigation of the variable crest weir at station TE28-01 shows no project affect and no variability change. Again, it appears that structure no. 14 is not having an effect on the water level variability. This may be attributed to the altered hydrologic connection between the structure and the interior marsh ponds as a result of Hurricane Lili.

One of the objectives of the project was to improve the retention of introduced freshwater and sediment. The data indicate that the retention of water may be occurring in the southern portion of the project by the increase in the mean weekly water elevations; however, the salinity data indicate that the water is more saline than the pre-construction data. One theory is that by the lack of freshwater introduction into the marshes and the project area from the north, the more saline waters south of the project are entering the project through weirs, barge bays, and armored channels. Without the adequate introduction of freshwater from the north, there is no flushing effect to reduce salinity spikes in the southern portion of the project. Instead, the saline waters are being held in the project area since the cross sections have been reduced with the construction of the embankment. With respect to the sediment portion of the project, the monitoring elements have not addressed this portion of the objective; therefore, no data has been collected with respect to sediment input. Through monthly field trips, there have been very few times when the water in the marsh has had an abundance of sediment in the water column.

Emergent vegetation, accretion, and submerged aquatic vegetation conclusions can not be made with certainty considering the environmental conditions the project and reference areas experienced during sampling. A month prior to the vegetation and submerged aquatic vegetation sampling for the post-construction period (2002) the area experienced a tropical storm and hurricane that drastically affected the area. During the data collection efforts concerning accretion, the entire state was experiencing a drought which may have affected the amount of sediment and biomass production that contributes to the accretion process. Any conclusions drawn from the data collection efforts would be more environmental and not a direct result of the constructed project features; therefore, no conclusions will be drawn as to how the project features have affected the emergent vegetation, accretion, and submerged aquatic vegetation in the project area.

b. Recommended Improvements

When using habitat mapping as a monitoring element, protocols shall be formulated to acquire the final product in a timely period.

As outlined in the conclusion of this report, there are many questions as to whether the goals and objectives of the project are being accomplished. This project is classified as a Hydrologic Restoration (HR) project and was implemented within the first few years of the CWPPRA program. Under the current design criteria, this type of project would have been designed with the aide of a hydrodynamic model. Considering the above, and if Engineering and Biological monitoring results indicated that the project was not producing the predicted or desired results, further investigations of the water flow patterns would be warranted. Hydrologic assessment should be conducted to determine if there are specific structures or existing topographic features that may be compromising the goals of the project. Additional surveys, calculations, and flow measurements may be required to properly evaluate flow patterns within the project boundary. In the event this target analysis of the systems features does not identify specific problems associated with the systems functionality, a more detailed Hydrodynamic model may be warranted. In this event, care should be taken selecting the model to insure that information developed is compatible with other modeling efforts that have been, or will be, conducted in the project basin.

It is also recommended that a planting program be developed to assist in the protection of existing earthen embankment features. Embankments constructed of earthen materials in this area are often exposed to excessive wave action causing cut banks and erosion of the project boundaries. An active plantings program would help reduce the operation and maintenance effort and cost of refurbishing existing earthen embankments.

c. Lessoned Learned

Monitoring plans should not include specific years for acquiring data. Previously, specific years were used to formulate project specific monitoring budgets; however, monitoring is transitioning towards a coast-wide approach through the Coast-wide Reference Monitoring System – *Wetlands (*CRMS-*Wetlands).* Consequently, monitoring plans could potentially incorporate years after construction rather than specific years. This would alleviate the problem where the years within the monitoring plan do not coincide with the construction of a project since many projects are not constructed during the estimated time when the monitoring plan was assembled.

When two CWPPRA projects have overlapping project boundaries, significant project components of one project should never be compromised in anticipation that the planned feature could be installed in the second project. In the case of the Brady Canal Hydrologic Restoration Project, the planned water control structure at the intersection of Bayou Penchant and Brady Canal, and the degradation of the existing overflow banks along Little Carencro were not constructed with the intention that these features could be evaluated further and constructed at a later date under the Penchant Basin Project. These project components mentioned above are essential elements for achieving the project objective to improve the introduction and retention of freshwater and sediment. On future projects, the overall goals and objectives of these type projects may require that the project be reevaluated should planned project features be eliminated during construction.

Project specific monitoring should be reevaluated at the conclusion of the construction phase. On this project the measurement of accretion was proposed, budgeted, and accepted due to the anticipation of an influx of freshwater and sediment from the Bayou Penchant / Brady Canal structure; however, some originally proposed features were not constructed. The collection of accretion data, particularly in the northern reaches of the project, is not providing information with respect to how the project has improved the retention of sediment and freshwater. Additionally, the monitoring in the northern portions of the project has little to no relevance to the project features that were constructed. Once construction was completed the monitoring plan should have been evaluated to discuss how monitoring should have changed in order to answer more specific questions regarding those features that were constructed.

As monitoring transitions towards CRMS-*Wetlands*, monitoring personnel and field engineers need to coordinate investigations of the interior marshes. With the transition and implementation of *CRMS-Wetlands,* monitoring personnel no longer have a regular presence in the project areas. Investigations need to be conducted to verify that the hydrologic connection between the interior marsh and the water control structures remains the same in order for the structures to perform as they were designed. Previous trips have revealed that tropical activity and floating aquatic vegetation seem to have altered the hydrologic connection at various places throughout the project.

Goals and objectives may need to be more specific with respect to target salinity and water levels. Instead of using the terminology “decreasing variability” or “increase” there should be some targets that are incorporated into the goals and objectives. When data are analyzed to determine if the project has met the goals and objectives it is often times hard to answer the question with a definitive answer. This problem arises because the analysis may indicate a statistical significance; however, there may not be an ecological significance. Often times the data must be investigated to see if there is an ecological significance is more important than a statistical significance.

Hydrologic restoration projects consisting of one or more water control features require a defined hydrologic barrier surrounding the project in order to effectively channel water in and out of the project through targeted areas. Unfortunately, after the completion of the Brady Canal Project, large gaps and breaches along Bayou Decade between Jug Lake and Turtle Bayou remained open allowing high saline waters to infiltrate the project area. However, to address this problem, a maintenance project was completed in August 2003 to close these large gaps as well as other openings in the hydrologic barrier along Turtle Bayou and Superior Canal.

In the special conditions of the project permit, the operations scheme for water control structures were not clearly defined causing significant delays in executing the water management plan for this project. Consequently, a water management plan was jointly determined by the federal and state agencies involved and was based on the analysis of monitoring data collected in the field. To avoid such delays in the future, a water management plan should be developed and in place prior to completion of the project. In permitting the water management plan for these type projects, it is sometimes beneficial to have a general operation schedule in that it allows for modifications and adjustments based on analysis of monitoring data.

The Brady Canal Hydrologic Restoration Project is unique in that the landowners are active participants in the on going restoration efforts by cost sharing in the construction, monitoring and maintenance, providing project support and in many cases expending their own resources to fulfill project needs at a reduced cost. The working relationship and active participation of landowners on CWPPRA projects has proven to be an asset to the overall restoration efforts and management of such projects.

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