E C O L O G I C A L R E V I E W

Freshwater Bayou Bank Stabilization - Belle Isle Canal to Lock
CWPPRA Priority Project List 9
State No. TV-11b

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Agaha Y. Brass and Kyle F. Balkum
Restoration Technology Section
Coastal Restoration Division
Louisiana Department of Natural Resources

This document reflects the project design as of the 95% Design Review meeting, incorporates all comments and recommendations received following the meeting, and is current as of January 22, 2004.

ECOLOGICAL REVIEW

Freshwater Bayou Bank Stabilization (Belle Isle to Lock)

In August 2000, the Louisiana Department of Natural Resources (LDNR) initiated the Ecological Review to improve the likelihood of restoration project success. This is a process whereby each restoration project's biotic benefits, goals, and strategies are evaluated prior to granting construction authorization. This evaluation utilizes monitoring and engineering information, as well as applicable scientific literature, to assess whether or not, and to what degree, the proposed project features will cause the desired ecological response.

I. Introduction

The Freshwater Bayou Canal, constructed between 1965 and 1967, provides major shipping access from the Gulf of Mexico to Intracoastal City on the Gulf Intracoastal Waterway (GIWW). In 1968, a lock was built at the southern-most end of the inland reach of the navigation channel near the Gulf of Mexico to control the intrusion of saltwater into Freshwater Bayou Canal. It is opened only to allow access for shipping traffic and to alleviate elevated water levels caused by periodic heavy rains. Between 1979 and 1986, approximately 300,000 tons of cargo were transported along the Freshwater Bayou Canal [United States Army Corps of Engineers (USACE) 1989], demonstrating the importance of this highly used channel.

The purpose of the proposed Freshwater Bayou Bank Stabilization (Belle Isle to Lock), TV-11b project is to stop shoreline erosion along the east bank of Freshwater Bayou Canal in Vermilion Parish, Louisiana. Between 1968 and 1992, the Freshwater Bayou Canal shoreline eroded at an average rate of 12.5 feet per year (Brown and Root 1992). Monitoring data, collected from shoreline reference stations as part of the Freshwater Bayou Wetland Protection (ME-04) project indicated that the shoreline eroded at an average of 6.69 feet per year between 1995 and 1996, and 11.15 feet per year between 1996 and 1998 (Vincent et al. 2000a). Ongoing LDNR monitoring efforts have indicated that from 1995 to 1998 the eastern shoreline of Freshwater Bayou Canal eroded at an average rate of 9.17 feet/year (Vincent et al. 2000a). Continued shoreline erosion, caused by vessel wakes, has breached the spoil bank in many areas, subjecting interior marshes to increased water salinities, wave energies, and tidal scour. Tidal scour has eroded organic soils of interior marshes, resulting in emergent vegetation loss within the project area (Vincent et al. 2000b).

The Freshwater Bayou Bank Stabilization project involves the construction of a foreshore rock dike along the east bank of Freshwater Bayou Canal. The project encompasses 11,000 acres of intermediate and brackish marsh and extends approximately 39,330 feet from the Freshwater Bayou Lock north to Belle Isle Bayou (Figure 1). It is anticipated that this strategy will stop erosion in this area, and reduce deterioration of interior marshes. *Coast 2050*, Louisiana's guiding document for the restoration of a sustainable coastal ecosystem, identifies the stabilization of major navigation channels as both a "Coastwide Common Strategy" and a "Regional Ecosystem Strategy" which will reduce future wetland loss (Louisiana Coastal Wetlands Conservation and Restoration Task Force and the Wetlands Conservation and Restoration Authority 1998).

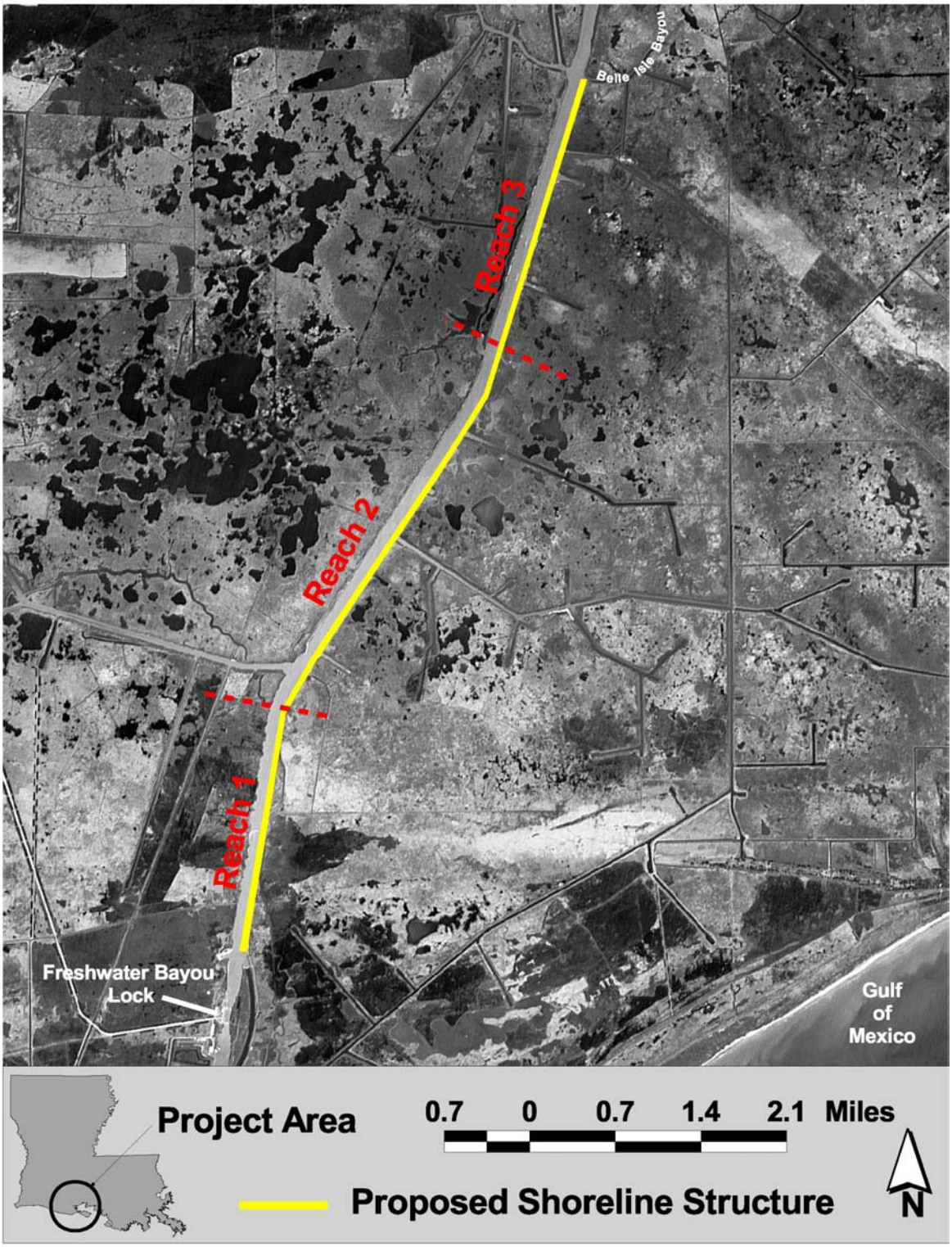

Figure 1: Freshwater Bayou Bank Stabilization (Belle Isle to Lock) project area.

II. Goal Statement

The goal of this project is to stop shoreline erosion along the east bank of Freshwater Bayou Canal from the Freshwater Bayou Lock to Belle Isle Bayou.

III. Strategy Statement

The project goal will be achieved through the construction of a foreshore rock dike along a 39,330-foot stretch of Freshwater Bayou Canal from Freshwater Bayou Lock to Belle Isle Bayou.

IV. Strategy-Goal Relationship

Construction of a foreshore rock dike will restore the integrity of the Freshwater Bayou Canal bank which has continued to erode and breach into the marsh to the east of the project area. The proposed permeable barrier will dissipate wave energy and effectively halt shoreline/bankline erosion.

V. Project Feature Evaluation

A geotechnical investigation was performed to assess the native soil's ability to withstand the designed weight of the proposed rock structure. Based on the results of this analysis, it was determined that the project area contained three distinct soil reaches which required the design of three separate shoreline protection features for each reach (Figure 1). Below is a summary of a geotechnical investigation that describes the settlement and slope stability suggestions associated with the different types of proposed project features. The accepted measure of a slope's stability is its "safety factor" or minimum factor of safety (FSmin), which is the ratio of the forces or moments tending to prevent failure (soil strength, primarily) to those that cause failure [soil and surcharge weights plus seepage forces, primarily (Soil Testing Engineers, Inc. 2001)]. The recommended safety factor that should be adhered to for rock structures built in this project area is a FSmin = 1.20. Table 1 summarizes the stability analyses for the three project reaches at +3.5 feet NAVD-88. Table 2 summarizes predictions of long-term structure settlement along the three reaches.

The general design for Reach 1 [the southernmost region (Station 40+10 to Station 163+60)] will include an onshore dike with 1 vertical (V) on 3 horizontal (H) side slopes for the land and channel sides of the reach. A 1V on 18H channel side berm is required for stability at locations where the mud line dips below -2 feet NAVD-88. This berm will act as a counterbalance against slope stability failure. At these locations, the adjacent top bank will be degraded to +2.5 feet NAVD-88. As currently designed the structure along Reach 1 meets the minimum factor of safety (Table 1). Reach 2 (centrally located between Reaches 1 and 3) of the project area (from Station 163+60 to Station 354+40) met the required factors of safety and soil stability requirements necessary for a successful structure. The rock dike was designed using slopes of 1V on 3H for the channel side and 1V on 2H for the bank side. Reach 3 [the northernmost reach (Station 358+19 to Station 469+77)] will have side slopes of 1V on 3H on both sides. Reach 3 will also contain an embedment berm to act as a counterbalance in certain areas of the reach. The embedment berm will be placed behind the primary structure built to +1.4 feet NAVD-88 with 1V on 2H side slopes. The geotechnical investigation determined that geotextile reinforcement and embedment berm are required to achieve the minimum factor of safety (Table 1).

Table 1. Description of Safety Factors for Proposed Project Features (USACE 2003a)

Reach Number	Minimum Factor of Safety for Extreme Low Water Elevation -4	Minimum Factor of Safety for Average Low Water Elevation -2.3
1 Bank Paving	1.20	(see note below)
2 Rock Dike	1.34	(see note below)
	1.33	(see note below)
3 Rock Dike	0.88*	(see note below)
	0.88**	(see note below)
	0.94***	(see note below)
	0.94****	(see note below)

* Geotextile reinforcement (tensile strength 300 #/in at 5% strain) required for FSmin = 1.20 for extreme low water case and embedment is insufficient, a berm must be added.

** Geotextile reinforcement (tensile strength 300 #/in at 5% strain) and embedment berm are required for FSmin = 1.20 for extreme low water case.

*** Reduced composite excludes the following sections: Sta.354+41, 358+19, 365+75, 408+08, 418+90, 422+50, 438+35, and 457+77. Geotextile reinforcement (tensile strength 240 #/in at 5% strain) required for FSmin = 1.20 for extreme low water case and embedment is sufficient FSmin = 1.20.

**** Geotextile reinforcement (tensile strength 320 #/in at 5% strain) required for FSmin = 1.20 for extreme low water case and embedment is sufficient FSmin = 1.20.

Note: For re-design at grade Elevation +3.5, only controlling cases were analyzed.

Table 2. Long-term structure settlement predicted for the 20-year project life (USACE 2002 and USACE 2003b).

Reach Number	Baseline Stations	20 Year Settlement	Ultimate Long Term Settlement
1	Station 40+10 to Station 163+60	6 inches	12 inches
2	Station 163+60 to Station 354+40	2 to 7 inches	7 to 12.5 inches
3	Station 354+40 to Station 469+78	1.5 to 5.5 inches	4.5 to 8 inches

All of the stone structures will be underlain by geotextile fabric and built to an elevation of +3.5 feet NAVD-88 with crown widths of 5 feet. The aforementioned geotextile fabric will be used to reduce potential stability failure and construction settlement. Material excavated from the floatation channel (dredged for access to the project area) will be beneficially placed between the dike and the existing shoreline no higher than the top of the adjacent rock dike.

A total of 13 proposed pipeline and canal openings along the rock dike's length will also serve as fisheries access points. The gaps at pipeline crossings are 100 feet wide (50 feet on each side of the pipeline). Gaps at canals and natural creeks vary in width depending upon the site. The rock dike terminus, created by each opening, will be built to the same side slopes and elevation as the rest of the dike within each respective reach; however, the crown widths at those positions will be wider (7 feet).

VI. Assessment of Goal Attainability

Coastal Wetlands Planning, Protection and Restoration Act (CWPPRA) shoreline protection projects similar to Freshwater Bayou Bank Stabilization (Belle Isle to Lock), have been implemented on Freshwater Bayou (Figure 2) and other navigation canals as a means of protecting those banks from further erosive elements. Monitoring results and anecdotal information from these projects indicate that shoreline protection measures have been effective at preventing or reducing further erosion.

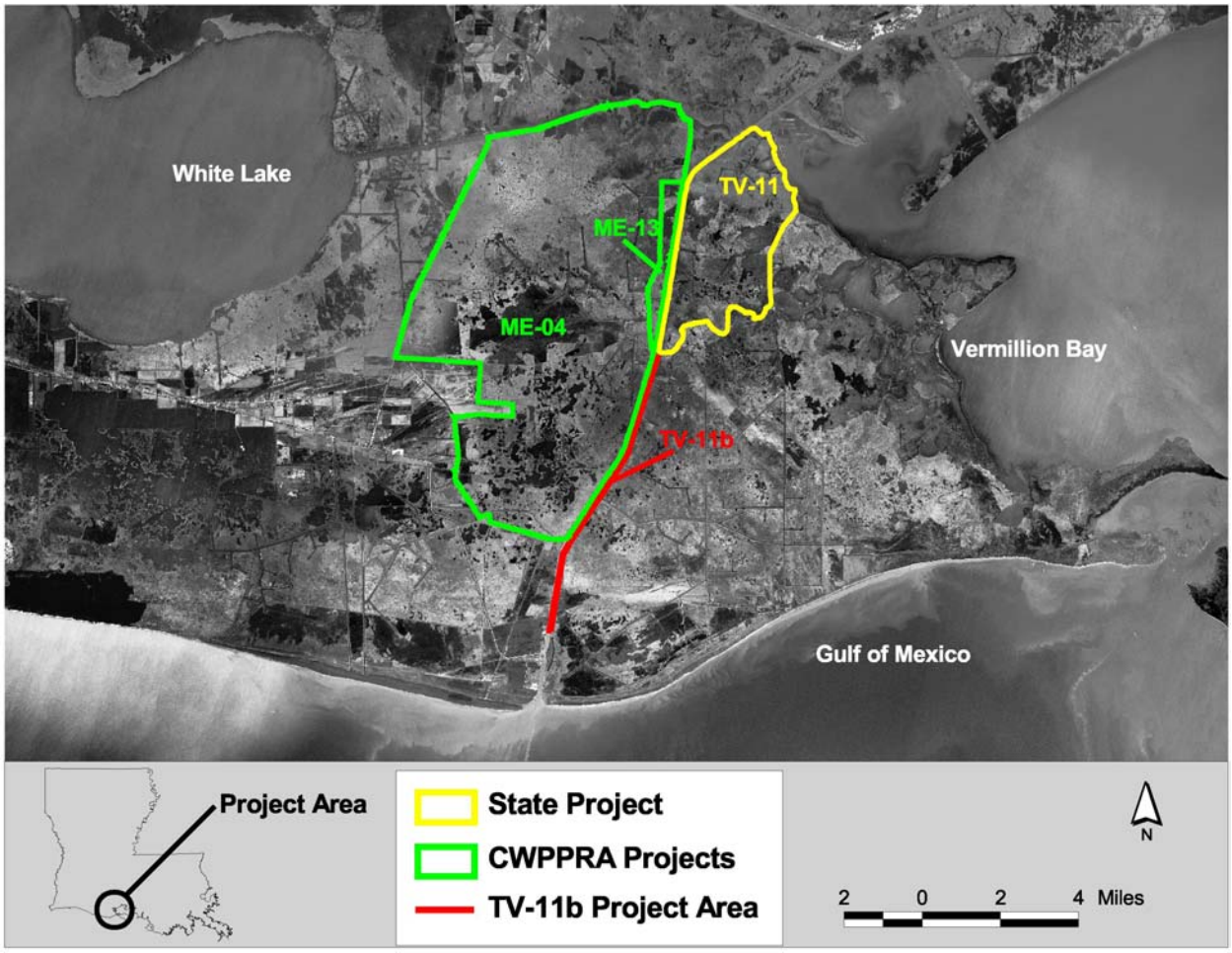

Figure 2: Freshwater Bayou Bank Stabilization (Belle Isle to Lock) and other CWPPRA and State projects along Freshwater Bayou Canal.

Projects on Freshwater Bayou Canal

- Freshwater Bayou Wetlands Protection (ME-04) is a CWPPRA project located on the western bank of Freshwater Bayou Canal directly across from the proposed TV-11b project (Figure 2). This project was initiated in January 1995 and included the construction of water control structures and a 28,000 linear foot foreshore rock dike at

+4.0 feet NAVD-88. The rates of subsidence and sea level rise in the project area were estimated to be relatively low, 0.13 inches per year and 0.25 inches per year, respectively (Penland et al. 1989). Although monitoring efforts are still ongoing, data analyses suggest that the rock dike significantly reduced wave-induced shoreline erosion after construction. Between June 1995 and July 1996, the shoreline behind the constructed dike actually prograded at an average rate of 2.17 feet per year while the reference area eroded at a rate of 6.69 feet per year (Raynie and Visser 2002). Between August 1996 and February 1998, the protected shoreline continued to prograde at an average rate of 0.89 feet per year as the reference area eroded at an average rate of 11.15 feet per year (Raynie and Visser 2002). However, between March 1998 and May 2001, the protected shoreline eroded an average of 2.62 feet per year while the reference area eroded an average of 9.99 feet per year (Raynie and Visser 2002). The steady decrease in the effectiveness of the project features over time is due in large part to the "substandard nature of the original construction material used, and the logistics of implementing a cost-effective maintenance lift to the structure" (Raynie and Visser 2002).

- Freshwater Bayou Bank Stabilization (ME-13), located in Vermilion Parish on the west bank of Freshwater Bayou Canal, is directly opposite from the TV-11 state project and northwest of the proposed TV-11b project (Figure 2). The main cause of wetland loss in the ME-13 project area is boat wake-induced shoreline erosion of the canal spoil banks and organic soils of the interior marsh (USACE and LDNR 1994). A 23,193 linear foot continuous rock dike, built to an elevation of +3.7 to +4.0 feet NAVD-88, was installed parallel to the western shoreline in 1998 to address this loss. Pre-construction data at the ME-13 reference areas on the east bank indicate that the canal eroded at an average rate of 6.54 feet per year between April 1995 and July 1996 (Vincent and Sun 1997). Post-construction data collected from July 1998 through July 2003 revealed that the shoreline behind the constructed rock dike prograded on average 0.84 feet per year (Vincent 2003). During the same period, the unprotected reference areas eroded on average 11.94 feet per year (Vincent 2003).

- The Freshwater Bayou Bank Protection (TV-11) state project, constructed in 1994, is located on the east bank of Freshwater Bayou Canal, immediately north of the proposed TV-11b project and consists of 25,800 linear feet of shoreline protection constructed at +4.0 feet NAVD-88 (Figure 2). Due to manpower deficiencies and budgetary constraints, little monitoring information exists for this project; therefore, no specific conclusions can be drawn regarding the performance of the breakwaters. The lack of post-construction aerial photography precludes any definitive analysis of shoreline movement and changes in land to water ratios within the project area (LDNR 1996).

<u>CWPPRA Projects on other Navigation Channels</u>

- The Cameron Prairie National Wildlife Refuge Shoreline Protection (ME-09) project was designed to protect 247 acres of marsh by preventing further widening of the GIWW. The shoreline erosion rate was estimated to be 2.5 feet per year prior to project

construction in 1994 (United States Fish and Wildlife Service 1991). Since construction of the 13,200 linear foot rock dike (built to an initial elevation of +3.7 feet NAVD-88), shoreline erosion in the project area has been halted, and the shoreline behind the structure has prograded. From 1995 to 2000, the shoreline within the project area prograded an average of 9.8 feet per year (Barrilleaux and Clark 2002). Meanwhile, the reference areas continued to erode at an average rate of 4.1 feet per year (Barrilleaux and Clark 2002). In addition, 3.03 acres of vegetated wetland were created behind the rock dike on the navigation channel, indicating that low sediment availability does not prohibit wetland creation (Courville 1997).

- The Clear Marias Bank Protection (CS-22) project in Cameron Parish is similar to the proposed TV-11b project. It is located along the north bank of the GIWW between the Alkali Ditch and Goose Lake. Pre-construction shoreline erosion rates along the northern shoreline of the GIWW were 3.9 feet per year (USDA 1994). Erosion rates along the southern shoreline were 16.0 feet per year (National Marine Fisheries Service 1996). In March of 1997, a 35,000 foot limestone breakwater, built to an elevation of +3.0 feet NGVD-29, was completed from the northern bank of the GIWW to prevent continued erosion of the management levee and the encroachment of the GIWW into the project area (LDNR 1998b). Post-construction shoreline data collected in 1997 and 2000 indicated that the total project area shoreline had prograded 12.99 feet per year (Miller 2001). The reference area for the same time intervals eroded 20.52 feet (Miller 2001).

- Perry Ridge Shore Protection (CS-24) and GIWW-Perry Ridge West Bank Stabilization (CS-30) projects were constructed in 1999 and 2001, respectively, along the northern bank of the GIWW in Cameron Parish. Both projects involved the construction of rock dikes to elevations of +3.7 to +4.0 feet NAVD-88 to prevent further shoreline erosion, but recent construction has precluded a definitive evaluation of project features. However, field observations indicate that the rock dike has halted shoreline erosion within the CS-24 project area (LDNR 2002).

Summary/Conclusions

The goal of the proposed Freshwater Bayou Bank Stabilization (TV-11b) project is to stop shoreline erosion along the east bank of Freshwater Bayou Canal from Freshwater Bayou Lock north to Belle Isle Bayou. The geotechnical investigation of the TV-11b project area concluded that soil characteristics within Reach 2 met all the soil stability requirements necessary for the construction of a foreshore dike. However, the data indicated that soil characteristics along Reaches 1 and 3 were not stable enough to support the initially proposed dike structure. Therefore, the designs were modified to incorporate an onshore pavement structure for Reach 1 and the use of both embedment berms and geotextile reinforcement for Reach 3. These project modifications will improve structure stability.

Data collected from constructed shoreline protection projects along Freshwater Bayou Canal and the GIWW indicate that foreshore rock dikes are successful at stopping and/or reducing

shoreline erosion rates. The decreasing effectiveness of the ME-04 project features, located on the opposite bank from TV-11b, reinforces the need for the appropriate rock gradation for use in dike construction.

VII. Recommendations

Based on the investigation of similar restoration projects and a review of engineering principles, the proposed strategies of the Freshwater Bayou Bank Stabilization (TV-11b) project will likely achieve the desired goal of stopping shoreline erosion. At this time, the level of design of the project's physical effects warrant continued progress toward construction pending a favorable 95% Design Review and resolution of the following issue:

- The Operations and Maintenance budget should be significant enough to provide for a maintenance lift to the structure should the dike's integrity be compromised.

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