MISSISSIPPI RIVER GULF OUTLET (MRGO)

ECOSYSTEM RESTORATION PLAN

FINAL FEASIBILITY REPORT

SUPPLEMENTAL REPORT OF THE CHIEF OF ENGINEERS

IN RESPONSE TO THE WATER RESOURCES DEVELOPMENT ACT OF 2007

U.S. Army Corps of Engineers
New Orleans District
7400 Leake Avenue
New Orleans, Louisiana 70118

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S.1 STUDY INTRODUCTION AND INFORMATION

Approximately 3,000 years ago the Mississippi River followed a different course than it does today as it drained water from the interior of the continent to the Gulf of Mexico. Geologists call this ancient river pathway the St. Bernard Delta. While on this course, the river created a vast complex of coastal wetlands east of New Orleans that remain between the city and the gulf today. Tidal salt marshes in this one part of Louisiana‘s coast alone surpass the total acreage of salt marsh found along the entire east coast of the United States.

The area‘s rare and sensitive coastal habitats are home to thousands of resident and migratory waterfowl, numerous fresh water, estuarine and marine fish species, as well as many reptiles and mammals. Cypress swamps are generally found close to the river in the fresher portions of the estuary. Coastal ridges that were formed by the ancient tributaries of the Mississippi River support oak trees and other woody vegetation offering refuge habitat to the estuary‘s non-aquatic inhabitants. The outer barrier islands protecting the estuary form a unique wild landscape along the Louisiana coast. These sand islands harbor submerged seagrasses that provide food and shelter for fish, marine turtles, and diving birds. In addition, the island beaches provide important spawning habitat for gulf fishes. President Roosevelt visited Breton Island at the southern end of the Chandeleur Island chain. Out of concern for nesting shore birds on the island the President designated it as the Nation‘s second National Wildlife Refuge in 1904.

New Orleans is world renowned for its rich culinary tradition. A large part of this tradition stems from the bounty that fishermen catch and haul from the area‘s wetlands and waterways. The marshlands east of the river are recognized by the state‘s wildlife and fisheries commission as the ―backbone of the oyster industry." Blue crabs, both jumbo hard crabs and soft shell crabs, are a delicacy shipped far and wide to tables in some of the Nation‘s best restaurants. With the downturn in oyster and crab harvests in the Chesapeake Bay region, supplies from Louisiana estuaries have increased in notoriety and economic importance.

Sportsmen from the New Orleans area and beyond depend on area marshes for recreational pursuits. Charter trips for fishing in the Biloxi Marsh, a large wetland complex located between Chandeleur Sound and Lake Borgne, are commonplace. Many fly fishermen and other salt water fishermen travel to this area that has been nicknamed ―the land of the giants" because of the large schools of red drum that populate the wetlands, bayous and bays in the system. From a waterfowl perspective, the wetlands near New Orleans has been described as a location of ―extreme importance" and ―by far the one of the most important areas in southeast Louisiana."

From a historical perspective, the wetlands east and southeast of New Orleans have played an important role for our Nation and the world. In 1815 the British army approached the American forces at New Orleans by marching up the banks of Bayou Bienvenue after disembarking from their ships in Lake Borgne. Those same soldiers made their retreat along the bayou after the American victory at the Battle of New Orleans. During a later war, the waterways and wetlands of the area served as a testing ground for Andrew Higgins‘ beach landing craft. The specialized shallow draft vessels were designed and manufactured in New Orleans. The boats were key equipment needed to land Allied forces on the beaches of Normandy. General Eisenhower later credited Mr. Higgins and his boats with helping to win World War II.

After the war, America‘s soldiers returned home and the Nation turned its focus to economic development. The Port of New Orleans, a key maritime center for the country, viewed the wetlands east of the city and along the Gulf Intracoastal Waterway as prime areas for industrial and maritime expansion. Plans were devised to expand the port to accommodate more international trade and better secure naval defense forces. This vision led to the creation of a Tidewater Development Association that promoted the concept of a seaway canal for ships. The port commission, the development association and the Louisiana Congressional delegation worked to have the Corps of Engineers create navigation plans for a new canal linking the port to the Gulf of Mexico. The purpose of the canal was to eliminate the need for vessels to make the difficult and dangerous trip from the Gulf of Mexico up and down the Mississippi River to the riverside wharfs in New Orleans. After ship channel studies were completed, Congress provided funds in 1956 for the Corps of Engineers to construct the Mississippi River Gulf Outlet.

The Mississippi River Gulf-Outlet (MRGO or ―Mister Go”) was a 76-mile manmade navigation channel built to provide a shortcut from the inner harbor area of the Port of New Orleans to the Gulf of Mexico. Constructed in 1950s-1960s, the MRGO navigation channel directly removed wetland habitat and influenced ecosystem changes. The channel allowed the intrusion of saltwater into the vast wetland complex bordering the City of New Orleans and surrounding coastal communities east of the Mississippi River. The dredging and filling during the construction of MRGO destroyed thousands of acres of wetlands, interrupted the local circulation patterns of natural waterways that transected the channel, and breached an important hydrologic boundary when the channel was cut through the ridge at Bayou La Loutre.

After the MRGO was completed, significant habitat shifts occurred as the area converted to a higher salinity system as a result of saltwater intrusion from the gulf into the estuary. Operation of the MRGO resulted in high rates of shoreline erosion from ship wakes, further destroying wetlands and threatening the integrity of the Lake Borgne shoreline and adjacent communities, infrastructure, and cultural resources. Erosion of the MRGO channel banks and the daily influx of saltwater in the tides facilitated the transition of the estuary toward a more saline system.

Prior to construction of the MRGO, tidal movement into Lake Borgne was dominated by flow from Mississippi Sound. The tidal flow from Breton Sound was reduced as it moved northwest across the marshes and wetlands toward Lake Borgne. Following construction of the MRGO the circulation pattern reversed, with the dominant tidal flow into Lake Borgne coming from the Breton Sound area via the MRGO. Before channel construction, habitats were aligned along salinity gradients and reflected a varied landscape and interspersed watercourses.

Public controversy surrounding the channel arose even before its construction and spanned over five decades before the landfall of Hurricane Katrina in 2005. After the storm, the Corps of Engineers responded to Congressional direction and developed a channel closure plan. In 2009, the ship channel was closed with a large rock structure at the site of a prominent coastal ridge (Bayou La Loutre) that had been severed during channel construction. As a result of the closure, ship traffic no longer transits the channel and environmental conditions are improving with salinity falling throughout the estuary. Although positive, these environmental benefits will not replace the habitats lost in the area.

In the Water Resources Development Act (WRDA) 2007, Congress requested an ecosystem restoration plan for the areas affected by the MRGO channel and a plan to restore natural features that reduce storm surge damages. This report tells how the United States Army Corps of Engineers (USACE), along with an interagency team and local stakeholders, developed a plan to restore one of the most unique and productive ecosystems in the world.

S.2 STUDY AND PROJECT AUTHORITY

The study is authorized by WRDA of 2007 Section 7013 to develop a plan that would:

- physically modify the MRGO and restore the areas affected by the navigation channel;
- restore natural features of the ecosystem that will reduce or prevent damage from storm surge;
- prevent the intrusion of saltwater into the waterway;
- integrate the recommendations of the Louisiana Coastal Area Report and the Louisiana Coastal Protection and Restoration Technical Report; and
- consider the use of native vegetation and diversions of fresh water to restore the Lake Borgne ecosystem.

The plan is conditionally authorized for construction, pending the determination by the Assistant Secretary of the Army (Civil Works) (ASA(CW)) that the project is cost-effective, environmentally acceptable, and technically feasible. This conditional authorization also assumes that a viable sponsor(s) will be identified as required by Section 221 of Public Law 91-611, Flood Control Act of 1970, as amended and by Section 103 of the WRDA 1986, as amended.

Additionally, the MRGO Ecosystem study initiated study of the Violet, Louisiana Freshwater Diversion project, as authorized by Section 3083 of WRDA 2007, for the design and implementation of a freshwater diversion at or near Violet, Louisiana for purposes of reducing salinity in the western Mississippi Sound, enhancing oyster production, and promoting the sustainability of coastal wetlands. The report recommends that the feasibility-level study regarding the Violet, Louisiana Freshwater Diversion be continued under the authority of Section 3083 of WRDA 2007, together with those elements of the MRGO Ecosystem Restoration project for which success requires the implementation of the Violet, Louisiana Freshwater Diversion Canal.

S.3 STUDY AND PROJECT AUTHORITY

MRGO ECOSYSTEM RESTORATION PLAN: VIEWS OF THE STATE OF LOUISIANA:

The study is 100% Federally funded. After extensive discussions with the State of Louisiana, a non-Federal sponsor has not been identified for implementation of the MRGO Ecosystem Restoration Plan authorized by Section 7013 of WRDA 2007.

The State of Louisiana has been involved in the development of the MRGO ecosystem restoration plan. The plan has been formulated to be consistent with Louisiana's Comprehensive Master Plan for a Sustainable Coast (Master Plan). For example, the 2007 State Master Plan specifically recommended restoration of wetlands and swamps in the Central Wetlands and Golden Triangle areas, which is included in the FIP. The Master Plan was developed with intensive public input and was unanimously adopted by the Louisiana Legislature.

In a letter dated August 12, 2010, the State of Louisiana expressed ―its continuing support of the Mississippi River Gulf Outlet Ecosystem Restoration Project" and declared ―full support for the Mississippi River Gulf Outlet Ecosystem Restoration Program" (See Figure 4-2). However, this letter also expresses the State of Louisiana's view that the Mississippi River-Gulf Outlet Ecosystem Restoration Project should be undertaken at full Federal expense and that the state should have no financial obligations with respect to the Mississippi River Gulf Outlet Ecosystem Restoration Project.

Implementation of the ecosystem restoration plan would require identification of a non-Federal sponsor and execution of a binding cost sharing agreement. As of the date of this report, USACE has not received a letter of intent from the State of Louisiana to serve as the non-Federal sponsor to cost share in implementation of the ecosystem restoration plan. The USACE will continue to coordinate with the State of Louisiana in the development and implementation of the restoration plan.

VIOLET, LOUISIANA FRESHWATER DIVERSION PROJECT, VIEWS OF THE STATE OF LOUISIANA AND THE STATE OF MISSISSIPPI

Section 3083 of WRDA 2007, citing the Corps of Engineers feasibility study entitled ―Mississippi and Louisiana Estuarine Areas: Freshwater Diversion to Lake Pontchartrain Basin and Mississippi Sound" dated 1984, authorizes the Corps of Engineers to design and implement a project for the diversion of freshwater at or near Violet, Louisiana for the purposes of reducing salinity in the western Mississippi Sound, enhancing oyster production and promoting the sustainability of coastal wetlands. Section 3083 identifies the State of Louisiana and the State of Mississippi as non-Federal sponsors for the non-Federal 25% share of the design and implementation of the Violet, Louisiana Freshwater Diversion project.

The State of Mississippi, along with the State of Louisiana, has been actively involved in the development of the Violet, Louisiana Freshwater Diversion project. The final recommendations for the plan addressed in this report include a recommendation for additional analysis, design and implementation of the Violet Freshwater Diversion as authorized by WRDA 2007 Section 3083.. In a letter dated September 20, 2010 the Mississippi Department of Marine Resources (MDMR) declared its full support for the Violet, Louisiana Freshwater Diversion project (See Figure 4-3) and its understanding of its non-Federal cost sharing obligation. The State of Mississippi's letter also states its desire that the USACE, to the fullest extent possible, seek full Federal funding for the project. . USACE has not received a letter of intent from the State of Louisiana regarding the Violet project; however, since this report recommends further study and analysis, such a letter of intent is not required at this time..

Before the Violet, Louisiana Freshwater Diversion project can be implemented, the USACE will require a letter of intent to serve as the non-Federal sponsor and a self-certification of the non-Federal sponsor's financial capability from both the State of Mississippi and the State of Louisiana, including a clear statement of each State's willingness and ability to provide its required cost share and other items of local cooperation for the project, as described in this report. Prior to the commencement of construction by USACE, Federal law requires that both

States execute a binding written agreement wherein they agree to provide all of the non-Federal obligations for the construction, operation, maintenance, repair, rehabilitation and replacement of the Violet, Louisiana Freshwater Diversion project. USACE will continue to coordinate with the State of Mississippi and the State of Louisiana in the development and implementation of the Violet, Louisiana Freshwater Diversion project.

S.4 STUDY PURPOSE AND SCOPE

The MRGO was authorized as a 36-foot-deep, 500-foot-bottom-width waterway (38 feet deep, 600 feet wide at the Gulf of Mexico entrance) extending from the Inner Harbor Navigation Canal (IHNC) to the 38-foot depth contour in the Gulf of Mexico. Construction of the channel began in 1958 and the channel was completed in 1968.

In August 2005, Hurricane Katrina caused shoaling in the MRGO channel limiting its depth to 22 feet, and thus restricted deep-draft vessel access. Rather than continue funding operation and maintenance of the channel, in June 2006, the Congress requested a plan for deauthorization of the MRGO (see Public Law 109-234).

The USACE submitted an interim report in December 2006 highlighting a plan to close the MRGO from the Gulf Intracoastal Waterway (GIWW) to the Gulf of Mexico. In January 2008, the Chief of Engineers signed a report recommending deauthorization of the channel, construction of a closure structure across the channel at Bayou La Loutre, and development of a supplemental report to provide an ecosystem restoration plan for the areas affected by the MRGO. On June 5, 2008, the Assistant Secretary of the Army (Civil Works) (ASA(CW)) forwarded the *Final MRGO Deep-Draft De-authorization Report to Congress*, officially deauthorizing the MRGO federal navigation project from the GIWW to the Gulf of Mexico.

The MRGO Deep Draft De-authorization Report recommendations resulted in the construction of a rock closure structure across the MRGO near the Bayou La Loutre ridge in St. Bernard Parish, Louisiana, which was completed on July 9, 2009.

The Mississippi River Gulf Outlet (MRGO) Ecosystem Restoration Plan Feasibility Study is being developed as a supplement to the June 2008 MRGO Deep-Draft De-Authorization Report and is intended to fully meet the requirements of the Water Resources Development Act (WRDA) of 2007 Section 7013. This feasibility study will result in a Report of the Chief of Engineers describing the federally identified plan for MRGO Ecosystem Restoration and recommending construction of features for early implementation contingent upon the identification of a non-Federal sponsor. The Plan will address systematic ecosystem restoration and protection of the Lake Borgne ecosystem and areas affected by the MRGO navigation channel, and will include considerations of measures to reduce or prevent damage from storm surge. The study integrates the findings of ongoing comprehensive restoration planning efforts in the study area, including the Louisiana Coastal Protection and Restoration (LACPR) Final Technical Report, the Louisiana Coastal Area (LCA) Program, and Louisiana‘s Comprehensive Master Plan for a Sustainable Coast.

The cumulative effects of human and natural activities in the Louisiana coastal area have severely degraded the deltaic processes and shifted the coastal area to a net land loss condition. Many studies have been conducted to identify the major contributing factors (e.g., Boesch et al. 1994; Turner 1997; Penland et al. 2000), and many studies agree that land loss and the degradation of the coastal ecosystem are the result of both natural and human induced factors, producing conditions where wetland vegetation can no longer survive and land is lost. Establishing the relative contribution of natural and human-induced factors is difficult. In many cases, the changes in hydrologic and ecologic processes manifest gradually over decades and in large areas, while other effects occur over single days and impact relatively localized areas.

The study purpose is to develop alternative plans to restore natural features and processes in the Lake Borgne ecosystem and areas affected by the former navigation channel. Construction recommendations will be developed to restore historic habitat types and natural ecological processes in concert with other large-scale comprehensive ecosystem restoration plans.

S.4.1 Project Location / Congressional District

The study area (Figure S-1) includes portions of the Mississippi River Deltaic Plain in coastal southeast Louisiana and parts of coastal southwest Mississippi. It encompasses approximately 3.84 million acres (6,023 square miles) of land and open water.

The study area is located in Louisiana Congressional Districts 1, 2, and 3; and Mississippi Congressional District 4.

S.4.2 Prior Studies, Reports and Existing Water Projects

Information related to the study area has been accumulated over more than five decades. This study builds upon existing studies, reports and plans. For example, study area problems and opportunities have been documented in numerous prior studies. Where conditions have changed or new information has become available, additional analyses have been performed to develop an ecosystem restoration plan based on sound science and engineering.

S.4.3 Federal Interest

For ecosystem restoration projects, alternatives are evaluated using contributions to National Ecosystem Restoration (NER). The basis of this contribution is cost effectiveness and incremental cost analyses of the possible restoration alternatives and significance of ecosystem outputs (benefits) that accrue in the planning area and the nation.

By law and current and past Administration policy, ecosystem restoration, navigation and flood damage reduction are the primary missions of the Corps of Engineers. The need to reduce the loss of Louisiana coastal wetlands has been recognized by the current and past Administrations and Congress. The Coastal Wetlands Planning, Protection and Restoration Act program (CWPPRA or ―Breaux Act") provides targeted funds through 2019 to be used for planning and implementing projects that create, protect, restore and enhance wetlands in coastal Louisiana. The Coastal Impact Assistance Program (CIAP) was authorized by Section 384 of the Energy Policy Act of 2005, to assist coastal producing states and their political subdivisions in mitigating the impacts from Outer Continental Shelf (OCS) oil and gas production. Louisiana is one of the six coastal states selected to receive funds under this appropriation to implement this program. On November 8, 2007, Congress passed the Water Resources Development Act of 2007, authorizing the MRGO Ecosystem Restoration Plan.

In October 2009, President Obama formed the Louisiana-Mississippi Gulf Coast Ecosystem Restoration Working Group, co-led by the White House Council on Environmental Quality (CEQ) and the Office of Management and Budget (OMB) and comprising senior-level officials from the National Oceanic and Atmospheric Administration (NOAA), the U.S. Environmental Protection Agency (EPA), and the Departments of the Army (USACE), Homeland Security, the Interior, and Transportation. The Working Group has developed a Roadmap for Restoring Ecosystem Resiliency and Sustainability in the Louisiana and Mississippi Coast. One of the findings of this roadmap is that ―bold and decisive action is needed now to curtail the rate of wetland loss and barrier island erosion in the area and to restore some of these lost features and ecosystem services."

The Administration has repeatedly demonstrated a commitment to coastal restoration in Louisiana. President Barack Obama made the following statement during his 2009 visit to the Gulf Coast:

> *"We've already seen 220 miles worth of levees and flood walls repaired, and we are working to strengthen the wetlands and barrier islands that are the first line of defense for the Gulf Coast. This isn't just critical to this region's physical protection, it's critical to our environment, it's critical to our economy."* - President Barack Obama, October 15, 2009

During this visit, the Council on Environmental Quality visited the Bienvenue Triangle in the Central Wetlands. Restoration of this area is a key component of the study.

The nation derives significant benefits from the coastal Louisiana ecosystem: protection for the production and transport infrastructure for about 30 percent of the nation's oil and gas supply; the Nation's second largest commercial fishery; and navigation and port facilities which together support America's number one port complex by tonnage.

Figure S-1 Study Area

The plan would restore rare and unique habitat, including coastal ridge, cypress swamp, and fresh marsh. These habitat types are institutionally and technically significant due to relative scarcity and importance. The study area includes environmental resources that are protected by the Endangered Species Act of 1973; Fish and Wildlife Conservation Act of 1980; Fish and Wildlife Coordination Act of 1958, as amended; Migratory Bird Conservation Act; Migratory Bird Treaty Act; and Executive Order 13186 Migratory Bird Habitat Protection.

The USFWS, in a letter dated October 31, 2008, formally requested that significant fish and wildlife resources be fully considered and addressed in this study, including: seabirds, shorebirds, wading birds, migratory and resident waterfowl, and estuarine-dependant fishes and shellfishes.

Coastal Louisiana‘s wetlands support neotropical and other migratory avian species such as rails, gallinules, shorebirds, wading birds, and numerous songbirds, as well as many different furbearers, rabbits, deer, and alligators. Louisiana coastal wetlands provide neotropical migratory birds essential stopover habitat on their annual migration route. The coastal wetlands in the study area provide important and essential fish and wildlife habitats, used for shelter, nesting, feeding, roosting, cover, nursery, and other life requirements.

Emergent wetlands and shallow open water areas in the study area provide important habitat and Essential Fish Habitat (EFH). By letter dated October 27, 2008, the National Marine Fisheries Service (NMFS) indicated water bodies and wetlands in the study area provide nursery and foraging habitats supportive of a variety of economically important marine fishery species. Some of these species also serve as prey for other fish species managed under the Magnuson-Stevens Act by the Gulf of Mexico Fishery Management Council and highly migratory species managed by NMFS.

Wetlands of national interest that would benefit from the implementation of the FIP include those found in the Bayou Sauvage National Wildlife Refuge and the Pearl River and Biloxi Wildlife Management Areas.

S.4.4 Key Planning Assumptions

In formulating and evaluating alternatives, certain assumptions or simplifications were required. Table S-1 provides a brief summary of the major assumptions and the scientific basis or rationale behind each assumption.

Table S-1. Key Assumptions

Assumption	Rationale for the Assumption
Study Area	
The MsCIP (Mississippi Coastal Improvements Program) and other planning efforts led by the USACE Mobile District will address vegetated habitat ecosystem restoration needs in the portions of the study area located in Mississippi. Except for diversions of freshwater, the MRGO ecosystem restoration study will not formulate measures for the purpose of ecosystem restoration in Mississippi.	The MsCIP Comprehensive Plan addressed ecosystem restoration needs in the Bay St. Louis and western Mississippi Sound areas, such as barrier island and submerged aquatic vegetation restoration. To avoid redundancy and ensure consistency with that plan, the MRGO ecosystem restoration plan will not re-evaluate those authorized measures.
Plan Objectives	
It is not a study objective or restoration target to restore the study area to a pre-MRGO hydrologic condition.	This condition cannot be achieved within the study constraints due to authorized navigation and risk reduction protection projects and other landscape changes.
The primary purpose of the plan is ecosystem restoration. Hurricane and storm damage risk reduction through the protection and restoration of natural features contributes to the need for the plan and is an authorized goal of the study. The reduction of damages will not be monetarily quantified. This portion of the study authority will be achieved through the restoration of habitat in areas identified as critical landscape features for storm surge reduction in scientific literature.	The WRDA implementation guidance dated 28 April 2009 says, ―Alternative plans shall be formulated *for the purpose of ecosystem restoration* inclusive of the requirements set forth in Section 7013 of WRDA 2007." Ecosystem restoration studies do not require the quantification of economic benefits. Benefits of coastal landscape features with respect to hurricane and storm damage risk reduction are difficult to empirically quantify due to the complex interaction of dynamic variables.
Future Without Project Conditions	
Restoration of the Lake Maurepas swamps is assumed to be part of the future without project conditions.	Swamp restoration in these areas is addressed through several authorized LCA and CWPPRA diversion projects.
Period of Analysis	
For comparison of alternatives, the total period of analysis is from 2011 to 2065.	The period of analysis includes implementation plus 50 years. The implementation phase is 2012 to 2015 (begins with the first PED year; concludes with first construction completion year). The 50-year period begins with the first year of operation (first year when benefits would be realized) and is 2015 to 2065. Consideration beyond the period of analysis is given to environmental factors.

Table S-1. Key Assumptions

Assumption	Rationale for the Assumption
Relationship to Violet, Louisiana Freshwater Diversion Authority	
Section 3083 of WRDA 2007 authorizes the design and implementation of a diversion at or near Violet, Louisiana, which is located within the MRGO Ecosystem Restoration Plan study area. A freshwater diversion project at or near the Violet Canal will be analyzed as a component of the MRGO Ecosystem Restoration Plan.	This study has identified that a freshwater diversion at or near Violet may be a key driver in the sustainability of the restoration of areas affected by the MRGO and the Lake Borgne ecosystem. Feasibility level investigations of the project authorized in WRDA 2007 Section 3083, will be included in this study, consistent with the Implementation Guidance for Section 7013 WRDA 2007 dated 28 April 2009.
Minimum Restoration Target	
The minimum restoration targets were developed to include direct and indirect habitat impacts of the former navigation channel by habitat type. Impacts include construction, operation, and maintenance of the MRGO through 2008.	These targets were set to produce a plan that meets the requirements of the study authority and USACE requirements for completeness, effectiveness, efficiency, and acceptability.
Measures	
Maintenance will be performed on all plan features.	Periodic maintenance actions will be developed to sustain benefits over the period of analysis.
Marsh restoration areas will include vegetative plantings but marsh nourishment areas will not.	Marsh nourishment is performed using a thin layer of sediment slurry over existing marsh so it is assumed that the existing marsh vegetation will survive.

S.5 STUDY OBJECTIVES

S.5.1 Problems and Opportunities

Study area problems and opportunities have been documented in numerous prior studies. Systemic problems were identified for the entire study area. The study area was divided into subunits, and each subunit was examined to determine specific problems and opportunities for these smaller areas. The overarching environmental problem in the study area is a lack of sustainability of the coastal ecosystem, primarily due to coastal land loss. Natural processes and human actions, such as the construction and operation of the MRGO, contributed to degradation in the Lake Borgne ecosystem, and threaten the long-term viability of the study area.

Table S-2 identifies study area problems and ecosystem restoration opportunities to address each problem (see also Figure S-3).

Table S-2. System-Wide Study Area Problems and Opportunities

Problems	Opportunities
Decreased Freshwater, Sediment, and Nutrient Inputs	Increase sediment, freshwater, and nutrient inputs Increase organic deposition.
Modification of Natural Hydrology	Restore altered tidal circulation patterns and improve water quality.
Saltwater Intrusion	Prevent saltwater intrusion.
Wetland Loss	Create wetlands, nourish, and prevent the continued loss of wetlands.
Ridge Habitat Degradation and Destruction	Restore ridge habitat.
Bank/Shoreline Erosion	Prevent bank and shoreline erosion.
Habitat Changes and Loss	Restore habitat types such as swamps, ridges, submerged aquatic vegetation, oyster reefs, and barrier islands.
Invasive Species	Eliminate or reduce invasive species.
Herbivory	Prevent herbivory.
Retreating and Eroding Barrier Islands	Restore barrier islands.
Human Development Susceptible to Storm Surge	Reduce or prevent storm surge damage through restoration of natural ecosystem features.

S.5.2 Planning Objectives

Planning objectives were developed to address systemic ecosystem problems and the Congressional mandate of the study authority. Construction and maintenance of the MRGO caused wetland loss and environmental damage in the study area. The study objectives were developed to address the habitat impacts of the former navigation channel to restore study area biodiversity and ecosystem function. The storm surge risk reduction component of the study authority was addressed by including restoration of critical landscape features in the objectives. While storm models show benefits from additional marsh, island, and landbridge habitat in some areas, the effects of allowing existing features to degrade in these areas are even more pronounced (USACE 2009).

The objectives for the MRGO Ecosystem Restoration Plan follow:

1. Restore historic salinity conditions in the study area to re-establish and maintain historic habitat types; optimize ecosystem services; and decrease stress to vegetation as measured by the monthly salinity targets in the Biloxi Marsh (as identified by Chatry et al. 1983) each month of the year, for at least four years out of every ten year period (see Figure S-2).

2. Restore native habitat acreages impacted by the MRGO and their ecosystem functions.
    a. Increase the year round spatial coverage of cypress swamp habitat in the Central Wetlands by at least 9,500 acres by 2065.
    b. Increase the year round spatial coverage of fresh/intermediate marsh in the Central Wetlands, Golden Triangle, MRGO, and South Lake Borgne by at least 6,800 acres by 2065.

c. Increase the year round spatial coverage of brackish marsh in Bayou Terre aux Boeufs, the Biloxi Marsh, and the East Orleans Landbridge by approximately 18,100 acres by 2065.

d. Increase the year round spatial coverage of vegetated wetlands in areas adjacent to the channel lost to increased tides and salinity by at least 3,900 acres by 2065.

e. Increase the year round spatial coverage of ridge habitat along Bayou La Loutre by 2065.

3. Increase the year round spatial coverage of critical landscape features that provide hurricane and storm damage risk reduction in the study area (i.e. areas located in the Biloxi Marshes, the East Orleans Landbridge, and forested habitats).

4. Increase awareness and understanding of the significance of resources in the study area through increased recreational and educational opportunities.

Figure S-2 Chatry Line

Figure S-3. System-Wide Problems and Potential Management Measures

S.5.3 Planning Constraints

Planning constraints are restrictions that limit the extent of the planning process. For this study, the planning constraints are:

- Avoid or minimize negative impacts to threatened and endangered species to the extent practicable.
- Avoid or minimize impacts to critical habitat to the extent practicable.
- Do not diminish the level of protection provided by authorized flood risk reduction projects and hurricane storm damage risk reduction projects.
- Avoid actions that negatively affect the ability of authorized navigation projects to continue to fulfill their purpose to the extent practicable.
- Minimize impacts to commercial fisheries (such as oysters).
- Avoid or minimize contributions to low dissolved oxygen concentrations or conditions that could result in detrimental algal blooms.

S.6 PLAN FORMULATION RATIONALE

Alternative plans are formulated across a range of potential scales to demonstrate the relative effectiveness of various approaches at varying scales. Alternatives are formulated recognizing study area problems and opportunities, as well as study goals, objectives and constraints with consideration of the four Principles and Guidelines (P&G) criteria: completeness, effectiveness, efficiency, and acceptability.

S.7 MANAGEMENT MEASURES AND ALTERNATIVE PLANS

A management measure is a feature (a structural element that requires construction or assembly on-site) or an activity (a nonstructural action) that can be combined with other management measures to form alternative plans. Management measures were developed to address study area problems and to capitalize upon study area opportunities. Management measures were derived from a variety of sources including prior studies, the National Environmental Policy Act (NEPA) public scoping process, and the multidisciplinary, interagency Project Delivery Team (PDT). Approximately 300 initial structural management measures considered can be grouped into the following categories (non-structural measures, such as invasive species control, were integrated into structural measures and were not considered independently):

- Freshwater diversions
- Hydrologic restoration (e.g. plugs, fill, weirs, sills, gaps)
- Marsh creation, marsh nourishment, and swamp creation or restoration
- Shore protection
- Ridge restoration
- Restoration/creation of forested habitat
- Vegetative Planting

- Barrier island restoration
- Submerged aquatic vegetation (SAV) restoration
- Oyster reef restoration

S.8 MINIMUM PLANNING INCREMENT

Several measures were considered necessary components of a plan that addressed the study authority, considered the significance of ecosystem outputs, and met the goals and objectives for the study. A minimum planning increment was included in the plan formulation process to produce alternatives that would address the study authority and consider significance of outputs, completeness, effectiveness, and acceptability, prior to the evaluation of efficiency through cost-effectiveness/incremental cost (CE/ICA) analysis.

S.8.1 Cypress and Coastal Ridge Habitat

In an abstract evaluation, cypress and coastal ridge restoration measures are not as cost-effective as other types of measures. These restoration measures require more sediment and more time to achieve benefits than marsh restoration, and therefore have much higher costs compared to benefits. Restoration of cypress and ridge habitat was considered necessary to fulfill the requirements of the study authority to ―restore the areas affected by the navigation channel," as documented in Habitat Impacts of the Construction of the MRGO and Louisiana Coastal Area Ecosystem Restoration Study (USACE 1999, 2004).

- The former navigation channel was cut through the Central Wetlands and the Bayou La Loutre ridge, directly impacting these areas.
- The Central Wetlands is the only area in the immediate vicinity of the MRGO that could support cypress swamp, a scarce habitat rich in biodiversity. Other locations are outside of the project area (Caernarvon) or far removed from the channel (LaBranche and Maurepas).
- The only remaining natural ridge in the immediate vicinity of the MRGO is the Bayou La Loutre ridge. This habitat is technically significant because of its scarcity, biodiversity, and function as a limiting habitat on which species of concern depend (Conner and Day 1988, Twedt and Portwood 1997, Barrow et al. 2000, USGS 2006, Barrow et al. 2006).
- Cypress swamp habitat is increasingly scarce and provides unique habitat and ecological functions, contributing to the technical significance of these resources (Lowery 1974, Conner and Toliver 1990, Messina and Conner 1998, Martin et al. 2002).
- The restoration of cypress swamp in the Central Wetlands is widely supported by the adjacent communities, NGOs, state and local government, and resource agencies, demonstrating its public significance (University of Wisconsin-Madison 2008 and 2009, SLFPA-E 2009, Day et al. 2006).
- The ecosystem services provided by these habitat types (e.g. avian and mammalian habitat) cannot be provided by other habitat types in the study area (Messina and Conner 1998, Barrow et al. 2000, USGS 2006, Barrow et al. 2006).

The restoration of these habitats was integral to the development of a complete, effective, efficient, and acceptable plan. By definition, the most effective and efficient plan would fully achieve the target objective. Therefore, IWR-PLAN formulation was developed to produce plans that include features to achieve these objectives. As the ridge habitat does not have a specified acreage amount, two scales of ridge restoration were developed, and the smaller feature closest to the channel was selected for inclusion in the minimum planning increment.

S.8.2 Recommendations for MRGO Channel

Similarly, the inclusion of some features in the MRGO is required to address the LCA Near-Term Project described in Section 7006 (c)(1)(A) of WRDA 2007 and the portion of the 7013 authority requiring “a plan to physically modify the Mississippi River-Gulf Outlet”, despite the relative cost-effectiveness of these features.

Bank reclamation and stabilization along the MRGO is important to prevent the further confluence of the MRGO and Lake Borgne and to maintain the MRGO/Lake Borgne Landbridge. A plan that did not include features in the MRGO would likely be unacceptable to the public and did not appear to meet the Congressional intent of the study. Stabilization of the MRGO banks would preserve estuarine wetlands and important structural features of the lake and marsh landscape. The MRGO features would prevent future land loss and restore degraded wetlands; stabilize and restore the endangered, critical Lake Borgne rim geomorphic structure; and protect vital socioeconomic resources, such as communities located adjacent to the MRGO.

Bank stabilization in the MRGO was identified as a critical near-term need in the LCA report. The implementation guidance for the MRGO Ecosystem Restoration Plan states that the Section 7006 project “shall be held in abeyance until the tentatively selected plan for ecosystem restoration, authorized by Section 7013 of WRDA 2007, is identified.” The implementation guidance also states that the feasibility report and EIS for Section 7013 of WRDA 2007 will include recommendations regarding the Section 7006 project.

Although the MRGO features were determined to be less cost-effective than other restoration features considered, it was determined that the most cost-effective MRGO features should be included in the recommendations for this study. The inclusion of the most cost effective MRGO features in the recommendations for the study serves to “integrate the recommendations of the report with the program authorized under section 7003” as noted in the study authority.

S.8.3 Violet, Louisiana Freshwater Diversion

Alternatives that did not include a freshwater diversion were considered in the initial development of alternatives. These alternatives were ultimately eliminated from further study as inconsistent with the study goals and objectives.

Restoration of historic salinity is technically significant because the man-made separation of the Mississippi River from the wetlands has decreased biodiversity and increased the scarcity of native marsh habitats. These effects were exacerbated by the construction of the MRGO and the resultant saltwater intrusion (USACE 1999). A freshwater diversion would restore this connection and increase marsh productivity and vertical accretion (DeLaune et al. 2003).

A freshwater diversion could fully restore historic salinity conditions and increase freshwater and nutrients to nourish existing and restored wetlands in the study area. WRDA 2007 Section 3083 authorizes the achievement of the benefits described in *Mississippi and Louisiana Estuarine Areas Freshwater Diversion to Lake Pontchartrain and Mississippi Sound Feasibility Study* (also known as the Bonnet Carrè study) through the design and implementation of a freshwater diversion at or near Violet, LA. However, additional study is needed to improve decisions about where, when, and how to divert Mississippi River flows in a systems context. The ongoing Mississippi River Hydrodynamic and Delta Management Study will evaluate ecosystem restoration alternatives in concert with dynamic flood risk management and navigation; multipurpose management scenarios of the river; and dynamic conditions in a comprehensive systems context. The information gained from this study will improve decision-making for the Violet, Louisiana Freshwater Diversion. Therefore, the final recommendations for the MRGO Ecosystem Restoration Plan include additional analysis of the Violet, Louisiana Freshwater Diversion under the WRDA 2007 Section 3083 authority.

S.9 FINAL ARRAY OF ALTERNATIVES

The Corps' Institute for Water Resources (IWR) has developed procedures and software to assist in conducting CE/ICA analysis. IWR-PLAN Decision Support Software was used to assist in performing CE/ICA. IWR-PLAN software generated 6,721 plan combinations. Including the No Action plan (Plan A), there were 285 cost-effective plans and 19 ―Best Buy" plans ranging in costs up to $6.5 Billion (October 2009 Price Levels). The most efficient plans are called Best Buys. They provide the greatest increase in output at the lowest average cost. Best Buys have the lowest incremental costs per unit of output. A summary of the costs and benefits associated with the plans generated in IWR-PLAN is provided in Table 2-10 of this Feasibility Report.

Three Best Buy plans generated using IWR-PLAN software, along with the No Action plan, were selected for the final array. Best Buy plans #2, #7, and #10 (Plans B, C, and D, respectively) were chosen based on cost effective increments, contribution to addressing the study authority, and achieving planning objectives. These plans represent a wide range of costs and outputs.

Plan B includes 10,287 acres of brackish marsh restoration and nourishment on the East Orleans Landbridge and the Bayou Terre aux Boeufs area. 9,343 acres of intermediate marsh in South Lake Borgne and along the MRGO would be restored as part of Plan B. Cypress swamp restoration and nourishment in the Central Wetlands (10,318 acres) are included in Plan B. Coastal ridge habitat restoration along Bayou La Loutre is also a component of Plan B (54 acres). Along the MRGO, Plan B includes approximately 32.5 miles of bank protection and 548 acres of marsh restoration. Plan B does not include any shoreline protection features along Lakes Borgne or Pontchartrain, oyster reef restoration, or restoration features in the Biloxi Marsh. Further analysis of the Violet, Louisiana Freshwater Diversion under WRDA 2007 Section 3083 is also included in Plan B.

Plan C includes all of the measures in Plan B and adds 22,224 acres of brackish marsh restoration and nourishment on the East Orleans Landbridge, Bayou Terre aux Boeufs, Hopedale and the Biloxi Marsh. Plan C also includes the restoration and nourishment of 3,281 acres of imperiled fresh marsh in the Central Wetlands and 280 acres of intermediate marsh at the confluence of the MRGO and GIWW. Restoration of globally scare oyster reef habitat is proposed for 5.8 miles of the Biloxi Marsh shoreline between Point Eloi and the mouth of Bayou

La Loutre as part of Plan C. Approximately 41 miles of shoreline protection features included in Plan C fill in the gaps between existing and planned projects, creating a complete plan for the protection of the East Orleans Landbridge and the Lake Borgne shoreline.

Plan D incorporates all of the measures in Plan C and adds 12.8 miles of shoreline protection in the Biloxi Marsh and an SAV restoration measure in Lake Pontchartrain.

Plan B was chosen for further consideration because it was the least costly Best Buy Plan. Plan B does not achieve all of the goals and objectives of the study, but includes some restoration measures for all of the targeted habitat types. Plan B would restore or protect 9,518 acres of fresh and intermediate marsh, 10,253 acres of brackish marsh, and 10,431 acres of cypress swamp. Plan B does not meet the target acre objectives for brackish marsh. Additionally, 10,456 acres of brackish marsh would be converted to another habitat type that would not be restored elsewhere in the study area. Therefore, it did not meet the objective to add to the total amount of each habitat type in the study area. Plan B has no features in the Biloxi Marsh and only includes two features on the East Orleans Landbridge: therefore, Plan B does not fully address the objective to restore and protect critical landscape features for storm surge reduction.

Plan C is the first Best Buy Plan that meets all of the objectives, including reasonably maximizing restoration and protection of the Biloxi Marsh and East Orleans Landbridge. Plan C was selected for further evaluation in the final array of alternatives because it appeared to be a complete plan for the Lake Borgne ecosystem and the areas affected by the MRGO.

Plan D includes additional restoration measures in the Biloxi Marsh and East Orleans Landbridge. Because of these additions, Plan D improves upon Plan C by further protecting these critical landscape features, and better meets the storm surge objective. Plan D was included for further evaluation because it was the first Best Buy after Plan C to include more measures to protect both of these features. Table S-3 provides a summary of each plan.

Table S-3. Final Array of Alternatives

Plan	Estimated Construction Cost[1]	Measure AAHUs[2]	Plan AAHUs[3]	Acres Restored[4]
A	$0	0	0	0[5]
B	$1.7 B ($67 M annual)	6,008	13,608	30,250
C	$2.9 B ($124 M annual)	10,324	17,575[6]	58,861
D	$3.1 B ($130 M annual)	10,399	17,116	59,823

Notes: 1. Based on preliminary costs in October 2009 Price Levels. Does not include real estate, OMRR&R, or adaptive management costs.

2. The AAHUs presented in this column are the total AAHUs of all measures in the plan added together and does not consider interactions between restoration features, except for areas influenced by the freshwater diversion. The influence of the authorized Violet, Louisiana Freshwater Diversion was considered in the calculation of all benefits in this table.
3. The AAHUs in this column are for the entire plan, and does consider synergies.
4. The acres in this column are the total acres restored, nourished, and protected by the plan.
5. The table shows only the costs and benefits associated with this plan. Therefore, all values are zero for the no-action plan.
6. This number is reflective of the initial WVAs that were performed for the project in the plan formulation phase. WVAs were revised for the FIP based on a revised WVA methodology. In this final plan analysis, the Violet, Louisiana Freshwater Diversion was assumed operational in 2027. The total AAHUs for Plan C considering synergies is now 37,980 because the revised methodology considers the value of existing habitat, significantly increasing total benefits.
The historic rate of sea level rise was selected for primary display of ecological benefits in this table because this rate is supported by data.

S.10 COMPARISON OF ALTERNATIVES

Alternative plans were compared against each other, with emphasis on the outputs and effects (beneficial and adverse) with respect to study goals and objectives and NER benefits and costs. Table S-4 provides a summary of how each alternative plan meets the study objectives.

Plans A and B were not selected because they do not fully achieve all of the study objectives and would not comply with the Congressional mandate in WRDA 2007, Section 7013. Plan C is the FIP because it was determined to be the lowest cost plan that fully achieves all of the planning objectives and provides a complete plan to restore the Lake Borgne ecosystem. Key features and processes would be restored by Plan C. Plan C provides significantly greater benefits at a relatively small increase in average costs, and therefore better meets the effectiveness criteria than Plan B. Plan D would provide more benefits to the ecosystem than Plan C; however, in this evaluation, the additional benefits do not justify the increased cost. Plan D is a cost effective means of achieving the objectives of the study, but due to increased incremental costs compared to Plan C, it is not the most efficient plan.

Table S-4. Comparison of the Alternative Plans and Plan Objectives

Objective	Plan A	Plan B	Plan C	Plan D
1. Salinity Target	No	Yes	Yes	Yes
2. Cypress (Minimum 9,500 acres)	No	Yes	Yes	Yes
3. Fresh/Intermediate (Minimum 6,800 acres)	No	Yes	Yes	Yes
4. Brackish (Minimum 18,100 acres)	No	No	Yes	Yes
5. Various Marsh types lost from increased tides and salinity(Minimum 3,900 acres)	No	No	Yes	Yes
7. Ridge Habitat	No	Yes	Yes	Yes
8. Landscape Features for Surge Reduction [a]	No	Yes 5,100 acres	Yes 20,234 acres	Yes 21,165 acres

[a] Landscape features for surge reduction include acres restored, nourished or protected on the East Orleans Landbridge and the Biloxi Marsh.

Risks and Uncertainty

There are significant risks and uncertainties associated with all of the plans. The greatest risks to restoration are damage from tropical storms, increased sea level rise, and climate change. A single storm event could destroy restored wetlands, significantly reducing or eliminating benefits. Increased sea level rise would convert emergent wetlands to shallow open water, and shallow open water to deeper water habitat. This conversion would reduce the effectiveness of restoration plans. Extreme changes in climate could result in conditions that cannot support the types of habitat restored, reducing the effectiveness of the restoration plan.

Large uncertainties affect future conditions in the study area, including: climate change; sea level rise rates; subsidence rates; timing of tropical storm events; changes in frequency and intensity of tropical storm events; and/or changes in drought conditions. All of these factors could contribute to accelerated degradation in the study area, changing forecast conditions and diminishing the effectiveness of restoration plans.

Some features of the plan are more susceptible to these risks and uncertainties. Management measures were assessed for each of the following four sustainability factors:

1. Elevation – Features at higher elevations are more sustainable under relative sea level rise, e.g. ridges, than features at marsh elevation.
2. Freshwater influence – Features that are influenced by rivers or river diversions have a sustainable source of freshwater and sediment to nourish them and aid in accretion.
3. Wave energy – Features that are protected from wave energy (e.g. interior marsh) are more sustainable than features subjected to high wave energy.
4. Natural features – Features that are natural, living features of the ecosystem such as marsh are more sustainable than hard structures such as rock that subside more quickly and cannot sustain themselves and therefore require more O&M.

The most sustainable features are the freshwater diversion, cypress swamp restoration, and ridge habitat restoration. Shoreline protection features are less sustainable than other features, but are considered critical to address systemic erosion. These features protect the marsh from wave energy, and increase the sustainability of the marsh by allowing natural vegetative shoreline stabilization to occur.

The timing and availability of financial resources is a major uncertainty that must be considered. If the plan is not implemented in the near future, the problems in the study area will continue to degrade conditions. The impact of the uncertainties associated with the future condition of the study area could increase restoration costs, decrease restoration benefits, or both. These uncertainties are increased because a non-Federal sponsor has not been identified.

The FIP has a phased implementation schedule to reduce risk. With phased implementation, costs are expended periodically, rather than all at once, which reduces risk to the monetary investment. Phased implementation also provides the opportunity to adjust project design and construction from lessons learned from projects built in the earlier phases.

The selection of the FIP represents a tradeoff of environmental benefits and monetary costs. Plan B is the least costly alternative in the final array. However, Plan B only partially addresses the study objectives. Additional restoration features requiring additional costs are needed to meet the study objectives. Plan D is a more effective plan than Plan C, because it better addresses study area problems and opportunities. However, the additional benefits provided by Plan D do not justify the additional cost.

The adaptive management plan for the FIP addresses the potential impacts of increased sea level rise rates. The implementation plan provides opportunities for adaptive management through phased construction.

The long-term impacts of the Deepwater Horizon oil spill on coastal Louisiana are uncertain at this time. This spill has impacted USACE water resources projects and studies in the Louisiana coastal area. Potential impacts to this study include factors such as changes to existing or baseline conditions, as well as changes to Future Without Project (FWOP) and Future With Project (FWP) conditions. The USACE will continue to monitor and closely coordinate with other

Federal and state resource agencies and local sponsors in determining how to best address potential problems associated with the oil spill that may adversely impact projects and studies. This may include revisions to proposed actions as well as supplemental environmental analysis and documentation for specific projects and studies.

S.11 SYSTEMS / WATERSHED CONTEXT

The overarching principle adopted for this study (based on the LACPR technical report) is that sustaining the integrity of the estuarine environments in coastal Louisiana, including various landscape features that make up those environments, is critical to the ecological health, social and economic welfare of the region.

System-wide problems and opportunities were used to identify and define more geographically specific problems and opportunities throughout the study area. The alternative plans were formulated to address systemic problems in the ecosystem, as well as specific problems in each subunit. The FIP includes multiple types of management measures to address factors contributing to ecosystem degradation. Public and agency coordination undertaken for the study has assisted in the development of a system based plan that complements other private, local state and federal restoration activities in the study area.

The systems-based planning approach for the study supports the strategic approach described in the Louisiana-Mississippi Gulf Coast Ecosystem Restoration Working Group *Roadmap for Restoring Ecosystem Resiliency and Sustainability*. Specifically, the planning process recognizes the following key points of the strategic approach:

- Enhancing essential coastal processes and the ecological services they provide.
- Incorporating a multiple lines of defense strategy.
- Safeguarding the region‘s rich cultural history and economic resources.
- Addressing the potential impacts of accelerated sea level rise and subsidence as a strategy to protect communities, infrastructure, and to restore ecosystems and the services they provide.

Representatives of Federal and State agencies were members of the Project Delivery Team (PDT). Agencies are also involved through the NEPA process, with some agencies serving as official cooperating agencies and others with official coordination and consultation roles.

Cooperating Agencies (as defined under 40 CFR 1501.6) include: U.S. Department of the Interior – U.S. Fish and Wildlife Service (USFWS); U.S. Department of Commerce – National Oceanic and Atmospheric Administration – National Marine Fisheries Service (NMFS); U.S. Department of Agriculture – Natural Resources Conservation Service (NRCS); U.S. Environmental Protection Agency (EPA) and the Bureau of Ocean Energy Management, Regulation and Enforcement (BOE), formerly Minerals Management Service (MMS). Other participating agencies include the Louisiana Department of Environmental Quality (LDEQ), Louisiana Department of Wildlife and Fisheries (LDWF), the Louisiana Department of Natural Resources (LDNR), and the Mississippi Department of Marine Resources (MDMR).

Figure S-4. Systems Context

S.12 FEDERALLY IDENTIFIED PLAN

Plan C was chosen as the FIP because it is the lowest cost alternative that meets all of the study objectives and provides a complete plan to restore the Lake Borgne ecosystem. The National Ecosystem Restoration account is best achieved by Plan C, because it meets all of the study objectives, reasonably maximizes benefits for the associated costs, includes key restoration features to restore and sustain the form and function of the Lake Borgne ecosystem, and fully addresses the Congressional mandate of WRDA 2007 Section 7013.

Plan C is a complete plan for the Lake Borgne ecosystem because it protects and restores the portions of the Lake Borgne ecosystem that are not addressed by existing and authorized restoration projects. Existing and authorized shoreline protection projects along the shores of Lake Borgne do not comprehensively address erosion in the lake. Plan C would provide protection in the areas in between existing and authorized projects to stabilize the entire shore of Lake Borgne. Marsh restoration features included in Plan C would work synergistically with existing and authorized projects to restore the structure of the Lake Borgne ecosystem.

The restoration of historic salinity conditions is a key system driver. The Violet, Louisiana Freshwater Diversion, as authorized for design and implementation in WRDA 2007 Section 3083, would fully restore salinity conditions, mimic natural processes, and enhance the sustainability of the system through the input of freshwater, nutrients and sediment. Full restoration of historic habitat types in the area is dependent upon salinity conditions. Plan C addresses salinity impacts of the MRGO by recommending further analysis of the Violet, Louisiana Freshwater Diversion under WRDA 2007 Section 3083.

Plan C is illustrated in Figures S-5 and S-6.

Approximately 11,222 acres of the restoration and protection features would be located in the East Orleans Landbridge/Pearl River area and approximately 9,012 acres of restoration would be located in the Biloxi Marsh, which have been determined to be critical landscape features with respect to storm surge. Additionally, the cypress swamp and ridge restoration features would include forested habitats, having some storm surge damage risk reduction benefits.

The plan would restore technically significant habitat, such as 3,281 acres of imperiled fresh marsh in the Central Wetlands, 10,318 acres of ecologically important cypress forest, and 54 acres of rare coastal ridge habitat. The plan would restore and nourish 12,797 acres of brackish marsh in the Hopedale and Bayou Terre aux Boeufs area south of the channel. In the Golden Triangle area, 4,317 acres of intermediate marsh would be restored on the Lake Borgne side of the IHNC Surge Barrier and 280 acres of significant urban marsh would be restored on the GIWW/MRGO side of the barrier.

Implementation

Following the identification of the FIP, a construction sequence was developed. Assumptions factoring into construction sequence include production rates for building rock projects, dredge equipment availability, land loss rates, alternating dredging cycles in the lobes of Lake Borgne.

The timing and availability of financial resources for implementation is a major uncertainty that must be considered given current Federal budgetary constraints. If the plan is not implemented in the near future, conditions will continue to degrade. The impact of the uncertainties associated with the future condition of the study area could increase restoration costs, decrease restoration benefits, or both. The uncertainties associated with implementation are increased because a non-Federal sponsor has not been identified.

Funding assumptions, as detailed in the Engineering Appendix, were required for planning purposes and to develop costs and benefits for the plan. Construction sequencing assumed optimal funding appropriations and an aggressive schedule to complete implementation as soon as realistically possible. Given the considerable need for the plan, Federal interest, significance of resources, and the conditional authorization for implementation, an aggressive implementation sequence was considered appropriate. However, current budgetary conditions and the lack of a non-Federal sponsor make it very likely that reality will differ from these optimal assumptions. Risk and uncertainties related to implementation have been assessed in the Cost Risk Analysis, as detailed in the Engineering Appendix. However, due to uncertainties associated with the timing and availability of funding for the plan, only features that are sustainable without the implementation of any other feature are recommended for construction at this time.

Tiered Implementation Sequence

Recommendations are divided into tiers by the level of uncertainty regarding conditions for ecological success and long-term sustainability including the need for additional study.

- Tier 1 includes features that have been developed to a feasibility level of detail and are not dependent on a freshwater diversion. Tier 1 features are recommended for construction through the WRDA 2007 Section 7013 authority upon the identification of a non-Federal sponsor.
- Tier 2 includes features with feasibility level detail that are dependent upon salinity conditions but may be sustainable without the implementation of a freshwater diversion. If future conditions and further analysis indicate that favorable conditions for ecological success and long term sustainability exist (as defined in the adaptive management plan[1]), then these projects may be constructed. Tier 2 features would be constructed through the WRDA 2007 Section 7013 authority upon the identification of a non-Federal sponsor.
- Tier 3A includes further study of the Violet, Louisiana Freshwater Diversion under the WRDA 2007 Section 3083 authority. The non-Federal cost-share responsibilities for the Violet, Louisiana Freshwater Diversion would be consistent with the 75 percent/25 percent Federal/non-Federal cost share identified in Section 3083 of WRDA 2007, together with such other items of cost-share responsibilities as may be identified in the Feasibility Report for the project, as approved by the decision of the Chief of Engineers. Presently, as identified in the 1984 Chief's Report for *Mississippi and Louisiana Estuarine Areas Freshwater Diversion to Lake Pontchartrain and Mississippi Sound Feasibility Study*, the 25 percent non-Federal share of the cost of the design and implementation of the Violet, Louisiana Freshwater Diversion project is allocated 80 percent to the State of Louisiana and 20 percent to the State of Mississippi. It is not anticipated that this allocation will change as a result of completing the feasibility study

[1] Average annual salinity: fresh marsh: <1.1 parts per thousand (ppt); intermediate marsh: <4.1 ppt; brackish marsh: <8.3 ppt, and swamp <4.0.

for the project; however, if it does, the change in allocation will be addressed in the study, as approved by the decision of the Chief of Engineers.

- Tier 3B includes any features that are dependent on freshwater diversion, and features in Tier 2 that future conditions and further analyses indicate are not sustainable. Subsequent to the completion of Tier 3A, Tier 3B features would be constructed through the WRDA 2007 Section 7013 authority upon the identification of a non-Federal sponsor.

S.13 EXPECTED PROJECT PERFORMANCE

The implementation of the plan would improve the health of marsh vegetation through structural restoration projects. Healthier vegetation is more resilient and would improve air, water, and soil quality. The implementation of Plan C would produce a healthier, more sustainable Lake Borgne ecosystem and address the impacts of the MRGO.

S.13.1 Project Costs

The Engineering Appendix provides the detailed preliminary design costs for all measures and the summary cost estimates for the final array of alternatives considered in detail - Alternatives B, C, and D. These cost analyses are deemed adequate for making a federal interest determination. Further, these estimates allow for the use of the CE/ICA optimization comparison and selection of a federally identified plan in accordance with Corps Ecosystem Restoration policy. The Mii cost estimate and narrative summary is provided in the Engineering Appendix. This appendix also provides the scheduled construction costs for the FIP.

Based on October 2011 Price Levels, the Project First Cost of the FIP is estimated at $2.9 billion. The Project First Cost of Tiers 1 and 2 is estimated at $1.3 billion and $325 million, respectively. The Project First Cost of the Monitoring and Adaptive Management Plan (MAMP) is $190 million, including costs for potential adaptive management actions. The Project First Cost of the MAMP for Tiers 1 and 2 are $104 million and $46 million, respectively. The operation, maintenance, repair, replacement, and rehabilitation (OMRR&R) costs for the FIP is $427 million. The OMRR&R costs for plan features in Tiers 1 and 2 are estimated at $210 and $18 million, respectively.

Table S-5. Project First Costs (October 2011 Price Levels)

	Ecosystem Restoration	**Recreation Features**	**Total**
Project First Costs ($FY 2011)	$2,879,704,000	$4,443,000	$2,884,147,000

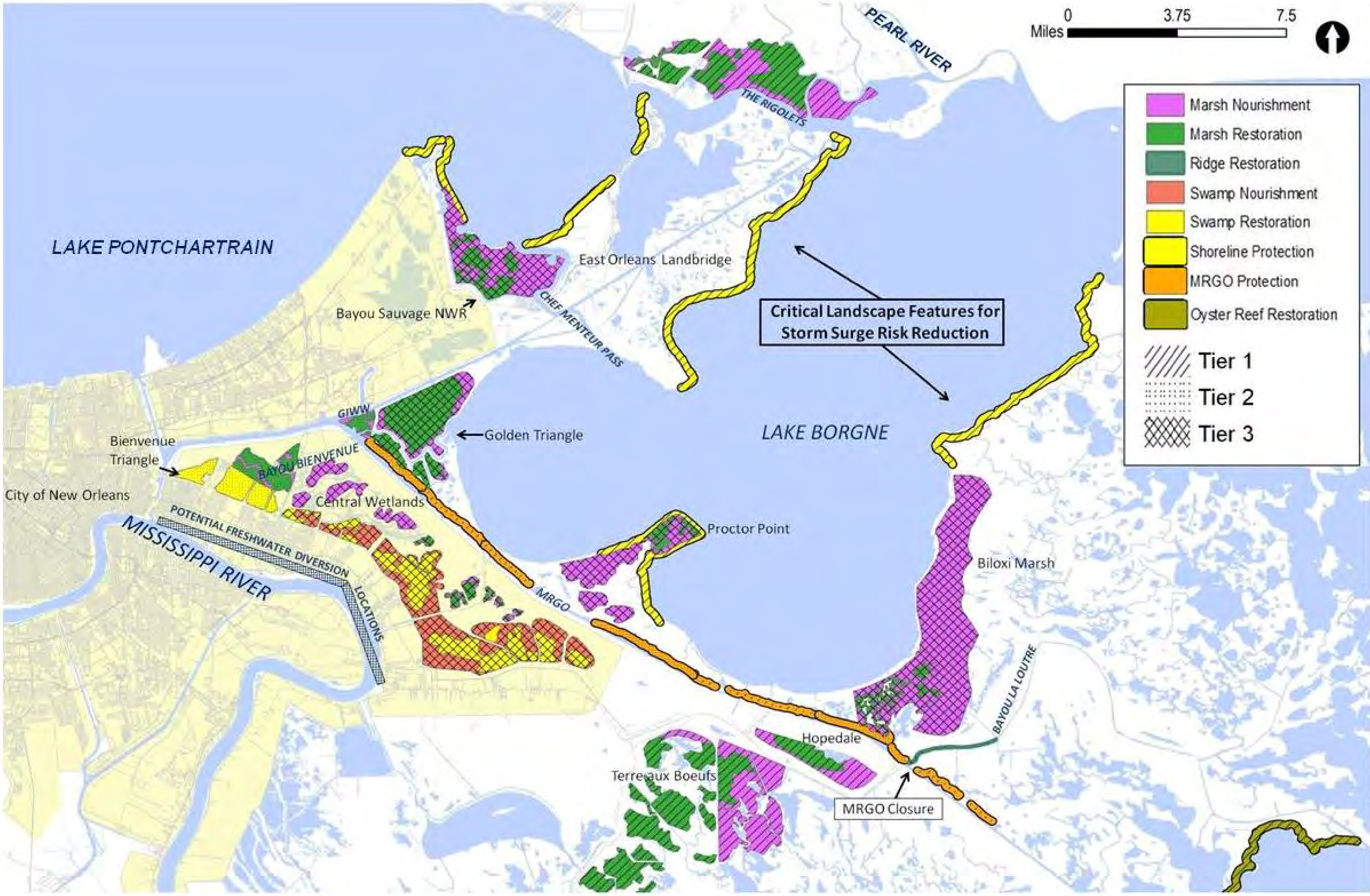

Figure S-5. Alternative C, Federally Identified Plan

Figure S-6. Alternative C, Federally Identified Plan – Perspective View

1 INTRODUCTION AND BACKGROUND

1.1 STUDY PURPOSE AND SCOPE

The Mississippi River Gulf Outlet (MRGO) Ecosystem Restoration Plan Feasibility Study is a supplement to the June 2008 MRGO Deep-Draft De-Authorization Report. It is intended to fully meet the requirements of the Water Resources Development Act (WRDA) of 2007 Section 7013 (Public Law [PL] 110-114). This feasibility study will result in a Report of the Chief of Engineers containing a recommended MRGO Ecosystem Restoration Plan. The plan has been conditionally authorized for construction by WRDA 2007 Section 7013. The Plan will address systematic ecosystem restoration and protection of the Lake Borgne ecosystem and areas affected by the MRGO navigation channel, and will include considerations of measures to reduce or prevent damage from storm surge. The study will integrate the findings of ongoing comprehensive restoration planning efforts for the study area, including the Louisiana Coastal Protection and Restoration (LACPR) Final Technical Report, the Louisiana Coastal Area (LCA) Program, and Louisiana‘s 2007 Comprehensive Master Plan for a Sustainable Coast.

The study purpose is to develop alternative plans to restore natural features and processes in the Lake Borgne ecosystem and areas affected by the former navigation channel. Construction recommendations will be developed in concert with large-scale comprehensive ecosystem restoration plans for the region. As noted in the Louisiana-Mississippi Gulf Coast Ecosystem Restoration Working Group *Roadmap for Restoring Ecosystem Resiliency and Sustainability*, the MRGO Ecosystem Restoration Plan will not necessarily provide comprehensive ecosystem restoration for the entire study area.

If the Assistant Secretary of the Army, Civil Works (ASA [CW]) determines that the recommendations of the MRGO Ecosystem Restoration Plan are cost-effective, environmentally acceptable, and technically feasible, no further Congressional authorization is needed. However, the execution of the implementation phase is subject to additional funding appropriations. Cost sharing is consistent with section 103(c) of WRDA 1986 (33 U.S.C. 2213(c)).

1.2 STUDY AND PROJECT AUTHORITY

In 2006, after Hurricane Katrina, Congress provided $75,000,000 for operation and maintenance of the MRGO channel (as authorized at that time) in the Department of Defense Emergency Supplemental Appropriations to Address Hurricanes in the Gulf of Mexico and Pandemic Influenza Act, 2006 (PL 109-148).

In 2006, the Congress directed the Secretary of the Army, acting through the Chief of Engineers, to develop a plan for deauthorization of deep-draft navigation on the MRGO in the Emergency Supplemental Appropriations Act for Defense, the Global War on Terror, and Hurricane Recovery, 2006 (PL 109-234). PL 109-234 also modified PL 109-148, to clarify that the $75,000,000 provided in PL 109-148 was to be used for "the repair, construction or provision of measures or structures necessary to protect, restore or increase wetlands, to prevent saltwater intrusion or storm surge."

The requirements for the deauthorization plan in PL 109-234 were addressed in the MRGO Deep-Draft De-Authorization Study that was submitted to the Congress on June 5, 2008, by providing a comprehensive plan, at full Federal expense, to deauthorize deep draft navigation on the MRGO from the Gulf of Mexico to the Gulf Intracoastal Waterway (GIWW). At the time that report was undergoing State and Agency review, WRDA 2007 became law, expanding the scope of the MRGO Deep Draft De-authorization Study to include ecosystem restoration. The MRGO Deep Draft De-authorization Study preliminarily addresses the requirements of WRDA 2007; however, in order to continue processing the MRGO Deep Draft De-authorization Study, U.S. Army Corps of Engineers (USACE) leadership decided to develop a supplemental report to completely address the requirements of WRDA 2007.

WRDA 2007 Section 7013, the authority for this study, is provided below:

SEC. 7013. MISSISSIPPI RIVER-GULF OUTLET.

(a) DEAUTHORIZATION.-

(3) CLOSURE AND RESTORATION PLAN.-

(A) IN GENERAL.-Not later than 180 days after the date of enactment of this Act, the Secretary shall submit to the Committee on Environment and Public Works of the Senate and the Committee on Transportation and Infrastructure of the House of Representatives a final report on the deauthorization of the Mississippi River-Gulf outlet, as described under the heading "INVESTIGATIONS" under chapter 3 of title II of the Emergency Supplemental Appropriations Act for Defense, the Global War on Terror, and Hurricane Recovery, 2006 (120 Stat. 453).

(B) INCLUSIONS.-At a minimum, the report under subparagraph (A) shall include-

(i) a plan to physically modify the Mississippi River-Gulf Outlet and restore the areas affected by the navigation channel;

(ii) a plan to restore natural features of the ecosystem that will reduce or prevent damage from storm surge;

(iii) a plan to prevent the intrusion of saltwater into the waterway;

(iv) efforts to integrate the recommendations of the report with the program authorized under section 7003 and the analysis and design authorized by title I of the Energy and Water Development Appropriations Act, 2006 (119 Stat. 2247); and

(v) consideration of-

(I) use of native vegetation; and

(II) diversions of fresh water to restore the Lake Borgne ecosystem.

(4) CONSTRUCTION.-The Secretary shall carry out a plan to close the Mississippi River-Gulf Outlet and restore and protect the ecosystem substantially in accordance with the plan required under paragraph (3), if the Secretary determines that the project is cost-effective, environmentally acceptable, and technically feasible.

Section 7003 of WRDA 2007, which is referenced in Section 7013(a)(3)(B)(iv) above, refers to the LCA Program. Title I of the Energy and Water Development Appropriations Act, 2006 (119 Stat. 2247) refers to the LACPR Final Technical Report. Both are described in Section 1.5. The MRGO LCA Near-Term Project described in WRDA 2007 Section 7006 (c)(1)(A) is also addressed in this study.

WRDA 2007 Section 7012 (b) states that the activities described in Section 7013 will be carried out consistent with the cost-share requirements in PL 109-234. Therefore, the MRGO Ecosystem Restoration Plan Feasibility Study is being conducted at full federal expense. A portion of the $75 million appropriated in PL 109-148 is being used to fund the study.

The study is 100% Federally funded. After extensive discussions with the State of Louisiana, a non-Federal sponsor has not been identified for implementation of the MRGO Ecosystem Restoration Plan authorized by Section 7013 of WRDA 2007.

In accordance with Section 221 of Public Law 91-611, Flood Control Act of 1970, as amended (42 U.S.C. 1962d-5), and Section 103 of the WRDA 1986, as (33 USC 2213(c)), implementation of the MRGO Ecosystem Restoration Plan (Tiers 1, 2 and 3B) requires a non-Federal sponsor responsible for providing 35 percent of the costs assigned to ecosystem restoration; providing the lands, easements, rights-of-way, and dredged or excavated material disposal areas required for the plan, and performing all necessary relocations (LERRDs); and paying 100 percent of the costs of operation, maintenance, repair, rehabilitation, and replacement (OMRR&R). Implementation of recreation features requires a 50 percent non-Federal cost share. The value of LERRDs provided by the non-Federal sponsor would be credited toward the non-Federal share of the costs of implementing elements of the plan.

The State of Louisiana disagrees with USACE over the cost-share requirements for implementation of the MRGO Ecosystem Restoration features of the plan (Tiers 1, 2 and 3B) and has expressed its unwillingness to participate in plan implementation unless it is undertaken at full (100%) federal cost. The USACE will continue to coordinate with the State of Louisiana to finalize the ecosystem restoration plan and to identify a non-Federal sponsor to cost share in implementation of the plan.

The State of Mississippi, along with the State of Louisiana, has been actively involved in the development of the Violet, Louisiana Freshwater Diversion project preliminarily addressed in this report (Tier 3A). The non-Federal cost-share responsibilities for the Violet, Louisiana Freshwater Diversion would be consistent with the 75 percent/25 percent Federal/non-Federal cost share identified in Section 3083 of WRDA 2007, together with such other items of cost-share responsibilities as may be identified in the Feasibility Report for the project, as approved by the decision of the Chief of Engineers. Presently, as identified in the 1984 Chief's Report for *Mississippi and Louisiana Estuarine Areas Freshwater Diversion to Lake Pontchartrain and Mississippi Sound Feasibility Study*, the 25 percent non-Federal share of the cost of the design and implementation of the Violet, Louisiana Freshwater Diversion project is allocated 80 percent to the State of Louisiana and 20 percent to the State of Mississippi. It is not anticipated that this allocation will change as a result of completing the feasibility study for the project; however, if it does, the change in allocation will be addressed in the study, as approved by the decision of the Chief of Engineers.

In a letter dated September 20, 2010 the Mississippi Department of Marine Resources (MDMR) declared its full support for the Violet, Louisiana Freshwater Diversion project and its understanding of its non-Federal cost sharing obligation. The State of Mississippi's letter also states its desire that the USACE, to the fullest extent possible, seek full Federal funding for the project. A letter of intent has not been received from the State of Louisiana regarding the Violet, Louisiana Freshwater Diversion project (Tier 3A); however, since this report recommends further study of that project under the authority of Section 3083 of WRDA 2007, such a letter of intent will not be required until such time as that study nears completion and decision by the Chief of Engineers.

1.3 STUDY AREA

The study area (Figure 1-1) includes portions of the Mississippi River Deltaic Plain in coastal southeast Louisiana and parts of coastal southwest Mississippi. It encompasses approximately 3.86 million acres (6,023 square miles) of land and open water.

In Mississippi, the study area includes the Western Mississippi Sound, its bordering wetlands, and Cat Island. The Lake Borgne ecosystem and areas that may have been affected by the construction, operation, and maintenance of the MRGO navigation channel are included in the study area. The MRGO channel may have affected salinity as far northwest as Lake Maurepas. To the east, the MRGO channel was dredged through open water between Breton and Grand Gossier Islands (segments of the lower Chandeleur Island chain). The MRGO channel affected portions of the Lake Borgne ecosystem to the north and potentially altered hydrology to the west as far as the Bayou Terre aux Boeufs ridge.

Louisiana parishes in the study area include Ascension, Jefferson, Livingston, Orleans, Plaquemines, St. Bernard, St. Charles, St. James, St. John the Baptist, St. Tammany and Tangipahoa. Mississippi counties in the study area include Hancock and Harrison.

Lake Borgne is hydrologically linked to Lake Pontchartrain through tidal passes at The Rigolets, Chef Menteur Pass, and the Inner Harbor Navigation Canal (IHNC). The Lake Borgne ecosystem is influenced by the Pearl River to the north and is hydrologically connected to areas located as far south as Bayou Terre aux Boeufs.

Figure 1-1. Study Area

1.4 MRGO NAVIGATION CHANNEL

1.4.1 Authorization, Deauthorization, and Channel Closure

Congress authorized the MRGO in 1956 as a Federal navigation channel to provide a short route between the Port of New Orleans and the Gulf of Mexico. The MRGO was authorized as a 36-foot-deep, 500-foot-bottom-width waterway (38 feet deep, 600 feet wide at the Gulf of Mexico entrance) extending from the IHNC to the 38-foot depth contour in the Gulf of Mexico. Channel construction began in 1958 and the channel was completed in 1968.

In August 2005, Hurricane Katrina shoaled the MRGO channel limiting its depth to 22 feet and restricting deep-draft vessel access. Rather than continue funding operation and maintenance, in June 2006, Congress requested a plan to deauthorize of the MRGO (see PL 109-234).

The USACE submitted an interim report in December 2006 highlighting a plan to close the MRGO from the GIWW to the Gulf of Mexico. In January 2008, the Chief of Engineers signed a report recommending deauthorization of the channel, construction of a closure structure across the channel at Bayou La Loutre, and development of a supplemental report to provide an ecosystem restoration plan for the areas affected by the MRGO. On June 5, 2008, the ASA(CW) forwarded the *Final MRGO Deep-Draft De-authorization Report to Congress*, deauthorizing the MRGO federal navigation project from the GIWW to the Gulf of Mexico. Construction of a rock closure structure across the MRGO near the Bayou La Loutre ridge in St. Bernard Parish, Louisiana, was completed on July 9, 2009.

Figure 1-2. Completed MRGO Rock Closure Structure

1.5 MRGO ENVIRONMENTAL IMPACTS

The cumulative effects of human and natural activities in the coastal area have severely degraded the Mississippi River's deltaic processes and shifted the Louisiana coastal area to a net land loss condition. Many studies have been conducted to identify the major contributing factors (e.g., Boesch et al. 1994; Turner 1997; Penland et al. 2000), and many studies agree that land loss and the degradation of the coastal ecosystem are the result of both natural and human induced factors, producing conditions where wetland vegetation can no longer survive and wetlands are lost. Establishing the relative contribution of natural and human-induced factors is difficult. In many cases, the changes in hydrologic and ecologic processes manifest gradually over decades and in large areas, while other effects occur over single days and impact relatively localized areas.

Construction and operation of the MRGO contributed to wetland loss and damages to estuarine habitats in Louisiana from the outer tidal marshes in Breton Sound to the cypress forests and fresh mashes in the western reaches of the Lake Borgne basin. Loss of marsh and cypress swamp habitats has resulted in the decline of important ecological habitat as well as natural surge and wave buffers. Indirect and cumulative impacts associated with saltwater intrusion attributable to the MRGO occurred throughout the Lake Pontchartrain Basin. Due to the hydrologic connectivity of the system, the MRGO contributed to habitat changes and loss from Lake Maurepas to the north, Bayou Terre aux Bouefs to the west, Mississippi Sound to the east, and the outer reaches of Breton and Chandeleur Sounds to the south.

The direct and indirect habitat impacts of the construction and operation of the MRGO between 1956 and 1990 were estimated in *Habitat Impacts of the Construction of the MRGO* (USACE 1999). MRGO channel construction, including the dredging of the canal and placement of dredged spoil, resulted in the conversion of 19,400 acres of wetlands and 4,750 acres of shallow open water to deep open water or spoil.

Other contributing factors of land loss, such as subsidence, complicate the calculation of MRGO indirect impacts. The methodology for estimating indirect impacts utilized habitat data from the Louisiana Department of Natural Resources (LDNR) for 1956 and 1990 (USACE 1999). Increased land loss due to the MRGO was estimated by calculating a baseline loss by mapping unit, which included all land loss factors (such as subsidence and sea level rise) as well as the MRGO, and then estimating what percentage of the baseline loss was caused by the navigation channel to develop a ―without MRGO” loss rate. The percentages were developed based on the condition of the area prior to channel construction, proximity to the direct effects of the channel, and the significance of saltwater intrusion to each area. This loss rate was applied to the acres present in 1956; and the resulting 1990 acres were compared to calculate the possible increased loss. Additional losses due to erosion along the MRGO between 1990 and 2008 were calculated by U.S. Geological Survey team members. The methodology used in the 1999 report was re-assessed and validated. The ―without MRGO” loss rates are estimates based on a professional assessment of various contributing factors.

There are no new tools available to provide a more accurate picture of what the landscape would look like if the channel had never been built. These estimates, and the methodology used to develop them, were verified as the best available quantification of MRGO impacts. Table 1-1 summarizes the direct and indirect impacts by habitat type.

Table 1-1. Direct and Indirect Habitat Impacts of the MRGO Navigation Channel

Habitat Type	Impacts from 1956 to 1990 as Documented in *Habitat Impacts of the Construction of the MRGO**	
	Direct Impacts (acres lost)	Indirect Impacts (acres lost or converted)
Cypress swamp	1,510	8,000
Fresh/intermediate marsh	3,370	3,350
Brackish marsh	10,310	19,170
Saline marsh	4,210	N/A
Shallow open water converted to deep water or disposal	4,750	N/A
Additional marsh lost adjacent to the channel**	460	3,400
Total Impacts	24,610 Acres Lost	33,920 Acres Lost or Converted

*Direct impacts are due to construction and erosion. Indirect impacts are due to salinity or hydrological changes from the MRGO. Habitat shifts were estimated using 1956-1990 habitat composition data from LDNR.
**Direct impacts due to additional erosion between 1990 and 2008. Indirect impacts due to increased tides and salinity.
Does not include deeper water aquatic habitat effects due to salinity increases or Lake Maurepas area to be restored by LCA projects.

Other studies have attributed additional impacts to the MRGO. The Mister Go Must Go report estimates the total impact of the MRGO is 618,000 acres (Day et al. 2006). This estimate includes 488,400 acres of Lakes Pontchartrain and Borgne affected by salinity shifts. This also includes 64,000 acres of Lake Pontchartrain that exhibited seasonal hypoxic/anoxic conditions due to its hydrologic connection with the MRGO channel. The report cites *Habitat Impacts of the Construction of the MRGO* as the source for other impact figures (Day et al. 2006).

Initial monitoring data indicate that the channel closure at Bayou La Loutre has significantly decreased salinity upstream of the closure (USGS 2009). Results of sampling conducted near the mouth of the IHNC in Lake Pontchartrain prior to and after closure in summer 2009 indicate a substantial reduction in differences between surface and bottom salinity and dissolved oxygen levels (personal communication, Dr. Michael A. Poirrier, UNO). Low dissolved oxygen (DO) levels (<4.0 milligrams per liter [mg/L]) have not been observed in Lake Pontchartrain since the construction of the closure. Water quality monitoring has been conducted in and around the channel following the construction of the closure, and areas of low DO have been occasionally observed in the MRGO southeast of the closure. Based on preliminary data, these occurrences appear to be seasonal and temporary. Because there is limited water quality data from the MRGO prior to the construction of the closure, it is unclear what, if any, impacts to DO in the channel are related to the closure. The closure at Bayou La Loutre and other authorized projects are anticipated to continue to address the impacts of the former navigation channel in Lakes Pontchartrain and Borgne with respect to hypoxia and salinity changes. Therefore, these acreages are not included in impact quantifications used to formulate restoration plans.

Prior to construction of the MRGO, typical tidal flow within the Breton Sound area was reduced as it moved across the marsh inward toward Lake Borgne (USACE 2004). The MRGO was dredged through the Bayou La Loutre ridge, which provided a basin boundary limiting the flow of saline water from the Breton Sound area into Lake Borgne (Rounsefell 1964). Habitat changes in the study area are primarily related to saltwater intrusion, although other factors such as logging and the construction of impoundments contributed to these changes. The salinity changes based on pre- and post-channel water quality monitoring are documented in –Salinity Changes in Pontchartrain Basin Estuary, Louisiana, Resulting from Mississippi River-Gulf Outlet Partial Closure with Width Reduction, Final Report" (Tate et al. 2002) (Figure 1-3).

This study is a component of the larger coastal restoration efforts that will be required to ensure the resilience and sustainability of the coast. This study is specifically focused on restoration of historic habitat types in the areas affected by the MRGO channel and the Lake Borgne Ecosystem. Restoration objectives were developed using the quantities in Table 1-1 to achieve the overarching goals of the study and address the study authority. As discussed in detail in Section 2, it is not feasible to restore the study area to a historic state. Rather, this study intends to develop a plan to restore historic habitat types, processes, and conditions to the extent practicable to address systemic problems in the area.

1.6 PRIOR STUDIES, REPORTS, AND EXISTING WATER PROJECTS

Information related to the MRGO study area has been accumulated over five decades. Planning for this study builds upon existing studies and plans. For example, study area problems and opportunities have been documented in numerous prior studies. Where conditions have changed or new information has become available, additional analyses have been performed to develop an ecosystem restoration plan based on sound science and engineering. The following comprehensive planning efforts for the Mississippi and Louisiana coastal areas provided a foundation for the development of the MRGO Ecosystem Restoration Plan.

Coast 2050 (1998–1999). This conceptual restoration plan for the Louisiana coast incorporated public and scientific input through the Coastal Wetlands Planning, Protection and Restoration Act (CWPPRA) and other programs. The plan reflected a growing recognition that a more comprehensive approach to restoring coastal wetlands was needed. This plan informed the MRGO Ecosystem Plan Feasibility Study.

Louisiana Coastal Area (LCA) Program (2000–present). The 2004 LCA feasibility study built on the Coast 2050 strategies, incorporating the best available science and technology, to develop a plan addressing the most critical coastal ecological needs. WRDA 2007 Section 7006(c) authorized the construction and further study of specific projects in accordance with the January 2005 LCA Chief's Report. This plan proposed to construct rock breakwaters along the entire north bank of the MRGO and along important segments of the southern shoreline of Lake Borgne as a critical near-term need. In accordance with the implementation guidance for this study, the feasibility report and NEPA compliance document developed for the plan for ecosystem restoration authorized by Section 7013 will include recommendations regarding the project for MRGO environmental restoration referenced in Section 7006(c)(1)(A) of WRDA 2007. Data from the LCA report was used in the MRGO study, and alternative plans were evaluated for consistency with the LCA plan.

Louisiana Coastal Protection and Restoration (LACPR) Technical Report (2005–present). The LACPR report includes a coastwide analysis and design of a multiple lines of defense approach to –Category 5" hurricane damage risk reduction. The report includes structural measures (e.g. levees), nonstructural measures (e.g. elevating homes) and coastal restoration measures (e.g. marsh creation). Data and restoration measures from the LACPR report were incorporated in the MRGO Ecosystem Restoration Plan Feasibility Study. Alternative plans developed for the MRGO study were evaluated for consistency with LACPR.

Mississippi Coastal Improvements Program (MsCIP) Comprehensive Plan (2005–present). Concurrent with LACPR, Congress authorized the MsCIP study to address hurricane and storm damage reduction and coastal restoration in coastal Mississippi. In January 2010, the Final MsCIP Report was transmitted to Congress. This plan provided data and potential restoration measures included in the MRGO study. Alternative plans developed for the MRGO study were evaluated for consistency with MsCIP.

Integrated Ecosystem Restoration and Hurricane Protection: Louisiana's Comprehensive Master Plan for a Sustainable Coast (2007 State Master Plan) (2005–present). The Louisiana Legislature, through Act 8 of the First Extraordinary Session of the 2005 Louisiana Legislature, established the Coastal Protection and Restoration Authority (CPRA) to develop, implement, make reports on, and provide oversight for a comprehensive coastal protection master plan and annual coastal protection plans. The MRGO Ecosystem Restoration Plan incorporated data and proposed restoration measures from the Master Plan. Consistency with the 2007 State Master Plan was evaluated as part of the planning process.

In addition to the comprehensive planning efforts described above, Table 1-2 lists other prior Federal and state efforts and notes how each is relevant to the MRGO study.

Non-governmental organizations have also participated in various coastal restoration projects. Public and private parties involved in wetlands preservation or restoration activities in coastal Louisiana include Coastal America, Corporate Wetlands Restoration Partnership, Gulf Coast Joint Venture, Audubon Society, National Fish and Wildlife Foundation, The Nature Conservancy, and the National Wildlife Federation. These efforts are primarily preservation focused and did not appreciably influence plan formulation.

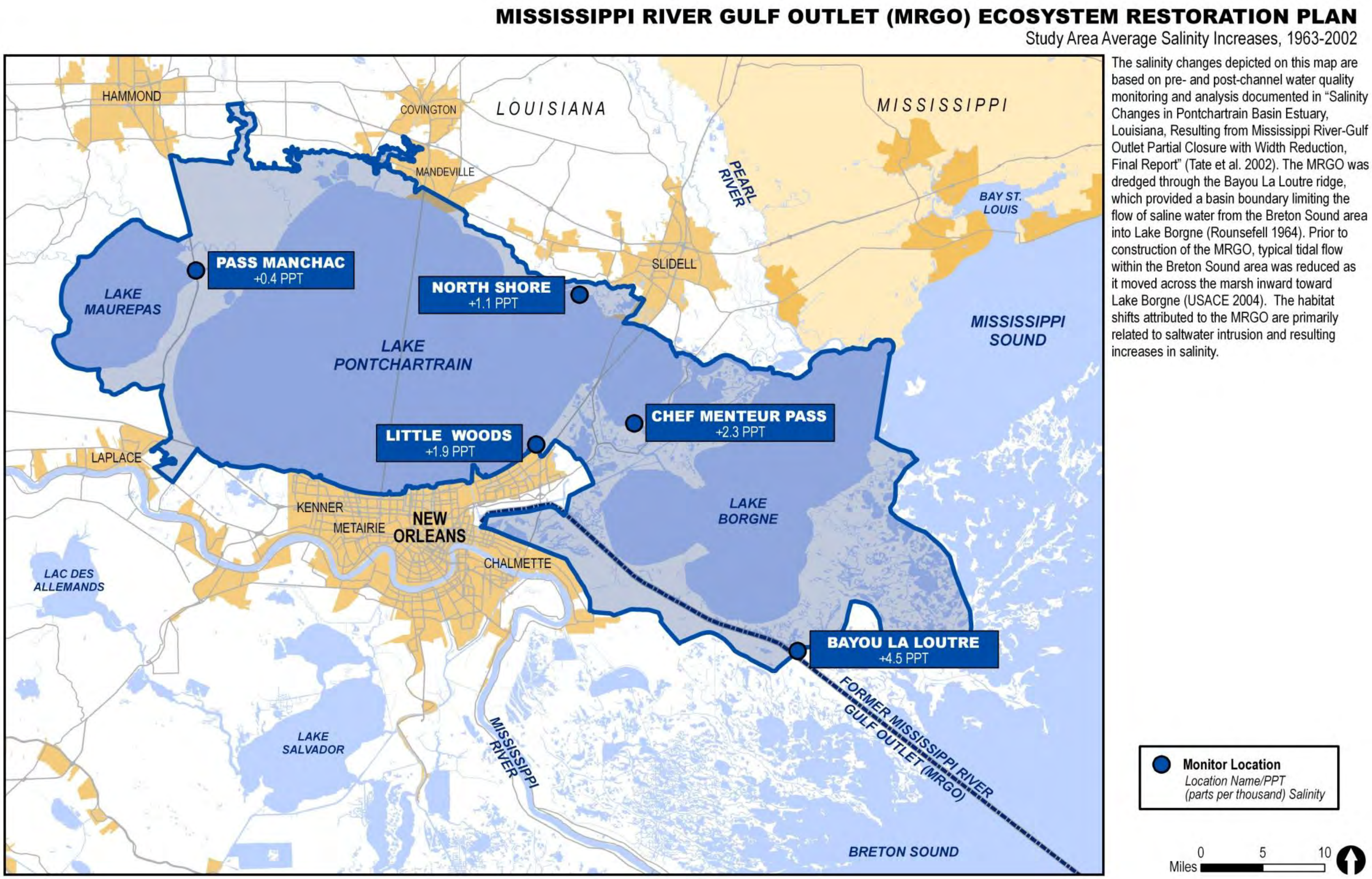

Figure 1-3. Salinity Impacts of the MRGO

Table 1-2. Prior Studies, Reports, Programs, Projects, and Laws					
Topic	**Prior Reports, Studies, Programs, Projects, and Laws**	**Data**	**Consistency**	**Measures included in the Initial Array**	**Future Without Project**
Former MRGO Navigation Channel and Projects in the Vicinity of Lake Borgne	Final Environmental Impact Statement (FEIS) for the Mississippi River-Gulf Outlet (MRGO), Louisiana, and Lake Borgne – Wetland Creation and Shoreline Protection Project, 2009	X	X	X	X
	Integrated Final Report to Congress and Legislative Environmental Impact Statement for the MRGO Deep-Draft De-authorization Study, 2008	X	X		X
	Measures undertaken pursuant to the authorization provided under the heading ―Operation and Maintenance" in Title I, Chapter 3 of Division B of PL 109-148, as modified by Section 2304 Title II, Chapter 3 of PL 109-234, 2006	X	X		X
	Ecological Review, Lake Borgne and MRGO Shoreline Protection, 2005	X	X	X	X
	MRGO Reevaluation Study, 2005	X			
	MRGO North Bank Foreshore Protection Evaluation, 1996	X		X	X
	MRGO St. Bernard Parish, Louisiana, Reconnaissance Report, 1988	X			
	MRGO, Michoud Canal, Louisiana Project, 1968	X	X		X
	Mississippi River Outlets, Venice, Louisiana, 1968	X			X
	Mississippi River Gulf Outlet, September 1956	X			
	Bayous La Loutre, St. Malo and Yscloskey, 1945	X			X
LACPR	Louisiana Coastal Protection and Restoration (LACPR) Final Technical Report, 2009	X	X	X	
LA Master Plan	Louisiana's Comprehensive Master Plan for a Sustainable Coast, 2007	X	X	X	
MS Portion of the Study Area	Mississippi Coastal Improvements Program (MsCIP) Comprehensive Plan Report, 2009	X	X	X	
	MsCIP Interim Report Near-Term Projects, 2006	X	X		X
	Coastal Wetlands Protection Act (Mississippi Code Section 49-27-1, 49-27-71), 2003		X		
	Wetlands Protection Act (Mississippi Code Section 49-27-5), 1992		X		
	Mississippi Sound and Adjacent Areas: Dredged Material Disposal Study, Feasibility Report, 1984	X			
CIAP	Coastal Impact Assistance Program (CIAP)	X	X	X	
	CIAP Projects Authorized for Construction or Under Construction	X	X		X

Table 1-2 Prior Studies, Reports, Programs, Projects, and Laws

Table 1-2. Prior Studies, Reports, Programs, Projects, and Laws

Topic	Prior Reports, Studies, Programs, Projects, and Laws	Data	Consistency	Measures included in the Initial Array	Future Without Project
Louisiana Coastal Area (LCA)	LCA Near Term Projects Authorized in WRDA 2007: 1. Mississippi River Gulf Outlet (MRGO) environmental restoration features 2. Small diversion at Hope Canal (1,000 – 5,000 cfs) 3. Small diversion at Convent/Blind River (1,000 – 5,000 cfs) 4. Increase Amite River Diversion Canal influence by gapping banks 5. Medium diversion at White Ditch (5,001 – 15,000 cfs) 6. Modification of Caernarvon diversion	X	X		X
CWPPRA	The Coastal Wetlands Planning, Protection and Restoration Act (CWPPRA) Program	X	X	X	X
	CWPPRA Projects with Approved Grants	X	X		X
	CWPPRA Violet Freshwater Distribution (Deauthorized September 11, 2006)	X			
	CWPPRA Bayou Lamoque Diversion	X	X		X
	CWPPRA White Ditch Siphon	X			
	CWPPRA Goose Point/Pointe Platte Marsh Creation	X			X
	CWPPRA Fritchie Marsh Restoration	X			X
	CWPPRA Lake Borgne Shoreline at Shell Beach and Bayou Dupre	X	X		X
Violet Diversion	Violet, LA, (WRDA 2007)	X	X	X	
Bonnet Carré	Bonnet Carré Diversion	X		X	
	Bonnet Carré Spillway	X			X
Gulf Intracoastal Waterway	Draft Environmental Assessment Maintenance Dredging and Disposal of Dredged Material Mississippi and Louisiana Portions of the Gulf Intracoastal Waterway Federally Authorized Navigation Project Hancock, Harrison and Jackson Counties, Mississippi and Coastal Louisiana, 2008	X	X	X	
	Gulf Intracoastal Waterway (GIWW), 1826 and other dates	X			X
Caernarvon	Caernarvon Freshwater Diversion	X	X		X
IHNC Lock	Inner Harbor Navigation Canal Lock Replacement Project, 1956	X	X		X
MR&T	Mississippi River and Tributaries (MR&T), 1928	X			X

Table 1-2 Prior Studies, Reports, Programs, Projects, and Laws

Table 1-2. Prior Studies, Reports, Programs, Projects, and Laws					
Topic	**Prior Reports, Studies, Programs, Projects, and Laws**	**Data**	**Consistency**	**Measures included in the Initial Array**	**Future Without Project**
Risk Reduction System	Greater New Orleans Hurricane and Storm Damage Risk Reduction System (HSDRRS)	X	X		X
	Inner Harbor Navigation Canal (IHNC) Surge Barrier	X	X		X
	Individual Environmental Report #11, Improved Protection on the Inner Harbor Navigation Canal, Orleans and St. Bernard Parishes, Louisiana, 2008	X	X		X
	Investigation of the Performance of the New Orleans Flood Protection Systems in Hurricane Katrina on August 29, 2005, Final Report, 2006	X	X		
	Performance Evaluation of the New Orleans and Southeast Louisiana Hurricane Protection System, Draft Final Report of the Interagency Performance Evaluation Task Force (IPET), USACE, 2006	X	X		
	Southeast Louisiana Urban Flood Control Project (SELA), 1996	X	X		X
	Lake Pontchartrain and Vicinity, Louisiana, Hurricane Protection Project, 1965	X	X		X
Public Laws	Second Emergency Supplemental Appropriations Act to Meet the Immediate Needs Arising from the Consequences of Hurricane Katrina, 2005 (PL 109-062)	X	X		X
	Department of Defense, Emergency Supplemental Appropriations to Address Hurricanes in the Gulf of Mexico, and Pandemic Influenza Act, 2006 (PL 109-148) (Authorization for LACPR)	X	X	X	
	Emergency Supplemental Appropriations Act for Defense, the Global War on Terror, and Hurricane Recovery, 2006 (PL 109-234)	X	X		X
Other	Coast 2050 Report, 1999	X		X	
	Other Environmental Assessments and Environmental Impact Statements	X	X		X

1.7 ENVIRONMENTAL OPERATING PRINCIPLES

In 2002, the USACE reaffirmed its long-standing commitment to environmental conservation by formalizing a set of Environmental Operating Principles applicable to decision-making in all programs. The principles are consistent with NEPA; the Department of the Army‘s Environmental Strategy with its four pillars of prevention, compliance, restoration, and conservation; other environmental statutes and WRDA that govern USACE activities. The Environmental Operating Principles inform the plan formulation process and are integrated into all proposed program and project management processes.

The Environmental Operating Principles are as follows:

1. Strive to achieve environmental sustainability, and recognize that an environment maintained in a healthy, diverse, and sustainable condition is necessary to support life.

2. Recognize the interdependence of life and the physical environment, and proactively consider environmental consequences of USACE programs and act accordingly in all appropriate circumstances.

3. Seek balance and synergy among human development activities and natural systems by designing economic and environmental solutions that support and reinforce one another.

4. Continue to accept corporate responsibility and accountability under the law for activities and decisions under our control that impact human health and welfare and the continued viability of natural systems.

5. Seek ways and means to assess and mitigate cumulative impacts to the environment and bring systems approaches to the full life cycle of our processes and work.

6. Build and share an integrated scientific, economic, and social knowledge base that supports a greater understanding of the environment and impacts of our work.

7. Respect the views of individuals and groups interested in USACE activities, listen to them actively, and learn from their perspective in the search to find innovative win-win solutions to the nation‘s problems that also protect and enhance the environment.

Ecosystem sustainability and diversity have been integrated into the goals and objectives for the study and have guided the plan development, evaluation and selection processes. Target acres by habitat type, a salinity regime, and restoration of critical landscape features have been used as metrics for incorporating sustainability and habitat diversity into plan formulation. Sections 2.5 through 2.10 detail the plan formulation, evaluation and selection processes, including discussions of the significance of a healthy, sustainable, and diverse ecosystem.

Generally, consequences of restoration measures evaluated in this study are beneficial to both the natural and human environments. For example, improving aquatic habitat can have a positive impact to commercial fishing interests. In some instances, beneficial effects in the natural environment can result in adverse impacts to the human environment, and vice versa. In cases where an environmental benefit may have adverse effects to another environmental or human resource, the beneficial and adverse consequences have been carefully considered in the plan formulation process.

Decisions and recommendations that may result from this study would be compliant with all applicable laws, regulations and policies. The potential adverse and beneficial impacts of any proposed actions would be evaluated with particular attention to the continued viability of the ecosystem and potential impacts to the health, safety and welfare of the public.

This study has undertaken a proactive public involvement campaign, including an interactive website, technical workshops, regular stakeholder visits, focus group meetings, and targeted stakeholder forums. Active and responsive public involvement has informed the development of solutions to the problems this study seeks to address, and has facilitated the sharing and distribution of data and knowledge. The relationships that the study team has developed with non-governmental organizations (NGOs), local officials, community and special interest groups, the academic community and agency partners are intended to facilitate the consensus-building process. The public coordination for this study is discussed in Section 3.0.

1.8 ENVIRONMENTAL PLANNING GUIDING PRINCIPLES

Several of the guiding principles established in the LACPR Technical Report, Coastal Restoration Appendix applicable to this study area were adopted. The overarching principle adopted from the LACPR technical report is that sustaining the integrity of the estuarine environments in coastal Louisiana, including various landscape features that make up those environments is critical to the ecological health, social and economic welfare of the region. Model analysis conducted for the LACPR of storm surge levels and wave magnitudes demonstrate the value of coastal features to lowering storm risks (USACE 2009). While the models show benefits from additional marsh, island and landbridge habitat, the effects of allowing existing features to degrade are even more pronounced.

Guiding principles include:

- Relatively intact estuarine ecosystems are a key attribute in coastal Louisiana, and alternatives should seek to enhance the resilience and self-sustainability of the estuarine environments, including protection of existing high-quality estuaries.
- Restoration of key processes and dynamics are critical to the long-term health of the ecosystem.
- Riverine diversions must be carefully sited to maximize sediment retention within the coastal ecosystem and avoid sediment loss to the Gulf because of reduced Mississippi River sediment loads. Therefore, measures and alternatives must seek to maximize the combined benefits of diversions that seek to restore natural processes with mechanical marsh creation measures.
- Additional sources of sediments should be sought where feasible; recognizing that such measures should not contribute to ecosystem degradation in the source area.

- Measures should be combined synergistically to maximize possible cumulative benefits. Thus, the position of features within the landscape has a direct influence on the potential benefits derived.
- Capacity to assess and quantify benefits and impacts from various measure combinations may be limited due to the state-of-the-science, uncertainty with future development, relative sea level rise and other factors. Flexibility is required in project design and implementation to permit adaptive management as conditions change and more is learned.
- A concerted monitoring and adaptive management program should be a component of the restoration plan.

1.9 ROADMAP FOR RESTORING ECOSYSTEM RESILIENCY AND SUSTAINIBILITY

In October 2009, President Obama formed the Louisiana-Mississippi Gulf Coast Ecosystem Restoration Working Group, co-led by the White House Council on Environmental Quality (CEQ) and the Office of Management and Budget (OMB) and comprising senior-level officials from the National Oceanic and Atmospheric Administration (NOAA), the U.S. Environmental Protection Agency (EPA), and the Departments of the Army (USACE), Homeland Security, the Interior, and Transportation. The Working Group has developed a Roadmap for Restoring Ecosystem Resiliency and Sustainability in the Louisiana and Mississippi Coast. One of the findings of this roadmap is that ―bold and decisive action is needed now to curtail the rate of wetland loss and barrier island erosion in the area and to restore some of these lost features and ecosystem services."

The systems-based planning approach for this study is in accordance with the strategic approach described in the Louisiana-Mississippi Gulf Coast Ecosystem Restoration Working Group *Roadmap for Restoring Ecosystem Resiliency and Sustainability*. Specifically, the planning process was cognizant of the following key points of the strategic approach:

- Enhancing essential coastal processes and the ecological services they provide.
- Incorporating a multiple lines of defense strategy.
- Safeguarding the region's rich cultural history and economic resources.
- Addressing the potential impacts of accelerated sea level rise and subsidence as a strategy to protect communities, infrastructure, and to restore ecosystems and the services they provide.

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2 PLAN FORMULATION

The guidance for conducting Civil Works planning studies (ER 1105-2-100) requires the systematic formulation of alternative plans that contribute to the Federal objective. To ensure that sound decisions are made, the plan formulation process requires a systematic and repeatable approach. The Economic and Environmental Principles and Guidelines for Water and Related Land Implementation Studies (Principles and Guidelines) describe the USACE study process and requirements.

Step 1 – Identify Problems and Opportunities. The first phase of the planning process defines study area problems and opportunities, as well as study goals, objectives, and constraints. Because this is an ecosystem restoration study, problems and opportunities are developed to address the Federal objective of National Ecosystem Restoration (NER). Goals, objectives, and constraints are developed to help solve the problems and achieve the opportunities within the confines of legislative authority, policies, and other restrictions.

Step 2 – Inventory and Forecast Conditions. The second planning step consists of inventorying and forecasting study area resources. This inventory step accounts for the level or amount of a particular resource that currently exists within the study area, i.e., identification of existing conditions. This step also involves forecasting to predict what changes will occur to resources throughout the 50-year period of analysis, assuming no actions are taken to address the problems in the study area. Comparison of the existing and forecast conditions of the study area measures the problems resulting from the change in resources over time. Study area problems are quantified based on this predicted change in resources. This second step also results in the delineation of opportunities that fully or partially address the study area problems. An opportunity is a resource, action, or policy that, if acted upon, may alter the conditions related to an identified problem.

Step 3 – Formulate Alternatives. The third step is to generate alternative solutions. Alternative plans are formulated across a range of potential scales to demonstrate the relative effectiveness of various approaches at varying scales. Alternatives are formulated in consideration of study area problems and opportunities, as well as study goals, objectives and constraints with consideration of four criteria: completeness, effectiveness, efficiency, and acceptability.

1. **Completeness** is the extent to which a given alternative plan provides and accounts for all necessary investments or other actions to ensure the realization of the planned effects.
2. **Effectiveness** is the extent to which an alternative plan alleviates the specified problems and achieves the specified opportunities.
3. **Efficiency** is the extent to which an alternative plan is the most cost-effective means of alleviating the specified problems and realizing the specified opportunities, consistent with protecting the nation‘s environment.
4. **Acceptability** is the workability and viability of the alternative plan with respect to acceptance by state and local entities and the public and compatibility with existing laws, regulations, and public policies.

Step 4 – Evaluate Alternatives. In the fourth step, alternative plans are evaluated for their potential results to address the specific study problems, needs, and objectives. The measure of output is expressed by the difference in amount or effect of a resource between the –No-Action Alternative” conditions and those predicted to occur with each –Action Alternative” in place. This difference is referred to as the benefits of the action alternative. This evaluation focuses on ecosystem benefits, which are measured in metrics that reflect the area, productivity, and value of restored or conserved habitats.

Step 5 – Compare Alternatives. The planning process continues with the fifth step, comparison of alternative plans to each other utilizing the benefit outputs and costs of the alternatives. A relationship between costs and varying levels of ecosystem restoration outputs across a full range of scales is compared.

Step 6 – Select a Plan. The sixth and final step in the process is selection of the plan that best meets the study objectives and the four criteria in the Principles and Guidelines: completeness, effectiveness, efficiency, and acceptability. Using the six-step planning process, the recommended plan is identified.

The USACE Planning Manual (IWR Report 96-R-21) describes planning as a dynamic and iterative process, in which steps are repeated and may occur out of order. For instance, the identification of existing and future conditions contributes to the understanding of system-wide problems and opportunities. During every point in the process, previous steps may be revised and subsequent steps may be anticipated. This planning approach allows the process to progress based on the best information available at any given time.

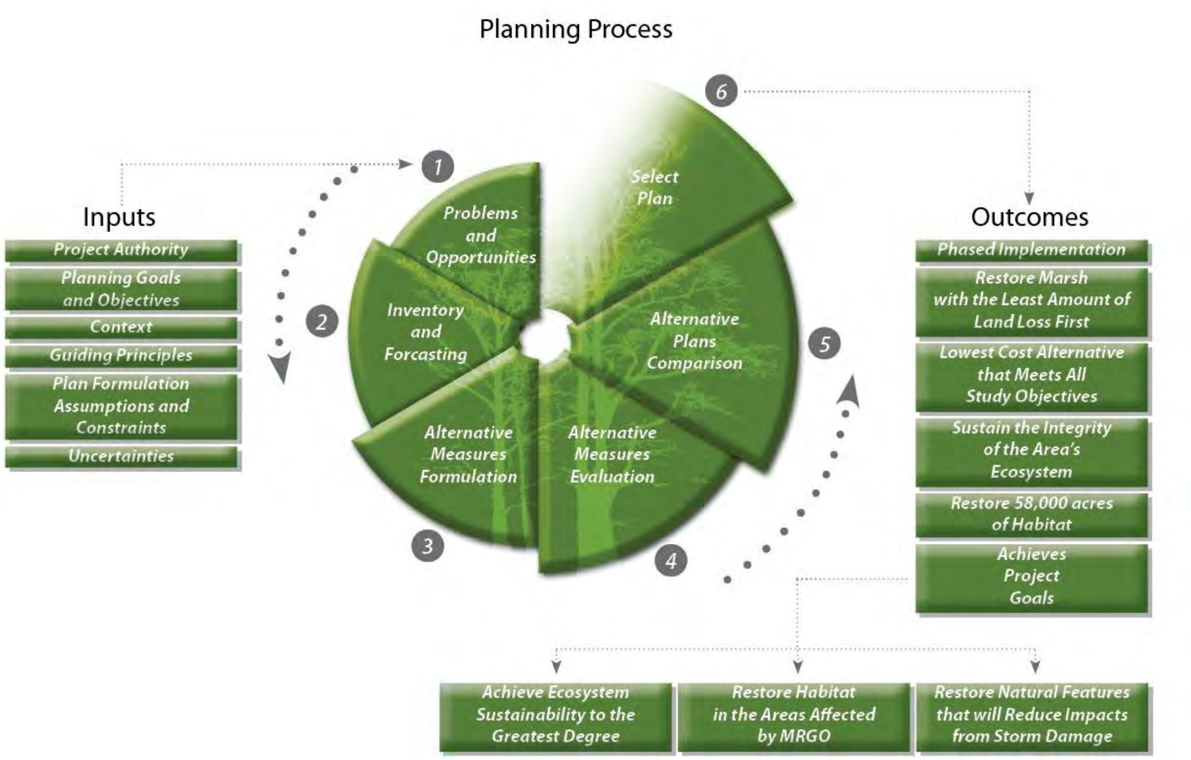


Figure 2-1. Planning Process

2.1 KEY PLANNING ASSUMPTIONS

In formulating and evaluating alternatives, certain assumptions and/or simplifications were required. Table 2-1 provides a brief summary of the major assumptions and the scientific basis or rationale behind each assumption. Additional assumptions specific to plan formulation and evaluation are described in sections 2.6, 2.7, and 2.8, as well as the Environmental Impact Statement (EIS) and Engineering Appendix for this study.

Table 2-1. Key Assumptions

Assumption	Rationale for the Assumption
Study Area	
The MsCIP effort and other planning efforts led by the USACE Mobile District will address vegetated habitat ecosystem restoration needs in the portions of the study area located in Mississippi. Except for diversions of freshwater, the MRGO ecosystem restoration study will not formulate measures for the purpose of ecosystem restoration in Mississippi.	The MsCIP Comprehensive Plan addressed ecosystem restoration needs in the Bay St. Louis and western Mississippi Sound areas, such as barrier island and submerged aquatic vegetation restoration. To avoid redundancy and ensure consistency with that plan, the MRGO ecosystem restoration plan will not re-evaluate those measures.
Plan Objectives	
It is not a study objective or restoration target to restore the study area to a pre-MRGO hydrologic condition.	This condition cannot be achieved within the study constraints due to authorized navigation and risk reduction protection projects and other landscape changes.
The primary purpose of the plan is ecosystem restoration. Hurricane and storm damage risk reduction through the protection and restoration of natural features contributes to the need for the plan and is an authorized goal of the study. The reduction of damages will not be monetarily quantified. This portion of the study authority will be achieved through the restoration of habitat in areas identified as critical landscape features for storm surge reduction in scientific literature.	The WRDA implementation guidance dated 28 April 2009 says, ―Alternative plans shall be formulated *for the purpose of ecosystem restoration* inclusive of the requirements set forth in Section 7013 of WRDA 2007. Ecosystem restoration studies do not require the quantification of economic benefits. Benefits of coastal landscape features with respect to storm damage risk reduction are difficult to empirically quantify due to the complex interaction of dynamic variables.
Future Without Project Conditions	
Restoration of the Lake Maurepas swamps is assumed to be part of the future without project conditions.	Swamp restoration in these areas is addressed through several authorized LCA/CWPPRA diversion projects.
Period of Analysis	
For comparison of alternatives, the total period of analysis is from 2012 to 2065.	The period of analysis includes implementation plus 50 years. The implementation phase is 2012 to 2015 (begins with the first PED year; concludes with first construction completion year). The 50-year period begins with the first year of operation (first year when benefits would be realized) and is 2015 to 2065. Consideration beyond the period of analysis is given to environmental factors.

Table 2-1. Key Assumptions

Assumption	Rationale for the Assumption
Relationship to Violet, Louisiana Freshwater Diversion Authority	
Section 3083 of WRDA 2007 authorizes the design and implementation of a diversion at or near Violet, Louisiana, which is located within the MRGO Ecosystem Restoration Plan study area. A freshwater diversion project at or near the Violet Canal will be analyzed as a component of the MRGO Ecosystem Restoration Plan.	This study has identified that a freshwater diversion at or near Violet may be a key driver in the sustainability of the restoration of areas affected by the MRGO and the Lake Borgne ecosystem. Feasibility level investigations of the project authorized in WRDA 2007 Section 3083, will be included in this study, consistent with the Implementation Guidance for Section 7013 WRDA 2007 dated 28 April 2009.
Minimum Restoration Target	
The minimum restoration targets were developed to include direct and indirect habitat impacts of the former navigation channel by habitat type. Impacts include construction, operation, and maintenance of the MRGO through 2008.	These targets were set to produce a plan that meets the requirements of the study authority and USACE requirements for completeness, effectiveness, efficiency, and acceptability.
Measures	
Maintenance will be performed on all plan features.	Periodic maintenance actions will be developed to sustain benefits over the period of analysis.
Marsh restoration areas will include vegetative plantings but marsh nourishment areas will not.	Marsh nourishment is performed using a thin layer of sediment slurry over existing marsh so it is assumed that the existing marsh vegetation will survive.

2.2 EXISTING CONDITIONS

The long-term impacts of the Deepwater Horizon oil spill on coastal Louisiana are uncertain at this time. This spill may impact USACE water resources projects and studies within the Louisiana coastal area. Potential impacts include factors such as changes to existing or baseline conditions, as well as changes to Future Without Project (FWOP) and Future With Project (FWP) conditions. The USACE will continue to monitor and closely coordinate with other Federal and state resource agencies and local sponsors in determining how to best address potential problems associated with the oil spill that may adversely impact projects and studies. This may include revisions to proposed actions as well as supplemental environmental analysis and documentation for specific projects and studies.

2.2.1 Coastal System Processes

An estuary and its immediate catchment form a complex system of ecological, physical, chemical and social processes, which interact in a highly involved and, at times, dynamic fashion. The following sections summarize the key processes involved in this ecosystem. These are discussed in detail in the 2004 LCA report and Section 3.5 of the EIS.

The Deltaic Processes

The Mississippi River Deltaic Plain and its associated wetlands and barrier shorelines are the product of the accumulation of sediments deposited by the river and its distributaries during the past 7,000 years. Regular shifts in the river's course have resulted in four ancestral and two active delta lobes, which accumulated as overlapping, stacked sequences of unconsolidated sands and muds. As each delta lobe was abandoned by the river, its main source of sediment, the deltas experienced erosion and degradation due to compaction of loose sediment, rise in relative sea level, and storms. Marine coastal processes eroded and reworked the seaward margins of the deltas forming sandy headlands and barrier beaches. As erosion and degradation continued, segmented low-relief barrier headlands formed and eventually were separated from the mainland by shallow bays and lagoons forming barrier islands (USACE 2009).

Marine Processes

Water fluxes in the coastal marshes are driven by the water-level differences across the estuary. These change over the long term, seasonally, and daily. Long-term rises in sea level have been documented by many investigators, and recently average about 0.04 to 0.08 inch (1 to 2 millimeters) per year, but are projected to increase due to climate change (Titus and Richman 2001). These marine processes serve to redistribute sediments and nutrients, as well as regulate salinity levels and fluxes in the estuaries.

Fluvial Processes

The Mississippi River discharges into the Gulf of Mexico. Most of the Mississippi River waters are carried westward along the coast, freshening the Gulf waters that move in and out of the Barataria and Terrebonne estuaries, rather than reaching estuaries in the study area (USACE 2009). Some water is discharged through Baptiste Collette, Cubit's Gap and Pass a Loutre. This plume can influence the study area especially Breton Sound. The Mississippi River is leveed for most of its length so sediment no longer reaches many of the Louisiana marshes. The Pearl River discharges into the Lake Borgne ecosystem via The Rigolets. Other smaller rivers in the Pontchartrain watershed contribute additional water and sediments from local watersheds.

Chemical Processes

Elements and compounds can enter tidal wetlands by tidal exchange, precipitation, upland runoff, and groundwater flow. Once in the wetlands, they may be deposited on water bottoms, adsorbed to particles, or adhered in the tissues of rapidly growing vascular plants.

Biological Processes

Coastal fringe marshes provide habitat for a variety of vertebrate animals including fish, birds, mammals, and reptiles. Teal (1986) stated that one of the most important functions of salt marshes is to provide habitat for migrant and resident bird populations. Some wildlife species inhabiting tidal marshes are important game animals, valuable furbearers, and provide recreational opportunities for hunters, birdwatchers, nature enthusiasts, and wildlife photographers (USACE 2009).

The majority of wildlife species that utilize the wetlands have neither commercial nor recreational value, but simply are ecologically important members of the ecosystem. For example, the rice rat and other small mammals play a key role in marsh trophic cycles, providing food for several species of avian and mammalian predators. Many of the vertebrates that use the marsh ecosystem are highly mobile and serve as a transfer mechanism for nutrients and energy to adjacent terrestrial or aquatic ecosystems. Some of the larger vertebrates, including the muskrat and nutria, consume copious amounts of plants and, at high densities, may have significant impacts on marsh vegetation structure (USACE 2009).

Tidal marshes provide forage, spawning sites, predation refuge, and nursery habitat for resident and nonresident fishes and macrocrustaceans. These organisms use tidal marshes or adjacent subtidal shallows either year round or during a portion of their life history. These organisms are consumed by nektonic and avian predators and represent an important link in estuarine trophic dynamics (USACE 2009).

2.2.2 Geomorphic and Physiographic Setting

Louisiana

The study area lies within the Mississippi Delta Region, which is comprised of three geomorphic regions. Pleistocene Terrace Region is the area north of Lakes Maurepas, Pontchartrain and Borgne; The Marginal Deltaic Basin is comprised of estuarine marshes and forested wetlands around Lakes Pontchartrain and Maurepas. Maurepas Swamp includes some of the largest remaining tracts of forested wetlands in the Lower Mississippi River Valley. The Marginal Deltaic Basin region lies within the coastal zone of Louisiana, and is influenced by wetland loss, subsidence, saltwater intrusion and shoreline erosion. The Mississippi River Deltaic Region lies south and east of Lakes Maurepas and Pontchartrain. The salinity gradient within this region decreases from east (salt water of the Gulf) to west (fresher waters in the coastal plain) through the Pontchartrain Basin.

The eastern Louisiana coast consists of a deltaic system with fronting barrier islands built by the Mississippi River. High, firm land is rare in coastal Louisiana. Elevations of the wetlands are barely above mean gulf level and at best the soils are soft and poorly consolidated. Within the Deltaic Plain, finger-like patterns of narrow alluvial ridges, which reach out toward the gulf, are higher and firmer. These natural levees, formed by overbank processes, occur along active and abandoned Mississippi River distributaries (Coast 2050). The natural and man-made ridges form the skeletal framework to which the coastal wetlands are attached. They form hydrologic basin boundaries, and are more resistant to erosion than the wetlands.

Separating the wetlands from the open Gulf is the Chandeleur Island chain. The islands occur in an arc fringing an abandoned delta lobe (Morgan and Larimore 1957; Penland and Boyd 1981).

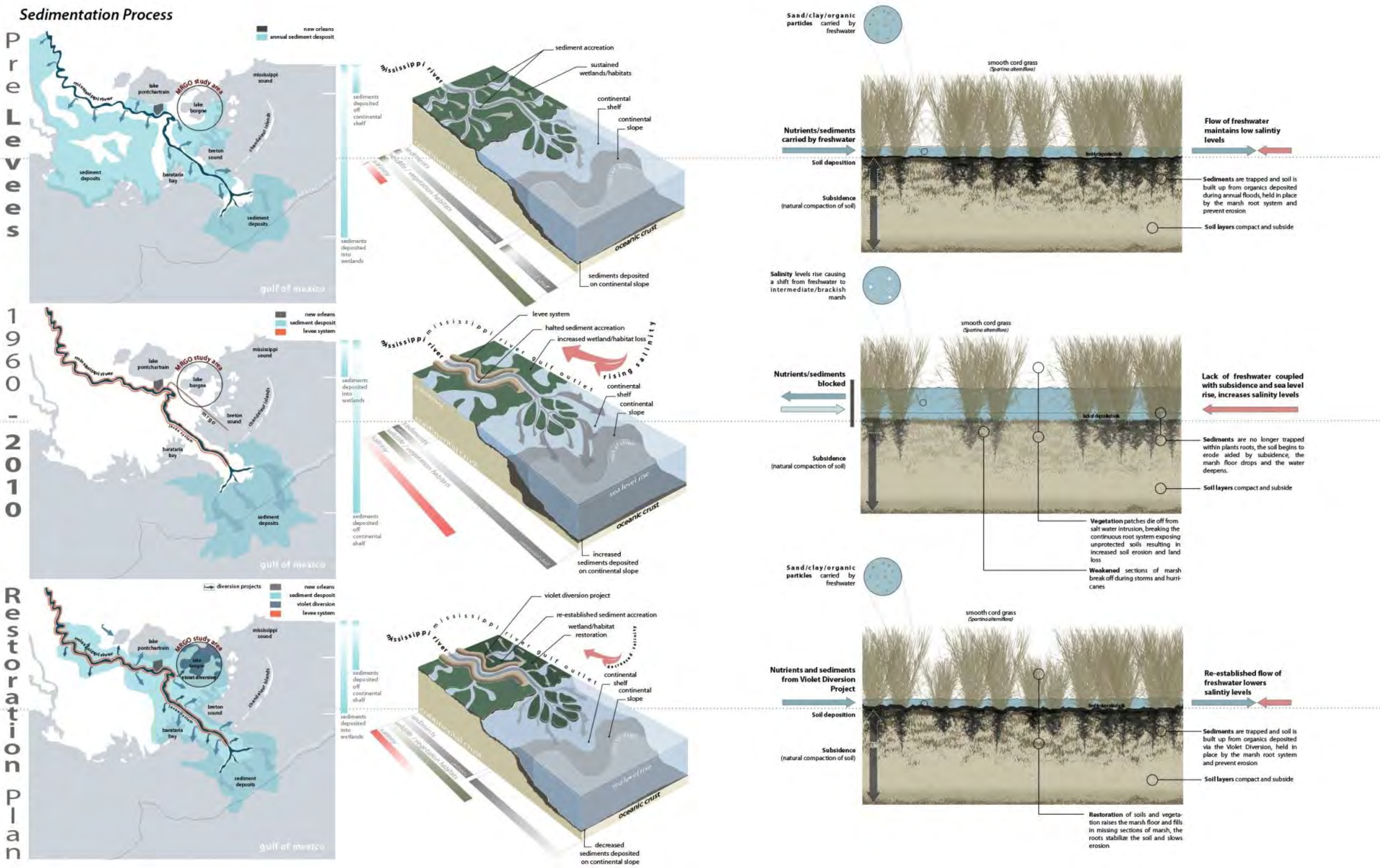


Figure 2-2. Sedimentation Process

Mississippi

The western boundary of the state consists of broad expanses of emergent tidal marsh and riverine swamps. The mainland of Mississippi is bordered on the south by Mississippi Sound, a shallow body of water that separates the coast from Cat Island, a barrier island that lies approximately 6 miles offshore.

The geomorphology of Cat Island is more closely related to the geomorphology of the Louisiana islands. The geologic evolution of Cat Island was also influenced by the extension of the St. Bernard subdelta 4,000 to 2,000 years ago (Roberts 1997). Cat Island is the only barrier island in the Mississippi Barrier Island Chain with a significant fringing coastal marsh habitat.

2.2.3 Hydrology

A detailed discussion of study area hydrology is included in the EIS and Engineering Appendix.

Hydrologic Basins

The study area includes the Pontchartrain Basin and the southernmost portion of the Pearl River Basin. The Lake Pontchartrain Basin consists of Lake Maurepas, Lake Pontchartrain, Lake Borgne, the Biloxi Marshes, Chandeleur Sound, and associated marshlands and waterways. Lakes Maurepas and Pontchartrain are hydrologically connected by Pass Manchac, separated only by landbridges of cypress swamp and fresh/intermediate marsh. Lake Borgne is hydrologically connected to Lake Pontchartrain through Chef Menteur Pass and The Rigolets.

The Pontchartrain Basin has several freshwater tributaries. These are the most important factor affecting salinity in Lake Pontchartrain. The annual freshwater flow into Lake Pontchartrain averages about 3,800 cubic feet per second (cfs). The Pearl River discharges a mean annual flow of about 10,000 cfs into The Rigolets, and is the largest recurring natural freshwater influence in the basin. Lake Borgne is connected to the Mississippi River Gulf Outlet by several bayous, principally Bayous Bienvenue, Dupre, Yscloskey, and La Loutre. Prior to the construction of levees, seasonal flooding of the Mississippi River provided freshwater inputs into the study area estuaries.

The Pearl River Basin covers an area of about 7,800 square miles from the headwaters of the Pearl River in east-central Mississippi to western Mississippi Sound. From its headwaters, the Pearl River flows southwesterly, forming the boundary between Louisiana and Mississippi in the southern part of the basin, and discharging into Lake Borgne near The Rigolets. Near the coast, the river becomes estuarine, bounded by salt marsh and affected by tidal influence. The Pearl River is about 490 miles long and divides into the Pearl River and the West Pearl River about 50 miles above the mouth. Significant tributaries include the Yockanookany and Strong Rivers.

Tides

Tides in the study area are diurnal, with mean ranges of 0.3 foot (Lake Maurepas) to 0.5 foot (Lake Pontchartrain) to 1.4 feet (Chandeleur Sound). Mean water levels are affected by winds, freshwater runoff, and seasonal trends in the Gulf of Mexico. Sustained winds can raise or lower peak astronomical tide levels by several feet for short periods. Currents and circulation are controlled by tides, winds, freshwater discharges, and gulf currents (Tate, et al. 2002).

Hydrodynamics

There are three Federal navigation channels that modified hydrologic conditions in the study area: the IHNC, the GIWW, and the MRGO navigation channel. The vast network of canals, pipelines, and production facilities that service the oil and gas industry have also altered natural hydrology in the study area. Dredged material spoil banks, which are higher than the natural marsh surface and the many smaller canals dredged for oil and gas exploration, alter the flow of water through area wetlands. Hydrodynamic alteration changes important hydrogeomorphic, biogeochemical, and ecological processes, including chemical transformations, sediment transport, vegetation health, and organism migration.

A hydrologic study across areas of the MRGO channel was conducted from 1959 – 1961 to evaluate the major hydrologic parameters, including circulation and salinity, prior to opening the MRGO to marine traffic in 1963 (Rounsefell 1964). These data indicated that the Bayou La Loutre ridge provided a basin boundary that limited the flow of saline water from the Breton Sound area into Lake Borgne and nearby wetlands. An analysis of typical tidal flow across the region indicates that since construction of the MRGO, circulation patterns have been altered along its length in areas from Breton Sound north to Lake Pontchartrain. The MRGO acted as a direct passage for tidal exchange, allowing a more direct flow of higher-density saline water inland.

Dredging performed for construction of the MRGO channel to an approximate depth of 36 feet resulted in the generation of an abundance of spoil for placement. The spoil was deposited in a continuous strip along the channel‘s southwestern limits. This deposition interrupted the local circulation patterns of natural waterways that transected the length of the channel, such as Bayou Bienvenue, Bayou Dupre, and Bayou La Loutre.

Salinity

The USACE – Engineer Research and Development Center‘s (ERDC) Coastal and Hydraulics Laboratory ran a numerical model investigation entitled *Salinity Changes in Pontchartrain Basin Estuary, Louisiana, Resulting from Mississippi River-Gulf Outlet Partial Closure Plans*. In the Historical Salinity section of the report data for five stations throughout the basin were analyzed. The mean pre- and post-MRGO salinity information is from 1951 to 1963 and 1963 to 1977, respectively. These data indicate that the salinity increased at all five stations throughout the year after the MRGO was opened.

A hypoxic/anoxic zone in Lake Pontchartrain was first described by Poirrier (1978). Its existence was verified by extensive water quality sampling done by DEQ in 1980 and 1982 (Schurtz and St. Pé 1984). This zone appeared to be caused primarily because the MRGO carries bottom water in excess of 20 parts per thousand (ppt), which enters the IHNC and then Lake Pontchartrain during the flood tide cycle (Georgiou and McCorquodale 2002). This saline water sinks to the bottom where it moves with the bottom lake currents and can cover at least 1/6 of the lake‘s bottom (Schurtz and St. Pé 1984). This stratified water inhibits both mixing and oxygenation, generally leading to hypoxic (low oxygen) or anoxic (no oxygen) conditions near the lake bottom. This hypoxic/anoxic zone seems to appear most often in the spring and summer (Abadie and Poirrier 2001).

Initial monitoring data indicate that the closure at Bayou La Loutre has contributed to decreased salinity upstream of the closure (USGS 2009). Results of sampling conducted near the mouth of the IHNC in Lake Pontchartrain prior to and after closure in summer 2009 indicate a substantial reduction in differences between surface and bottom salinity and dissolved oxygen levels (personal communication, Dr. Michael A. Poirrier, UNO). Detrimental DO levels (<4.0 mg/L) have not been observed in Lake Pontchartrain since the construction of closure.

The influx of rivers creates a salinity gradient within Mississippi Sound (Priddy et al. 1955). Both east-west and north-south gradients occur in the Sound in addition to vertical gradients. Generally, positive salinity gradients exist from the mainland seaward and vertically, surface to bottom (GMFMC 1998). Surface salinity is influenced by the discharge of freshwater from large rivers and is reduced during periods of higher flow in late spring and early summer (Thompson et al. 1999). Temperature follows expected salinity trends (USACE 2008b).

Figure 2-3. Average Salinity 1959-1961 (in parts per thousand)

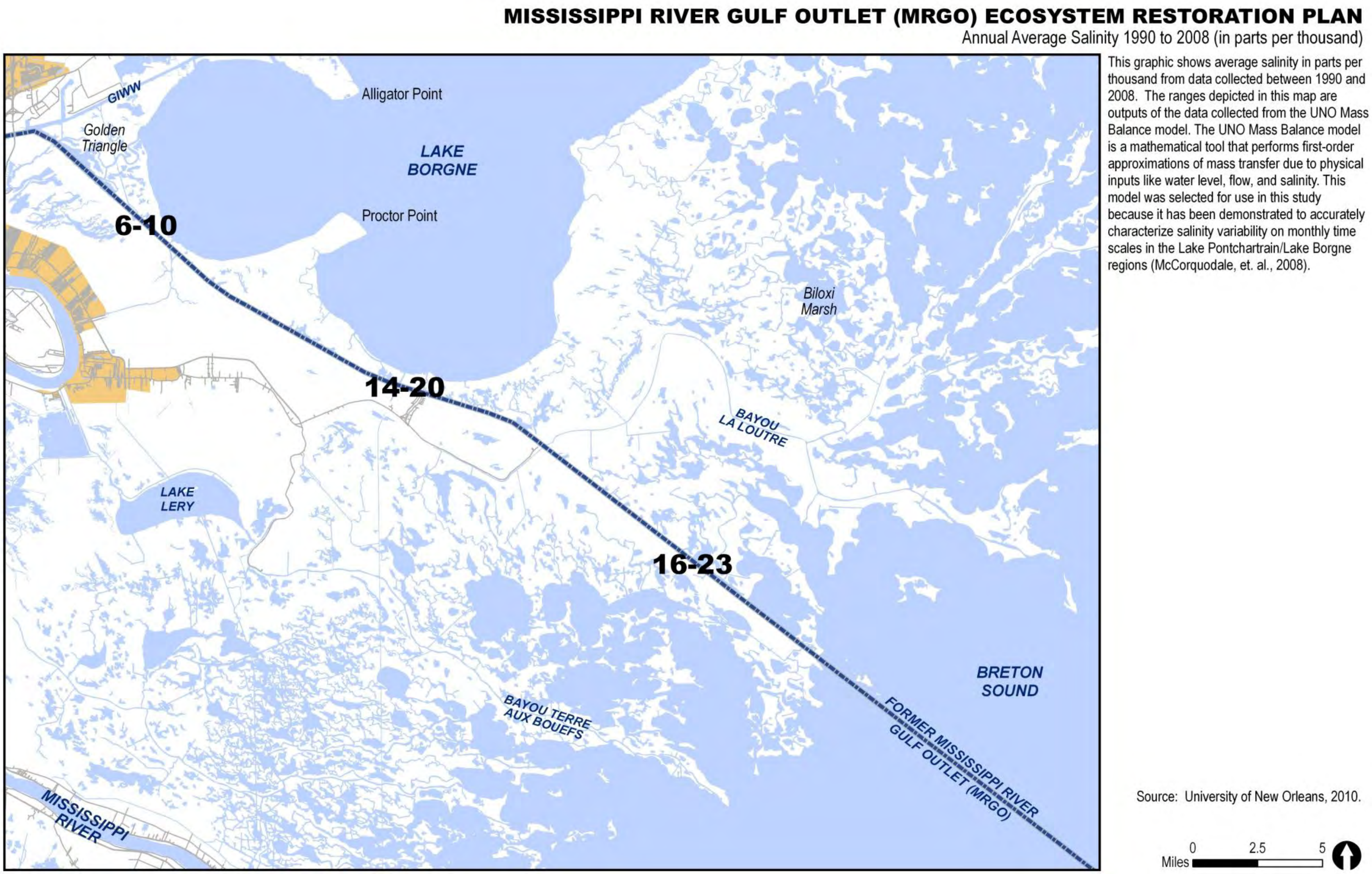


Figure 2-4. Annual Average Salinity 1990-2008 (in parts per thousand)

MISSISSIPPI RIVER GULF OUTLET (MRGO) ECOSYSTEM RESTORATION PLAN
Post-MRGO Closure Annual Average Salinity (in parts per thousand)

This graphic shows average annual salinity in parts per thousand generated in the UNO Mass Balance model. These values show predicted decreases in salinity following the construction of the closure of the MRGO near Bayou La Loutre and at the IHNC Surge Barrier. Salinity data for the post closure period are limited, but these model results are consistent with observed salinity reductions in the area following the construction of the closure near Bayou La Loutre. The UNO Mass Balance model is a mathematical tool that performs first-order approximations of mass transfer due to physical inputs like water level, flow, and salinity. This model was selected for use in this study because it has been demonstrated to accurately characterize salinity variability on monthly time scales in the Lake Pontchartrain/Lake Borgne regions (McCorquodale, et. al., 2008).

Source: University of New Orleans, 2010.

Figure 2-5. Post-MRGO Closure Annual Average Salinity (in parts per thousand)

2.2.4 Coastal Vegetation Resources

Nearshore marine and estuarine habitats, including wetlands, are the nursery grounds for the marine food chain in the Gulf of Mexico. As this habitat erodes or changes, it depletes the species that form the base of the food chain throughout the Gulf of Mexico. Failure to address the loss of this habitat in the Gulf region threatens the long-term health of the entire ecosystem and human culture.

Coastal vegetation resources are institutionally significant because of the Coastal Barrier Resources Act of 1982; Coastal Zone Management Act of 1972; Emergency Wetlands Resources Act of 1986; Estuary Protection Act of 1968; Fish and Wildlife Conservation Act of 1980; the Fish and Wildlife Coordination Act of 1958, as amended; Migratory Bird Conservation Act; Migratory Bird Treaty Act; Endangered Species Act of 1973 (ESA); Magnuson Fishery Conservation and Management Act 1990; National Environmental Policy Act (NEPA) of 1969; the North American Wetlands Conservation Act; the Water Resources Development Acts of 1976, 1986, 1990, and 1992; Executive Order 13186 Migratory Bird Habitat Protection; and Executive Order 13547 Stewardship of the Ocean, Our Coasts, and the Great Lakes.

Coastal vegetation resources are technically significant because they are a critical element of coastal habitats. In addition, coastal vegetation resources serve as the basis of productivity, contribute to ecosystem diversity, provide various habitat types for fish and wildlife, and are an indicator of the health of coastal habitats.

Coastal vegetation resources are publicly significant because of the high priority that the public places on their aesthetic, recreational, and commercial value. Overall, plant communities provide protection against substrate erosion and contribute food and physical structure for cover, nesting, and nursery habitat for wildlife and fisheries. Continued degradation and loss of existing wetland areas, in concert with truncation of replenishing processes, will accelerate decline in the interdependent processes of plant production and vertical maintenance necessary for a stable ecosystem.

2.2.4.1 Land Cover

The vegetation classification descriptions within the study area are covered in detail in the EIS for this study. Acreages of the various vegetation classifications are provided below.

- Wetland Vegetation – 826,668 total acres
  - Palustrine Forested Wetland = 354,226 acres
  - Palustrine Scrub/shrub Wetland = 39,448 acres
  - Estuarine Scrub/Shrub Wetland = 2,050 acres
  - Estuarine Emergent Wetland = 430,944 acres
- Mixed Forest – 344 acres
- Deciduous Forest – 416 acres
- Evergreen Forest – 69,254 acres
- Developed, High Intensity – 19,916 acres

- Developed, Medium Intensity – 32,248 acres
- Developed, Low Intensity – 96,174 acres
- Developed, Open Space – 18,498 acres
- Open Water – 1,969,152 acres

2.2.4.2 Habitat Types

Common and scientific names of plants and animals in the study area mentioned throughout this report and appendices are also presented as an appendix in the EIS.

Since the source of salinity in coastal Louisiana and Mississippi is the Gulf of Mexico, salinity levels exist along a gradient, which declines as the saltwater moves inland and mixes with freshwater sources. A zonation of plant species that differ in salinity tolerance exists along that gradient.

The basic coastal wetland habitats within the study area are typically described as Swamp (Forested Wetlands), Fresh, Intermediate, Brackish and Saline Marsh (Day, et al. 1989) (Mitch and Gosselink 2000). These habitats are strongly influenced by the salinity regime of the surface water.

Historically, the habitats were maintained by freshwater introduced through the Mississippi River and other natural water sources. The construction of levees limits the flow of freshwater into the marsh, and the construction of canals allows additional saltwater into the estuary. These and other changes have resulted in the shift of higher salinity habitats inland.

Swamp (0–3 ppt salinity)

Forested coastal wetlands in the study area are dominated by bald cypress and water tupelo, which are the remnants of extensive logging of virgin forest more than 70 years ago. The Louisiana swamps generally lack a mature canopy as was present in colonial forests and have lower productivity where isolated from riverine influences (Shaffer et al 2003).

Fresh Marsh (0–3 ppt salinity)

Fresh marsh has the highest plant diversity of all the coastal habitat types including as many as 93 species. Floating aquatic and submerged plants are common and are significant for waterfowl. Soils may be highly organic and prone to settlement. Many species of duck and waterfowl use coastal Louisiana and Mississippi as overwintering grounds for foraging of diverse invertebrates, plant roots, and tubers.

Intermediate Marsh (2–8 ppt salinity)

Intermediate marsh has lower species diversity than fresh marsh, but may have higher productivity. This habitat provides important nurseries for brown shrimp, white shrimp, blue crab, and Gulf menhaden or pogy. Soils may be very poor due to very high organic content. Submerged aquatic vegetation within lakes and bays are vital to secondary productivity.

Brackish Marsh (4–18 ppt salinity)

Brackish marsh has the lowest plant diversity, but may be the most productive type of marsh. The dominant species is marshhay grass. Oysters are exceptionally significant due to filtration, biomass, reef building, and commercial harvest and other fish found in reef communities.

Salt Marsh and Barrier Islands (8–29 ppt salinity)

Salt Marsh and barrier islands have high overall species diversity due to plants and animals. Bird rookeries are an important use of these habitat types. Nesting for sea turtles occurs on some islands. Some islands in the study area also have true seagrasses on their bay side lagoons and provide habitat for the endangered West Indian manatee during migration.

2.2.4.3 Invasive Species

Invasive plant species often increase and spread rapidly because the new habitat into which they are introduced is often free of insects and diseases that are natural controls in their native habitats. In coastal Louisiana, water hyacinth, alligator weed and hydrilla are well-known invasive plants. More recently, common salvinia, giant salvinia, and variable-leaf milfoil also have become invasive, displacing native aquatic species and degrading water quality and habitat quality (USACE 2009).

Invasive species are a major cause of the extinction of native species (second only to habitat loss). Muskrat, once trapped for their valuable fur throughout coastal Louisiana, have been crowded out by South American nutria. In summer 2000, masses of Australian spotted jellyfish along the Louisiana coast threatened to disrupt the gulf shrimp industry.

2.2.4.4 Rare, Unique and Imperiled Vegetative Communities

The following unique communities, nestled within the broader vegetative habitats, are important in that they contribute to the extensive diversity of the coastal ecosystem, and are essential to the stability of the bionetwork.

Marine Submergent Vascular Vegetation Communities

Also known as seagrass beds, marine submergent vascular vegetation communities occur in shallow, relatively clear offshore marine systems with unconsolidated substrate. The primary community species listed are turtle grass, manatee grass, and shoal grass.

Estuarine Submergent Vascular Vegetation Communities

Composed primarily of water celery, widgeon grass, southern naiad and horned pondweed, these brackish communities grow in sand/mud bottom substrates in shallow, protected waters with low turbidity. Activities that cause long-term increases in turbidity in the waters surrounding the beds are a serious threat to their viability.

Coastal Mangrove Thicket

Dominated by black mangrove, this estuarine community has several important ecological functions - the extensive root systems stabilize shorelines and reduce erosion, provide cover and food, improve surrounding water quality by filtering nutrients and suspended sediments, and provide nesting areas for colonial water birds.

Coastal Dune Grassland

Also known as maritime grasslands, coastal dune grassland occurs on beach dunes, relatively elevated backshore areas above intertidal beaches on barrier islands, and mainland shores. Marshhay cordgrass is usually the dominant species, but saltgrass, seashore paspalum, beach panicgrass, seacoast bluestem, and broomsedges are common associates.

Live Oak Forest

Live oak forests occur principally in southeastern Louisiana on natural levees, ridges, or frontlands, and on islands within marshes and swamps in the coastal zone. Live oak dominates the stand, but water oak, American elm, sugarberry, red maple, and green ash are usually prominent community members. There are only a small number of populations known to exist and they are vulnerable to extirpation (local extinction).

Coastal Live Oak-Hackberry Forest (Coastal Ridge)

Also known as chenier maritime forest, this natural community formed on abandoned beach ridges primarily in southwest Louisiana, although abandoned beach ridges and stream levees in the southeast are also locally known as cheniers. Live oak and hackberry are the dominant canopy species, and other common species are red maple, sweet gum, water oak, green ash, and American elm.

Fresh Marsh

Although the fresh marshes, as previously described, compose a large amount of the entire coastal marsh acreage, the Louisiana Natural Heritage Program ranks this community as imperiled because it has undergone the largest reduction in acreage of any of the marsh types over the past 20 years due to saltwater intrusion.

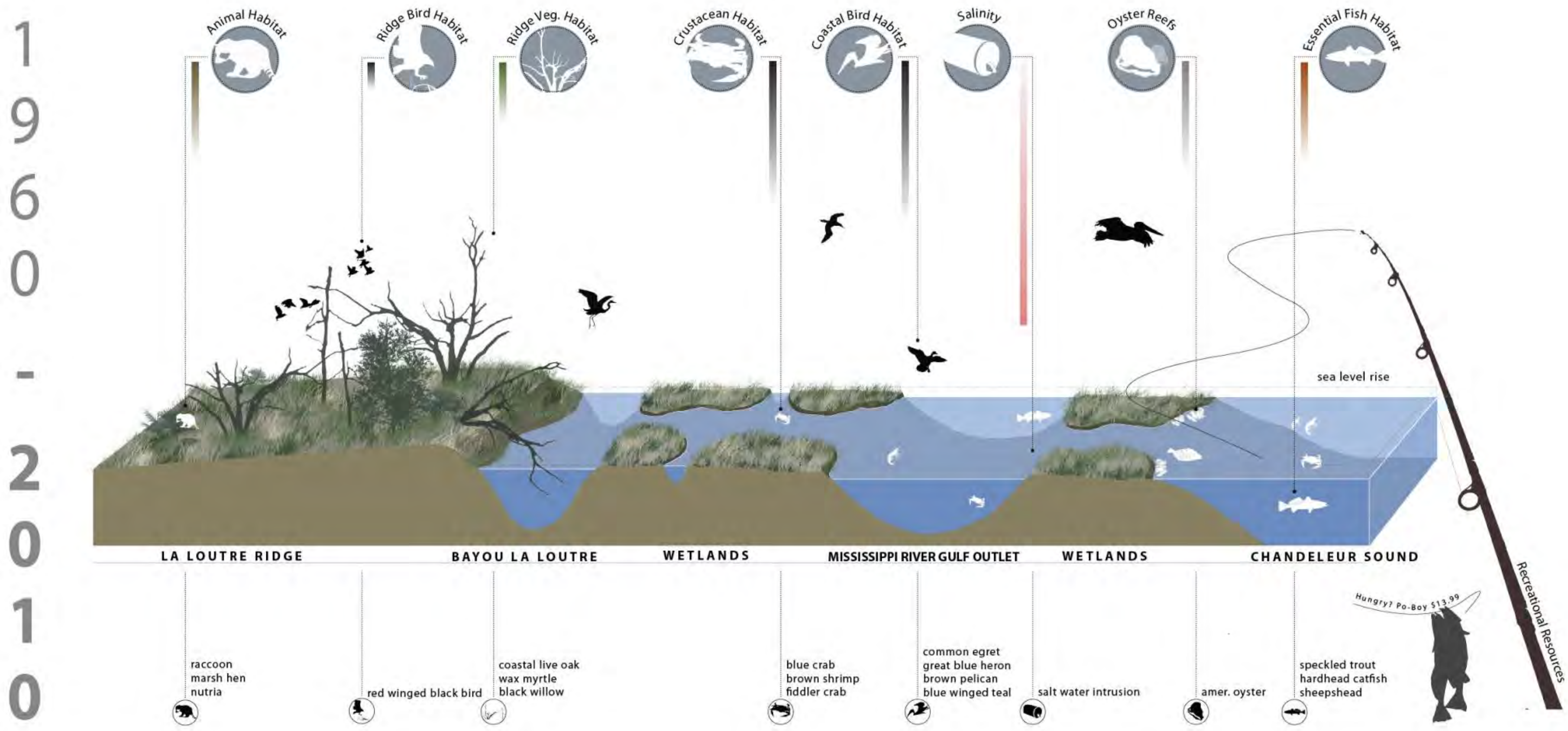


Figure 2-6. Habitat Diversity Degradation

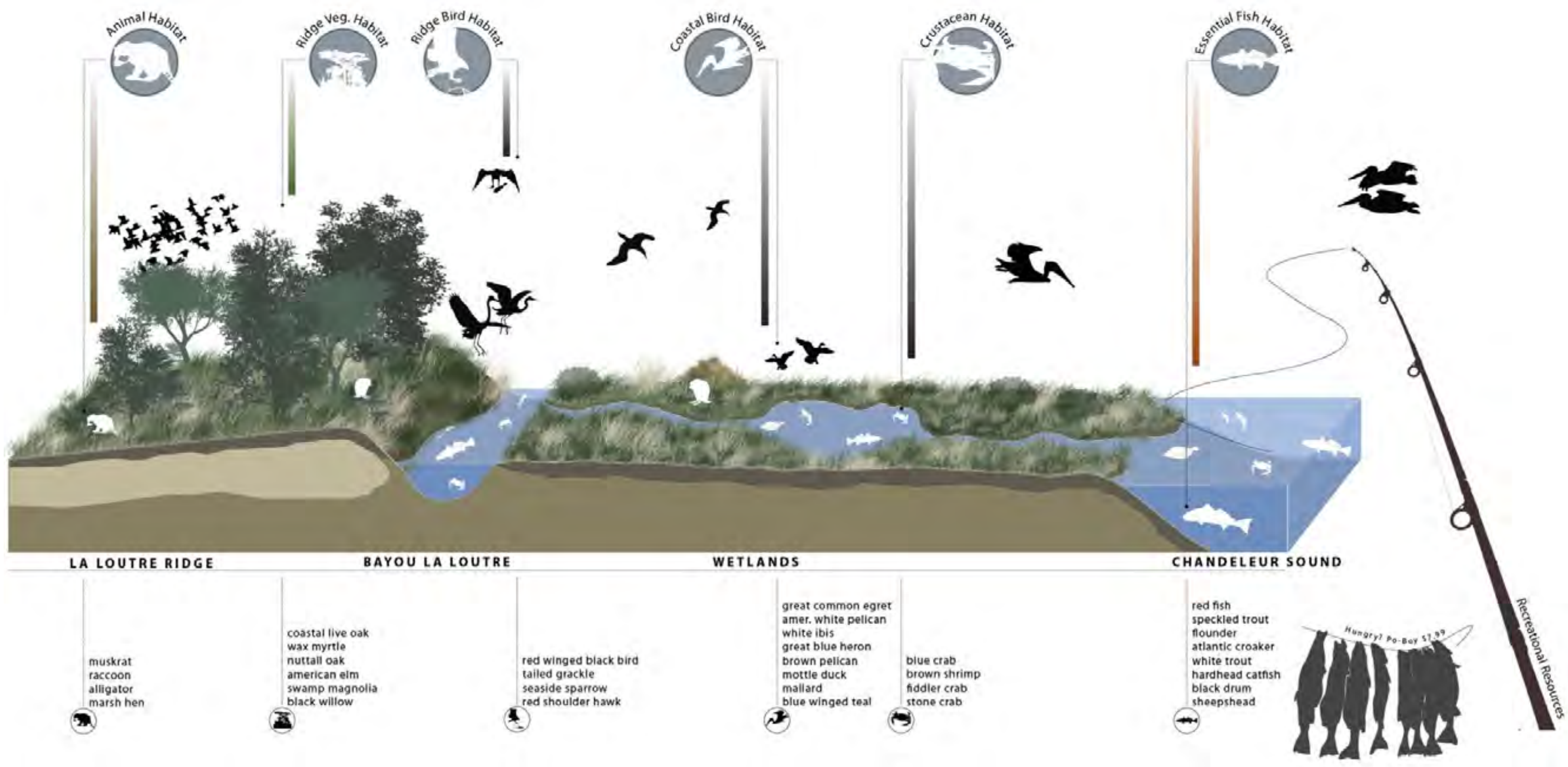


Figure 2-7. Pre-Altered Habitat and Biodiversity

2.2.5 Wildlife Resources

Section 3.15 of the associated EIS for this study provides a detailed discussion of wildlife resources in the study area.

The significance of wildlife resources is demonstrated by the multitude of legislative acts that exist to manage and conserve the resource. Pivotal among these are the National Environmental Policy Act of 1969; the Coastal Zone Management Act; the Estuary Protection Act; the Fish and Wildlife Coordination Act of 1958, as amended; the Migratory Bird Conservation Act of 1929, as amended; the Migratory Bird Treaty Act of 1918; the Endangered Species Act of 1973 (ESA), as amended; the Fish and Wildlife Conservation Act of 1980; the North American Wetlands Conservation Act; Executive Order 13186 Migratory Bird Habitat Protection; and the Marine Mammal Protection Act. Wildlife resources are critical elements of the coastal barrier ecosystem and important indicators of the health of coastal habitats. Wildlife resources are also important recreational and commercial resources as well and are regarded highly by the public for their aesthetic, recreational, and commercial value.

The USFWS, in a letter dated October 31, 2008, formally requested that significant fish and wildlife resources be fully considered and addressed in this study, including: seabirds, shorebirds, wading birds, migratory and resident waterfowl, and estuarine-dependant fishes and shellfishes.

Coastal Louisiana‘s wetlands support neotropical and other migratory avian species such as rails, gallinules, shorebirds, wading birds, and numerous songbirds, as well as many different furbearers, rabbits, deer, and alligators. Louisiana coastal wetlands provide neotropical migratory birds essential stopover habitat on their annual migration route. The coastal wetlands in the study area provide important and essential fish and wildlife habitats, used for shelter, nesting, feeding, roosting, cover, nursery, and other life requirements.

2.2.6 Aquatic and Fishery Resources

Section 3.16 of the associated EIS for this study provides a detailed discussion of aquatic and fisheries resources in the study area.

Fishery resources, including both finfish and shellfish, are institutionally, ecologically, and publicly important. They are institutionally important because of the Fish and Wildlife Coordination Act of 1958, as amended; Endangered Species Act of 1973; Magnuson-Stevens Fishery Conservation and Management Act of 1976, as amended (Magnuson-Stevens Act); Magnuson-Stevens Act Reauthorization of 2006; Coastal Zone Management Act; and Estuary Protection Act. They are ecologically important because they occupy various trophic levels in the aquatic environment. They are publicly important because of the high priority placed on their aesthetic, recreational, and commercial value.

Emergent wetlands and shallow open water areas in the study area provide important habitat and Essential Fish Habitat (EFH). The area historically and currently provides valuable habitat for recreational and commercial fishing, oyster culture, and nursery areas for a wide variety of finfish and shellfish (Rounsefell 1964; Penland et al. 2002).

By letter dated October 27, 2008, the National Marine Fisheries Service (NMFS) indicated water bodies and wetlands in the study area provide nursery and foraging habitats supportive of a variety of economically important marine fishery species, such as striped mullet, Atlantic croaker, gulf menhaden, spotted and sand seatrout, southern flounder, black drum, and blue crab. Some of these species also serve as prey for other fish species managed under the Magnuson-Stevens Act by the Gulf of Mexico Fishery Management Council (e.g., mackerels, snappers, and groupers) and highly migratory species managed by NMFS (e.g. billfishes and sharks).

Mississippi Sound Estuary

The Mississippi Sound estuary provides prime habitat for various lifestages of red snapper, tuna, redfish, Spanish and king mackerel, grouper, speckled trout, jack crevalle, cobia, amberjack, marlin, and various species of sharks. Mississippi Sound‘s productivity is ideal for sport fishermen, commercial fishing, and local recreational use (USACE 2008b).

The total value of commercial fisheries landings in Mississippi amounted to $43.6 million in 2008 (NMFS 2010). The recreational fishing industry, which includes saltwater and freshwater fishing, is also a significant economic contributor to the state.

Louisiana Estuaries

Louisiana‘s coastal estuaries are the most productive in the nation. Louisiana has historically been an important contributor to the nation‘s domestic fish and shellfish production, and one of the primary contributors to the nation‘s food supply for protein. Landings in 2008 for commercial fisheries in coastal Louisiana, estimated at 918 million pounds, were the largest for any state in the contiguous U.S. and second only to Alaska (NMFS 2009). These landings represent over 11 percent of the total landings in the U.S., with a value of approximately $272.9 million.

Fisheries are discussed in detail in the EIS. Fish were sampled in the MRGO area from 1959 to 1961 (El-Sayed 1961). Estuarine marine species dominated the fish communities with spot, Atlantic croaker, anchovy, and seatrout ranked among the top ten species in every area sampled. Nine freshwater species disappeared after the construction of the channel (Fontenot and Rogillo, 1970). More recent data shows that as the salinity levels increased in the areas immediately adjacent to the MRGO channel, more marine species began to appear in sampling trawls (LDWF 2000). Blue crab and brown and white shrimp are harvested in the study area.

Oysters

Adult oysters can tolerate salinity from 0 to 42 ppt, but the optimal salinity range is 5-15 ppt (EOBRT 2007). Oysters grow faster in areas with fluctuating salinity within their normal ranges, compared to constant salinity (Pierce and Conover 1954). In Louisiana, a total of 12.8 million pounds of oyster were harvested in 2008, with a dockside value of $38.8 million (NMFS 2009). The extent of oyster reefs in Mississippi is estimated at 10,000 to 12,000 acres, of which over half is located in the western Mississippi Sound south of Pass Christian. In 2008, 2.8 million pounds of oyster were harvested in Mississippi, with a value of $6.9 million (NMFS 2009).

2.2.7 Essential Fish Habitat

Section 3.18 of the associated EIS for this study provides a detailed discussion of essential fish habitat (EFH) in the study area.

Aquatic and tidally influenced wetland habitats within portions of the study area are designated as EFH for shrimp, red drum, reef fish, and stone crab, as listed in the Fisheries Management Plan and managed by the Gulf of Mexico Fishery Management Council (GMFMC). The 1996 amendments to the Magnuson-Stevens Fishery Conservation and Management Act of 1996 (MSA) set forth a mandate for the National Marine Fisheries Service (NMFS) of the National Oceanic and Atmospheric Administration (NOAA), regional Fishery Management Council (FMC), and other Federal agencies to identify and protect EFH of economically important marine and estuarine fisheries including critical habitat needed for various life stages. The public places a high value on seafood and recreational and commercial opportunities provided by EFH. Specific categories of EFH include all estuarine waters and substrates (mud, sand, shell, rock, and associated biological communities), subtidal vegetation (sea grasses and algae), and adjacent intertidal vegetation (marshes and mangroves).

By letter dated October 27, 2008, NMFS identified EFH resources in the study area as including estuarine emergent wetlands; submerged aquatic vegetation/seagrass beds; mud, sand and shell substrates; and estuarine and marine water column. Habitats in portions of the study area are designated as EFH for pink, brown and white shrimp; red drum; Gulf stone crab; lane snapper; dog snapper; dwarf sand perch; king mackerel; Spanish mackerel; cobia; bonnethead shark; and Atlantic sharpnose shark.

2.2.8 Threatened and Endangered Species

Section 3.19 of the associated EIS for this study provides a detailed discussion of threatened and endangered species that occur in the study area.

This resource is institutionally significant because of the Endangered Species Act of 1973, as amended, and the Marine Mammal Protection Act of 1972. Threatened and endangered species are technically significant because the status of such species provides an indication of the overall health of an ecosystem. These species are publicly significant because of the desire of the public to protect them and their habitats.

Within the State of Louisiana there are thirty animal and three plant species (some with critical habitats) under the jurisdiction of the USFWS and/or the NMFS, presently classified as threatened or endangered. The USFWS and the NMFS share jurisdictional responsibility for sea turtles and the Gulf sturgeon. Of the animals and plants under USFWS and/or NMFS jurisdiction, nine animal species and no plant species are potentially found within the project area. Although some of these species may be occasionally found in the project area, those species that may be potentially impacted by the proposed action are described below.

- One federally listed endangered avian species, the piping plover, may occur in the study area. Piping plovers winter on barrier islands along the Gulf coast, including Louisiana. Portions of the Mississippi Sound shore, the Mississippi River Delta, and Breton Island and Chandeleur Island chain are critical habitat for piping plovers.
- The West Indian manatee, a federally listed endangered marine mammal, may occasionally enter Lakes Pontchartrain and Maurepas, and associated coastal waters and marshes of Louisiana. The West Indian manatee is also found in the Mississippi Sound and St. Louis Bay.
- The pallid sturgeon is a federally listed endangered nonanadromous fish species inhabiting the Missouri and Mississippi Rivers from Montana to Louisiana.
- Gulf sturgeon, a federally listed threatened anadromous fish, occur in rivers and lakes of the Lake Pontchartrain basin. Portions of the Pearl and Bogue Chitto Rivers, Lake Pontchartrain east of the Causeway Bridge, Little Lake, The Rigolets, Lake St. Catherine, and Lake Borgne were designated as critical habitat for the Gulf sturgeon on March 19, 2003 (*Federal Register* Volume 68, No. 53).
- Five federally listed sea turtle species may occur in the study area: the Kemp‘s Ridley sea turtle (endangered), Atlantic green sea turtle (threatened), hawksbill sea turtle (endangered), loggerhead sea turtle (threatened and under review), and leatherback sea turtle (endangered).

State Rare, Threatened and Endangered Species

The Louisiana Natural Heritage Program lists thirty-one species as occurring in the study area not including federally listed species (LNHP 2009). These include: Cooper's Hawk, River Grass, Big Brown Bat, Southern Umbrella-sedge, Southwest Bedstraw, Bald Eagle, small flower hemicarpha, Malaclemys terrapin, Diamondback Terrapin, Glossy Ibis, Paddlefish, Clasping-leaf Pondweed, Ornate Chorus Frog, Sand Rose-gentian, Saw Palmetto, Dune Sandbur, Sand Dune Spurge, Snowy Plover, Reddish Egret, Creeping Spike-rush, Gull-billed Tern, American Oystercatcher, Gulf Halophila, Caspian Tern, Brown Pelican, coastal ground cherry, Roseate Spoonbill, Eared Greenbrier, Turtle-grass, and Sea Oats.

The Mississippi Natural Heritage Program lists five species as occurring in the Mississippi study area (MNHP 2009). These species include: marsh eryngo, coast sedge, naked-stemmed panic grass, harper's yellow-eyed grass, and Drummond's yellow-eyed grass.

2.2.9 Recreational Resources

Section 3.23 of the associated EIS for this study provides a detailed discussion of recreational resources in the study area.

Recreational resources are institutionally significant because of the Federal Water Project Recreation Act of 1965, as amended, and the Land and Water Conservation Fund Act of 1965, as amended. Recreational resources are technically significant because of the high economic value of recreational activities and their contribution to local, state, and national economies. Recreational resources are publicly significant because of the high value that the public places on fishing, hunting, and boating, as measured by the large number of fishing and hunting licenses sold in Louisiana, and the large per-capita number of recreational boat registrations in Louisiana.

Louisiana Recreational Resources

State and Federal recreation areas in the Louisiana portion of the study area include: Bayou Sauvage National Wildlife Reserve, Biloxi Wildlife Management Area, Breton National Wildlife Reserve, Fort Pike State Historic Site, and the Pearl River Wildlife Management Area. Other recreational features are provided by parishes and historic communities that attract visitors to a variety of heritage and cultural festivals, historical sites, parks offering opportunities for active and passive recreation that include tennis courts, soccer and softball fields, swimming pools, and golf courses.

Funds from the Land and Water Conservation Fund have supported 164 different recreational projects in the Louisiana portion of the study area since 1964. Land and Water Conservation Fund projects in the study area have provided numerous boat ramps and other facilities that enhance opportunities for recreation (LWCF 2008). Recreation areas in the study area include 15 miles of trails for hiking and biking, 38 boat ramps, four fishing piers, one classroom space, two visitor centers, and two picnic shelters. These recreation areas provide opportunities for hunting, hiking, biking, boating, bird watching, fishing and crabbing, crawfishing, shrimping, education, camping, picnicking, and playing.

Mississippi Recreational Resources

Buccaneer State Park is located in the study area in Hancock County. Due to damage from Hurricane Katrina, it has been closed since 2005.

The 2 miles of the western tip of Cat Island are within the boundaries of the Gulf Islands National Seashore under the jurisdiction of the National Park Service. The island is only accessible by private boat. Recreational opportunities include beaches, hiking, and overnight camping.

2.2.10 Historic and Cultural Resources

Section 3.22 of the associated EIS for this study provides a detailed discussion of cultural resources in the study area.

Historic and cultural resources are institutionally significant because of the National Historic Preservation Act (NHPA), as amended (16 U.S.C. 470 et seq.), and NEPA. Historic and cultural resources are technically significant to the fields of anthropology, archeology, architecture, and other disciplines. Historic and cultural resources are publically significant because of the desire of the public to protect them for future generations.

Louisiana

High probability areas for archaeological sites are the ridges adjacent to Bayou La Loutre and Bayou Terre aux Boeufs. One site situated along Bayou La Loutre is listed on the National Register of Historic Places (NRHP). Other areas with the possibility of encountering important cultural resources are the off-shore borrow areas, especially in and around Lake Borgne. The potential exists for finding boats and ships that took part in the 1814-1815 Battle of New Orleans in Lake Borgne. Archaeological sites are very common along the shorelines of Lakes Maurepas, Pontchartrain and Borgne. Archaeological sites are also common along the rivers and bayous draining into these lakes, especially along the lower reaches of these streams.

Historic plantations are very common along the main channel of the Mississippi River. These are often represented by the remains of sugar mills and plantation related grave yards. Important vernacular house types are also situated along the Mississippi River and along the upper reaches of Mississippi River distributaries.

Mississippi

Site types range from shell middens along streams and on beaches, historic forts and settlements and shipwrecks. Previous investigations in the area include Lauro 1995, Smith et. al 2007, and U.S. Army Corps of Engineers 1995.

2.2.11 Aesthetics

Section 3.24 of the associated EIS for this study provides a detailed discussion of aesthetic resources in the study area.

Aesthetic resources are institutionally significant because of the Louisiana Scenic Rivers Act Acts of 1988 and NEPA. Aesthetic resources are publically significant because of the desire of the public to protect viewsheds.

The visual complexity surrounding the study area‘s marshes, bayous, wetlands, ridges and levees provide a pleasing aesthetic. View points that provide some visual interest are based on the interplay of lines, forms, colors and textures found in water, vegetation and changes in elevation from the water‘s edge to dry land. Public significance is based on expressed public perceptions and professional analysis of the study area.

Louisiana Scenic Rivers and Streams

The Louisiana Natural and Scenic River System is one of the nation‘s largest, oldest, most diverse and unique state river protection initiatives (LSU Agricultural Center 2009).

The LDWF administers the Louisiana Natural and Scenic Rivers system established in 1970 for the purpose of preserving, developing, reclaiming and enhancing the wilderness qualities, scenic beauties and ecological regime of designated free-flowing water bodies.

There are 21 designated scenic streams or bayous located within the study area (Table 2-2). All of these streams are used for recreational activities such as boating, fishing, and canoeing.

Table 2-2. Louisiana Scenic Streams and Rivers in the Study Area

Scenic Stream/River	Location
Bayou Dupre	The Lake Borgne Canal to Terre Beau Bayou
Lake Borgne Canal	The Forty Arpent Canal to Bayou Dupre
Bashman Bayou	Origin to Bayou Dupre
Terre Beau Bayou	Bayou Dupre to the New Canal
Pirogue Bayou	Bayou Dupre to the New Canal
Bayou Bienvenue	Bayou Viuere to Lake Borgne
Bayou Chaperon	Origin to end
Bayou Cane	Fontainbleau State Park to Lake Pontchartrain
Bayou Chinchuba	West Causeway approach to Lake Pontchartrain
Bayou Dupre	Lake Borgne/Violet Canal to Terre Beau Bayou
Bayou LaBranche	Good Hope to Lake Pontchartrain
Bayou Lacombe	Talisheek to Lake Pontchartrain
Bayou St. John	Origin to Lake Pontchartrain
Bayou Trepagnier	Origin to Bayou La Branche
Blind River	Origin to Lake Maurepas
Tchefuncte River	Origin to Lake Pontchartrain
Pushepatapa Creek	East/West Fork to Cross Creek
Tangipahoa River	State line to Lake Pontchartrain
Terre Beau Bayou	Bayou Dupre to New Canal
Tickfaw River	State line to Springville
West Pearl River	Wilson/Bradley Slough to East/West mouth

2.2.12 Hazardous, Toxic, and Radioactive Materials

The Phase I Environmental Site Assessment for this study provides detailed information regarding the presence of hazardous, toxic, and radioactive materials in the study area and is presented as an appendix in the associated EIS.

During review of historic records the presence of a former World War II training facility known as the Shell Beach, Anti-Aircraft Training Center located on the southern shoreline of the eastern half of Lake Borgne was identified. Based on review of historic documents and information obtained from personnel interviews, ammunition was shot from both large and small caliber weapons at targets that were towed above Lake Borgne.

Magnetic surveys of the shoreline protection area between Doulluts Canal and Jahncke‘s Ditch were conducted by USACE Baltimore District, Munitions and Explosives of Concern dredging experts. These surveys did not identify the presence of Munitions and Explosives of Concern in the dredged material deposited within an existing shoreline protection project. The Munitions and Explosives of Concern dredging experts reported a low probability of encountering Munitions and Explosives of Concern in the study area. The Munitions and Explosives of Concern dredging experts also recommended that borrow area sediments are monitored during the project for Munitions and Explosives of Concern.

Should at anytime during the project Hazardous, Toxic, and Radioactive Waste (HTRW) concerns arise, the USACE New Orleans District would take immediate actions to investigate the concerns. Should an HTRW issue be determined and the development of a response action required, USACE New Orleans District would coordinate with the appropriate Federal and state authorities to implement an approved response action.

2.2.13 Socioeconomic and Human Resources

Section 3.20 of the associated EIS for this study includes detailed socioeconomic information for existing and historic conditions in the study area.

Socioeconomic and human resources are institutionally significant because of the National Environmental Policy Act of 1969; the Estuary Protection Act; the Clean Water Act; the River and Harbors Acts; the Watershed Protection and Flood Protection Act; and the Water Resources Development Acts. Of particular relevance is the degree to which the proposed action affects public health, safety, and economic well-being; and the quality of the human environment. This resource is technically significant because the social and economic welfare of the nation may be positively or adversely impacted by the proposed action. This resource is publicly significant because of the public‘s concern for health, welfare, and economic and social well-being from water resources projects.

Population

Population in the study area is spread among portions of eleven Louisiana parishes, including Ascension, Jefferson, Livingston, Orleans, Plaquemines, St. Bernard, St. Charles, St. James, St. John the Baptist, St. Tammany, and Tangipahoa. The eastern boundary of the study area includes portions of Hancock and Harrison Counties in Mississippi that do not include any permanent resident population. The total population of the eleven Louisiana Parishes was 1,382,975 persons in 2007 (City Data 2008). The study area itself, however, is smaller than the multi-parish area and encompasses only portions of this population. Orleans and St. Bernard Parishes are wholly included in the study area and had populations of 484,674 and 67,229, respectively, in 2000. July 2007 estimated post-storm populations were significantly lower.

Business and Industrial Activity

Business and industrial activity for the study area is well-represented by the commercial/ tourism industries of Orleans Parish and the agriculture/fishing industries of the remaining parishes. The large presence of oil and gas industries in southern Louisiana also impact business activity in the study area.

Public Facilities and Services

The study area contains the normal array of public facilities and services normally associated with a major metropolitan area. These include but are not limited to hospitals, medical facilities, schools, government offices/buildings, public wharves, parks, recreation areas, and public transportation.

Transportation

The transportation infrastructure of the study area includes major roadways and navigable waterways. Interstate 10 passes through the Greater New Orleans area and connects Louisiana with Texas and Mississippi along the southern corridor. Interstate 55 is its north/south counterpart, beginning in LaPlace, Louisiana, and ending in Chicago, Illinois. Major waterways include the Mississippi River and the GIWW. The GIWW is a navigable inland waterway running approximately 1,050 miles from Carrabelle, Florida, to Brownsville, Texas.

Risk Reduction Infrastructure

When completed in 2011, the 350-mile Hurricane and Storm Damage Risk Reduction System (HSDRRS) will consist of levees, floodwalls, gates and pumps providing 100-year level protection to a five-parish area. This system represents a $14.5 billion Federal investment in risk reduction in the area (Greater New Orleans Hurricane and Storm Damage Risk Reduction System Facts and Figures, December 2009). One of the major HSDRRS projects within the study area is the IHNC Surge Barrier. The IHNC Surge Barrier at Lake Borgne is a 1.8-mile-long barrier, the largest of its kind in the world, and includes three navigation gates and a barrier wall that will stand 24–26 feet above the water line.

Community and Regional Growth

Historically, most of the activities that have driven regional and community growth have centered on oil and gas production, tourism, port operations, fishing, and hunting. Development of the area's energy resources during the 1950s and 1960s was instrumental in the expansion of industrial growth in surrounding communities. More recently, saltwater sport fishing has become an important stimulus to local and regional economies. In the last 40 years this activity has increased in popularity due to the advancements in affordable and reliable power sources for small boats and the advent of fiberglass boat hulls. Recreational fishing has a substantial economic impact on the coastal Louisiana economy.

Community and regional growth have benefitted from the construction of an extensive network of levees along the Mississippi River for flood protection, and maintenance dredging of the river sufficient to accommodate deep-draft navigation and waterborne commerce. Numerous lesser flood control, hurricane protection, and navigation projects have also been developed in response to public officials seeking support for continued desirable community and regional growth.

2.2.14 Tropical Storms

Tropical storm events can directly and indirectly contribute to coastal land loss through a variety of ways: erosion from increased wave energies, removal and/or scouring of vegetation from storm surges, and saltwater intrusion into estuaries and interior wetlands carried by storm surges. These destructive processes can result in the loss and degradation of large areas of coastal habitats in a relatively short period of time (days and weeks versus years).

2.3 FUTURE WITHOUT PROJECT CONDITION

The No-Action Alternative is an analysis of the Future without Project (FWOP) Conditions for the period of analysis. Chapter 4 of the EIS, Environmental Consequences, describes the potential direct, indirect, and cumulative impacts of the No-Action Alternative for the MRGO Ecosystem Restoration Study in detail.

The No-Action Alternative would have no direct beneficial or adverse impacts. Most of the indirect and cumulative impacts resulting from the No-Action Alternative are related to coastal land loss, which is expected to continue into the future without action.

Without action, the key systemic problems in the study area would persist over the period of analysis (2011 to 2065).

- **Land loss**: 131,100 acres of emergent wetlands are projected to be converted to open water (USGS 2010).
- **Bank/shoreline erosion**: Erosion would continue to threaten the littoral structure of the ecosystem and the integrity of critical landscape features.
- **Habitat change and loss**: Wetland losses, saltwater intrusion, and further modification of natural hydrology would result in an increasingly homogenous system. Rare and unique habitat would become increasingly scarce.
- **Modification of natural hydrology**: Land loss would result in the convergence of open water areas into larger waterbodies, further altering the study area hydrology.
- **Decreased freshwater, sediment, and nutrient inputs**: Authorized freshwater diversions in the study area would not fully address the need for additional freshwater, sediments, and nutrients in the study area to nourish emergent vegetation and counteract subsidence and sea level rise.
- **Saltwater intrusion**: The channel closures at Bayou La Loutre and the IHNC are projected to decrease saltwater intrusion into the IHNC and Lake Pontchartrain via the former navigation channel. However, land loss and shoreline erosion would continue to allow more saline waters into the study area estuaries.
- **Retreating and eroding barrier islands**: The entire Chandeleur Island chain is projected to convert to subsurface shoals within the period of analysis.
- **Ridge habitat degradation and destruction**: The Bayou La Loutre ridge would continue to subside to marsh elevation.
- **Invasive species and herbivory**: Without action, invasive vegetation will continue to out-compete native species. Nutria would continue to destroy emergent wetlands.
- **Increasing susceptibility of coastal communities to storm surge**: As emergent vegetation along the marsh edge continues to degrade and erode, interior marshes and human development will become increasingly exposed to the open waters of the Gulf of Mexico.

2.3.1 Other Restoration Efforts

Wetland losses in the Louisiana study area would be offset to some extent by other Federal, state, local, and private restoration efforts, which were predicted by the LCA study to create, restore and/or protect approximately 64,410 net acres in the study area (LCA Subprovince 1).

These numbers are based on a 20-year project life for CWPPRA projects and 50-year project life for all others evaluated.

In addition, more recent restoration efforts would also cumulatively interact to help offset losses of soil resources in the study area, including the following:

- CWPPRA PO-30 Lake Borgne Shoreline Protection project.
- The MRGO 2006 Lake Borgne Shoreline Protection, (Doullut‘s Canal to Jahncke‘s Ditch), St. Bernard Parish, LA (06-C-0210) project.
- The MRGO 2007 North Bank Foreshore Dike Construction and Repairs, Mile 44.4 to Mile 39.9 (Non-Continuous), St. Bernard Parish, LA (07-C-0089) project.

WRDA 2007 authorizes the LCA Plan near-term restoration features, including construction and additional investigations. Implementation of the LCA program WRDA 2007 passed would provide positive cumulative impacts in reducing the loss of wetlands throughout the study area.

Other ongoing restoration projects include the Parish Coastal Wetlands Restoration Program (―Christmas Tree Program”), State of Louisiana projects, CIAP projects, civil works mitigation projects, regulatory permit mitigation projects, LDNR/NRCS/Soil and Water Conservation Committee Vegetation Planting Program, and private restoration efforts.

2.3.2 Coastal Land Loss

Land loss in the study area is expected to continue over the 50-year period of analysis. Without action, coastal vegetated resources would continue to decline, including bankline erosion and sloughing of the shoreline, and continued fragmentation and conversion of existing brackish and saline marsh to shallow open water habitats. Both human induced impacts and natural processes would contribute to the continued loss of vegetated habitats, including: continued shoreline erosion and subsidence, increased saltwater intrusion, increased water velocities, and increased herbivory.

The LCA Study (USACE 2004) estimated coastal Louisiana would continue to lose land at a rate of approximately 6,600 acres per year over the next 50 years. It is estimated that an additional net loss of 328,000 acres may occur by 2050, which is almost 10 percent of Louisiana‘s remaining coastal wetlands.

Wetland acreage data (1985 through 2006) was obtained from the USGS for the study area. FWOP wetland acreages were determined via a linear trendline through those data. Where applicable, annual net acreage benefits associated with pre-existing or soon to be constructed restoration projects were added to the base subunit FWOP acreages to obtain revised FWOP subunit acreages.

With no action, 131,100 acres of emergent wetlands in the Louisiana portion of the study area are predicted to be lost over the period of analysis (USGS 2010). Overall, the majority of direct land loss is expected to occur from interior wetlands. However, substantial wetland losses are also predicted to occur due to shoreline erosion. If the landbridges are breached, existing vegetated wetlands along these critical landbridges would be converted to open water; and those wetlands remaining in the area would be exposed to greater hydrologic forcing factors (tidal flow and wave action).

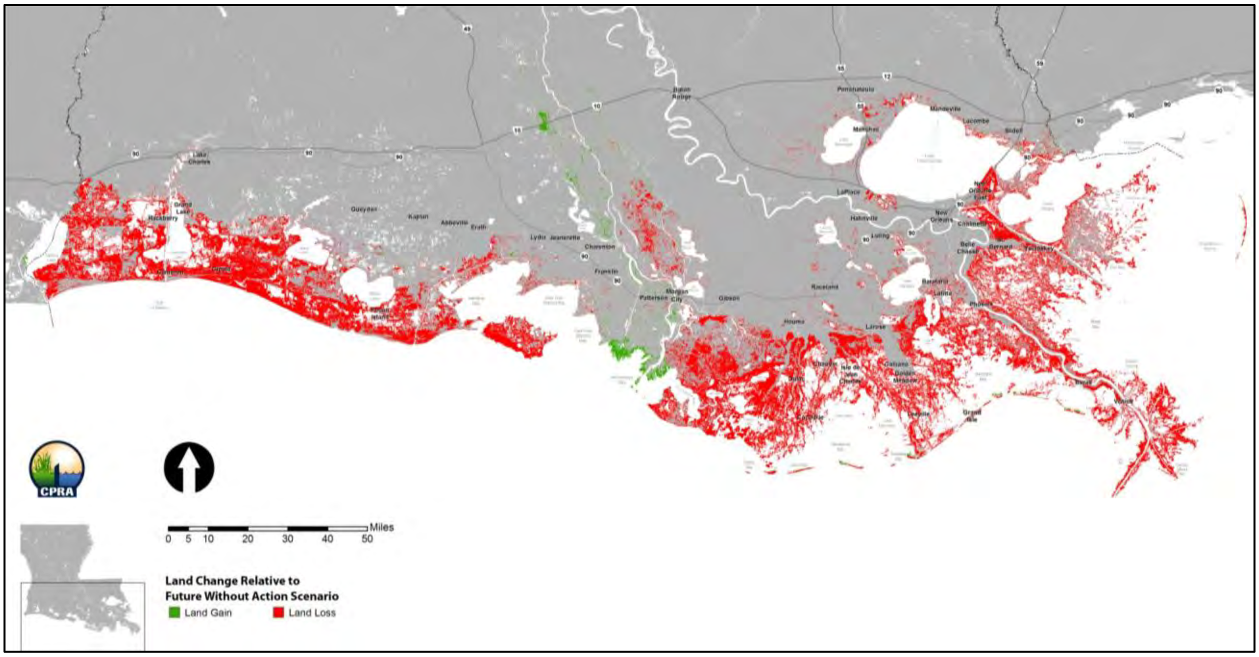


Figure 2-8. Projected Future Land Loss 2050.

Source: Louisiana Coastal Protection and Restoration Authority

2.3.3 Environmental Consequences of Coastal Land Loss

Adverse impacts that would result from the loss of important and essential vegetated habitats used by fish and wildlife are the loss of shelter, nesting, feeding, roosting, cover, nursery, and other life requirements for fish and wildlife; loss of productivity; loss of transitional habitat between estuarine and marine environments; and increased inter- and intra-specific competition between resident and migratory fish and wildlife species for decreasing wetland resources. This loss would also reduce the availability of important stopover habitats used by migrating neotropical birds.

The loss and deterioration of transitional wetland habitats would continue to impact all federally threatened and/or endangered listed species that utilize the study area including: Gulf sturgeon, green sea turtle, hawksbill sea turtle, Kemp‘s Ridley sea turtle, leatherback sea turtle, loggerhead sea turtle, piping plover, and the West Indian manatee.

Cultural Resources

Erosion and land loss would continue to adversely affect existing cultural resources in the study area. The loss of land within the study area threatens the existence and integrity of these sites.

Recreation and Aesthetics

Recreational areas may be affected both positively and negatively by the various projects that would be implemented without the MRGO ecosystem projects. Generally, projects that improve access to recreation areas or increase the diversity of species in an area would be beneficial to recreation. Projects that impede access to open waters or limit birding, hunting or fishing areas would be detrimental to recreation.

The borrow pits that would be created to supply material for structural projects may benefit recreational fishing by providing additional public access to fishing, additional ponds for freshwater fishing or for fish hatcheries, and additional habitat for waterfowl. If the borrow pits are large and in areas where there never was a recreational area, the borrow pits may provide entirely new recreation opportunities.

Marsh creation projects would benefit recreation by providing additional land for birding and hunting, but may be detrimental for recreational boating as open waters are removed. Shoreline restoration projects would reduce risk for recreational areas and would generally benefit recreation by providing increased areas for bird nesting. Shoreline erosion reduction projects cause silt and sediment to accumulate along shorelines, which facilitates access to the water providing a benefit for recreational fishing.

Subsistence bankline erosion and sloughing of the shoreline and conversion of existing fragmented wetlands to open water habitats would persist, possibly resulting in degraded viewscapes for those traveling the study area‘s designated scenic streams.

2.3.4 Socioeconomic Consequences of Coastal Land Loss

The continued coast wide decline of emergent wetlands would contribute to the deterioration of substrate upon which infrastructure features (e.g., levees; oil, gas and water pipelines, telephone and electric transmission wires) are constructed. The effects of land loss and degradation would increase potential infrastructure damage and associated adverse environmental impacts (e.g. pipeline leaks). Continued land loss would increase the cost of maintaining and repairing existing infrastructure. These increased costs would likely be passed on to consumers. An increase in the cost of oil and natural gas infrastructure in Louisiana would likely increase prices for these commodities nationally.

While hydrodynamic models show some benefits from additional marsh, island, and landbridge habitat, the effects of allowing existing features to degrade in these areas are even more pronounced (USACE 2009). Hurricane storm damage risk reduction systems cannot fully depend on coastal landscape features because of the vulnerability of these features to single storm events. However, the FWOP condition could pose a hazard to the efficacy of the $14.45 billion Federal investment in risk reduction systems, because the buffer between the structural system components and open water would continue to deteriorate.

The loss of wetlands in the study area would likely alter the detritus-based food web of the oyster thereby reducing the localized carrying capacity for oyster leases in the area. The resultant decline in oyster production in and near the study area would likely result in a local reduction of oysters, which could lead to higher local oyster prices as leases farther from ports would be relied upon to maintain harvests. There could be similar impacts to nearby state oyster seed grounds in Lake Borgne. This impact could reduce the local availability of seed oysters used to sustain the local oyster lease productivity. Because Louisiana and Western Mississippi Sound produce between 60 to 65 percent of the nation's oysters, these adverse impacts would affect oyster availability and prices across the country.

Continued land loss in the study area would gradually change the estuarine system to a saltwater system. This change could have adverse impacts to estuarine fisheries, as study area wetlands provide nursery and foraging habitats for a variety of economically important marine species. Negative impacts to the productivity of fisheries in the study area would affect the availability and cost of seafood nationally.

Continued degradation and loss of emergent wetlands in the study area would contribute to increased sedimentation and maintenance of the GIWW navigation channel. As the wetlands in the Golden Triangle fragment and convert to open water, the protection afforded to the GIWW from Lake Borgne wind-driven waves would be reduced. Some vessels utilizing the GIWW, especially barge traffic, would be subjected to more open water conditions as the landbridge continues to erode, thereby exposing this waterway directly to Lake Borgne. The integrity of the GIWW as an inland, protected waterway is paramount to its function for navigation and commerce. Costs to maintain this protection would likely increase if the landbridge breached.

2.3.5 Future Hydrology

Programs such as CWPPRA, CIAP, and LCA as well as ongoing hurricane protection projects would have indirect impacts on hydrology in the study area. The gates on the GIWW and Bayou Bienvenue would alter flow patterns in and near the western end of the study area. Construction of the storm surge barrier structure included dredging an access channel on the Lake Borgne side of the floodwall (USACE, 2008). The access channel connects the MRGO with the GIWW across the Golden Triangle, but will be closed after construction. The net effect has been determined to be negligible. The gates across Bayou Bienvenue and the GIWW would remain open, except when a storm surge is present or anticipated.

Construction of the storm surge barrier structure would alter the flow path of tidal propagation into the Central Wetlands area through the Bayou Bienvenue Control Structure. Prior to the construction of the surge barrier, tidal flow in and out of the Bayou Bienvenue Control Structure came from multiple directions (i.e. from across the MRGO as well as from north and from south in the MRGO). With this barrier in place, the tidal flow no longer comes from the south in the MRGO. Likewise the completed MRGO closure structure at the La Loutre Ridge has altered tidal flow paths to the Bayou Dupre Control Structure. The tidal connection with Breton Sound via the MRGO has been severed.

Cumulative Impacts

Cumulative impacts would be the synergistic effect of no action on hydrology with the additive combination of similar wetland degradation and wetland loss impacts to hydrology and hydraulics throughout coastal Louisiana, as well as the benefits and impacts to other state and Federal projects in the vicinity as detailed in the EIS.

2.3.5.1 Future Salinity Conditions

Hydrodynamic modeling was conducted for this study to determine historic, baseline, and future conditions in the study area. This effort is described in detail in Annex 1 of the Engineering Appendix for the study.

FWOP conditions are examined based on the final disposition of future diversions. FWOP scenarios include the baseline conditions at Violet Siphon, Caernarvon, and Bonnet Carré Spillway leakage and openings. Planned diversions at Maurepas Swamp (Convent/Blind River, Hope Canal/Maurepas Swamp River Reintroduction), Caernarvon operation modifications, and the Central Wetlands Wastewater Treatment Program are included in the FWOP conditions.

Planned diversions from the lower Mississippi River located below the Caernarvon Diversion were not included in the hydrodynamic model. The Bertrandville Siphon, Bohemia Mississippi River Reintroduction, Delta Building Diversion (North of Ft. St. Phillip), White Ditch, Bayou LaMoque and the Benney‘s Bay Diversion were deemed to be sufficiently removed from the Lake Borgne ecosystem to preclude significant influence on salinity conditions in the area. Additionally, there is little available information as to the proposed operational schemes for these diversions. The inflow due to existing cuts, overflows and diversions in the Mississippi River reach from Baptiste Collette to Bohemia was approximated as 12% of the River flow.

The freshwater diversion for the Violet Siphon was modeled as 100 cfs, which is assumed to be the average. Historic data were used in the model to include Bonnet Carré Spillway openings with a maximum flow of 240,000 cfs. The combined diversions into the Maurepas swamp area (Convent/Blind River Diversion, Hope Canal/Maurepas Swamp River Reintroduction) have a potential capacity of 4,500 cfs in the FWOP scenario. The Central Wetlands Wastewater Treatment Program flow totaled approximately 30 cfs.

Input flows for the Caernarvon diversion were increased by roughly 25 percent, which is consistent with the projected modifications to operations. The increase is calculated by increasing the actual flows for 2007 and 2008, in which the structure was operated to pulse large flows, by 25 percent. The resulting flows were then smoothed so as to eliminate rapid changes that might induce numerical instabilities in the model.

The hydrodynamic model results indicate that the planned diversions reduce salinity in the study area. However, the salinity reductions do not restore pre-MRGO conditions in the Lake Borgne ecosystem. Additional freshwater is needed to achieve the salinity targets developed for this study, as described in Section 2.5.6.

2.3.6 Future Water Quality

The FWOP includes direct adverse and beneficial impacts on water quality from the implementation of freshwater diversions or other programs, such as CWPPRA, CIAP, and LCA, within the study area. These diversions could have both adverse and beneficial impacts to water quality, as discussed in detail in the EIS. Current water quality conditions would likely persist and coastal wetlands could continue to be affected by natural and man-made factors that have both beneficial and adverse effects on water quality. The continual loss of emergent wetland plants under existing conditions, some of which absorb and transform pollutants in the air and water, could reduce the amount of pollution absorbed/transformed, which would likely have direct adverse effects on water quality.

2.3.7 Future Soils

The ongoing conversion of wetlands to shallow open water under existing conditions would continue in the FWOP. The projected loss of wetlands in the study area is 131,091 acres over the 50-year period of analysis; this would include the loss of wetland soil types over this area. The Clovelly muck and Lafitte muck soil types would primarily be lost, with some loss of Fausse clay soils. Net primary productivity within the study area would continue to decline and existing wetland vegetation would continue to diminish.

Cumulative impacts of the projected loss of soil resources from the study area would be in addition to the loss of soil resources throughout Louisiana and Mississippi. The LCA Study (USACE, 2004) estimated coastal Louisiana would continue to lose land at a rate of approximately 6,600 acres per year over the next 50 years. It is estimated that an additional net loss of 328,000 acres may occur by 2050, which is almost 10 percent of Louisiana‘s remaining coastal wetlands. However, these wetland soil losses would be offset to some extent by restoration projects implemented through other programs.

2.3.8 Future Barrier Island Resources

Chandeleur and Breton Islands would continue to deteriorate without the implementation of a restoration program. It is projected that by 2014, Breton Island would have no remaining subaerial acreage and the entire Chandeleur Island chain (that includes Breton Island) would be completely eroded. Without the Chandeleur and Breton Barrier Islands, important gradients and ecotones would not exist in landward bays and wetlands, resulting in decreases in estuarine habitat complexity followed by decreases in species diversity and biomass (Hester et al., 2005).

2.3.9 Future Coastal Vegetation Resources

Marsh habitat would continue to be restored through other restoration projects and programs, such as the Coastal Wetlands Planning, Protection and Reservation Act (CWPPRA), the Coastal Impact Assistance Program (CIAP), and the Louisiana Coastal Area (LCA), but not at a magnitude to completely restore natural processes and features vital to the long-term success of the watershed. Without action, the coastal vegetation resources of the project area would continue to decline through bankline erosion, sloughing of the shoreline, and continued fragmentation and conversion of existing brackish and saline marsh to shallow open water habitats. Continuing adverse impacts to coastal vegetation would result from both human activities and natural processes including continued shoreline erosion and subsidence, increased saltwater intrusion, increased water velocities, and increased herbivory.

2.3.10 Future Wildlife Resources

Without an extensive ecosystem restoration plan, marsh habitat in the study area would continue to be restored through other restoration projects and programs, such as those authorized for construction through CWPPRA, CIAP, and LCA; these projects would indirectly and cumulatively benefit wildlife, but not on a large enough scale to completely restore natural processes and features vital to the long-term success of the watershed.

Habitat quality would decline as wetlands continue to deteriorate and fragment, specifically in the critical landbridges within the study area. As interior wetlands convert to open water, there would be an expected loss of species richness. The continued degradation and loss of wetland habitat would also likely result in a localized decrease in wildlife use of the area. In general, for most amphibians, reptiles, birds, and mammals, the fresh, intermediate, and brackish wetlands are required or preferred to open water habitats (Chabreck, 1988).

2.3.11 Future Aquatic and Fisheries Resources

The persistence of existing conditions, such as wetland fragmentation and emergent wetland loss, as well as, shoreline and bank line erosion contributing to the continued degradation of aquatic habitat would continue in the FWOP. Over time, this would result in a substantial decrease of habitat needed for support the life stages of numerous fish species, therefore reducing the area‘s ability to adequately support fishery resources. Distribution and abundance of aquatic organisms would likely decrease, indirectly impacting species linked in the food web to directly affected species. Reduction in emergent wetlands would result in shifts of predator/prey relationships, decline in fish productivity, and reduced recreational fishing opportunities.

Continued restoration of emergent marsh and shoreline habitat, authorized through programs such as CWPPRA, CIAP, and LCA, as detailed in chapter 2, would benefit aquatic and fishery resources; however, these programs would not be as beneficial on a large scale as the MRGO Restoration program, which would restore natural processes and features vital to long-term success of aquatic and fisheries resources.

2.3.12 Future Storm Surge and Wave Conditions

Water levels are expected to be similar or greater than existing conditions in the future. Because of the uncertainty and wide ranges inherent in sea level rise projections, the MsCIP and the LACPR efforts used scenarios to evaluate the effects of different relative sea level rise rates (eustatic sea level rise combined with subsidence) over a 50-year planning period. The relative sea level rise values used for the MsCIP scenarios were 0 feet, 2 feet, and 3.4 feet (USACE 2008b). The relative sea level rise values used for the LACPR scenarios were 1.3 feet and 2.6 feet, and deltaic rates of 1.9 feet and 3.2 feet (USACE 2009). Because a variety of factors affect the height of storm surge, at this stage of scientific knowledge it is difficult to quantify the effect of wetland loss in the study area on storm surge.

The IHNC Surge Barrier will alter flow patterns in and near the middle end of the study area (Lake Borgne and eastern Lake Pontchartrain). For construction of this structure, an access channel was dredged on the Lake Borgne side of the floodwall (USACE 2008c). Modeling indicates that the net effect will be negligible. The gates across Bayou Bienvenue and the GIWW would remain open, except when storm surge is anticipated. This configuration would prevent salt-water intrusion into the Central Wetlands in storm situations, while not impeding tidal flows under normal circumstances. The concrete surge barrier across the MRGO channel south of Bayou Bienvenue will stop tidal flow on the channel, but the closure structure at Bayou La Loutre has a greater impact on non-storm flows in the MRGO. Nevertheless, the water flows near the sector gates are anticipated to be greater than preconstruction conditions. Additionally, modeling scenarios indicate that the Chalmette Loop Levee would raise the water levels by up to 0.1 foot (0.03 meter), with marshes experiencing up to 7 hours of additional wetted period per day (USACE 2008c).

2.3.13 Relative Sea Level Rise Scenarios

Recent climate research by the Intergovernmental Panel on Climate Change (IPCC) predicts continued or accelerated global warming for the 21st Century and possibly beyond, which will cause a continued or accelerated rise in global mean sea level. Subsidence of the deltaic sediments which characterize the study area is an ongoing process that will continue to contribute to relative sea level rise. Marsh accretion is a mechanism which allows marshes to keep pace with relative sea level rise through organic and inorganic sediment accumulation. Coastal marshes may accrete at a rate that keeps pace with a slow rate of sea level rise; however, as the rate of sea level rise increases, coastal mashes cannot maintain their elevation, and they submerge and are transformed to open water. Some Louisiana marshes are able to survive current sea-level rise conditions; increased sea-level rise may approach or cross this critical threshold (USGS website).Engineering Circular No. 1165-2-211 dated July 1, 2009, provides USACE guidance for incorporating the direct and indirect physical effects of projected future relative sea level rise in managing, planning, engineering, designing, constructing, operating, and maintaining USACE projects. The National Research Council‘s 1987 report *Responding to Changes in Sea Level: Engineering Implications* recommends a multiple scenario approach to deal with key uncertainties for which no reliable or credible probabilities can be obtained. In the context of USACE planning, multiple scenarios address uncertainty and help to develop better risk-informed alternatives. The final array of alternatives were evaluated using “low,” “intermediate,” and “high” rates of future relative sea level rise for both “with” and “without” project conditions as shown in Table 2-3.

Table 2-3. Relative Sea Level Rise Projections Over the Period of Analysis

Scenario	Based On	RSLR	
Low	Historic rates	1.8 feet	0.55 meters
Medium	NRC Curve I	2.2 feet	0.69 meters
High	NRC Curve III	3.7 feet	1.12 meters

The “high” rate exceeds the upper bounds of IPCC estimates from both 2001 and 2007 to accommodate for the potential rapid loss of ice from Antarctica and Greenland.

Wetland Acreage Predictions under Increased SLR Rates

For the medium and high scenarios, the future wetland loss rates were increased to simulate effects of increased wetland submergence. Using predicted future water levels (based on the Shell Beach gage) under medium and high sea-level rise scenarios, those water levels were converted into relative sea level rise (RSLR) rates, assuming that those water levels incorporate both subsidence and sea level rise effects. By subtracting the average accretion value of 7.4 mm/yr (an average of accretion measurements obtained throughout the project area), from the year 2011 baseline RSLR rate of 10.24 mm/yr, a net baseline submergence rate of 2.84 mm/yr was calculated. Likewise, the 7.4 mm/yr average accretion value was subtracted from predicted future submergence rates under both the medium and high SLR scenarios. To calculate future wetland loss rates under increased SLR scenarios, the baseline wetland loss rate, in acres lost per year, was multiplied by the year X submergence rate ratio (i.e., Submergence Rate Year X/Submergence Rate Year 2011).

Based on research conducted at the Madison Bay wetland loss hotspot in the Terrebonne Basin, it appears that when submergence reaches a certain critical threshold, plant productivity decreases rapidly and the marsh undergoes a rapid loss or collapse, when there is there inadequate sediment accretion to counter submergence. According to (Nyman et al. 2006), that threshold is 10 mm/yr. Under the high SLR scenario, this submergence threshold is reached in year 2023. It was assumed that once that threshold was reached, the marsh would undergo rapid collapse and be totally converted to open water in 10 years. Consequently, under the high SLR scenario, marshes not receiving additional sediment would totally disappear by year 2033.

2.4 PROBLEMS AND OPPORTUNITIES

The first step in the planning process is the identification of problems and opportunities. Problems are undesirable conditions that the study will attempt to improve. Opportunities are desirable conditions that could be achieved in the future. Study area problems and opportunities were drawn from prior comprehensive planning studies and from public input and inter-agency information exchange.

System-wide problems and opportunities were used to identify and define more geographically specific problems and opportunities throughout the study area. Through the NEPA public scoping process, the study team solicited input on problems and opportunities from members of the public, government resource agencies, and other stakeholders. A discussion of general study area problems and opportunities follows. The study area was divided into subunits and problems were documented on a subunit basis. Section 2.6, Evaluation of Management Measures, describes how study area opportunities were developed into management measures for each subunit.

2.4.1 Study Area Problems

The main water resource problems identified in the study area are as follows:

- Land loss
- Bank/shoreline erosion;
- Habitat change and loss;
- Modification of natural hydrology;
- Decreased freshwater, sediment, and nutrient inputs;
- Saltwater intrusion;
- Retreating and eroding barrier islands
- Ridge habitat degradation and destruction
- Invasive species;
- Herbivory; and
- Increasing susceptibility of coastal communities to storm surge.

Figure 2-9. System-Wide Problems and Potential Management Measures

A conceptual ecological model was developed to illustrate the stressors and drivers of the system.

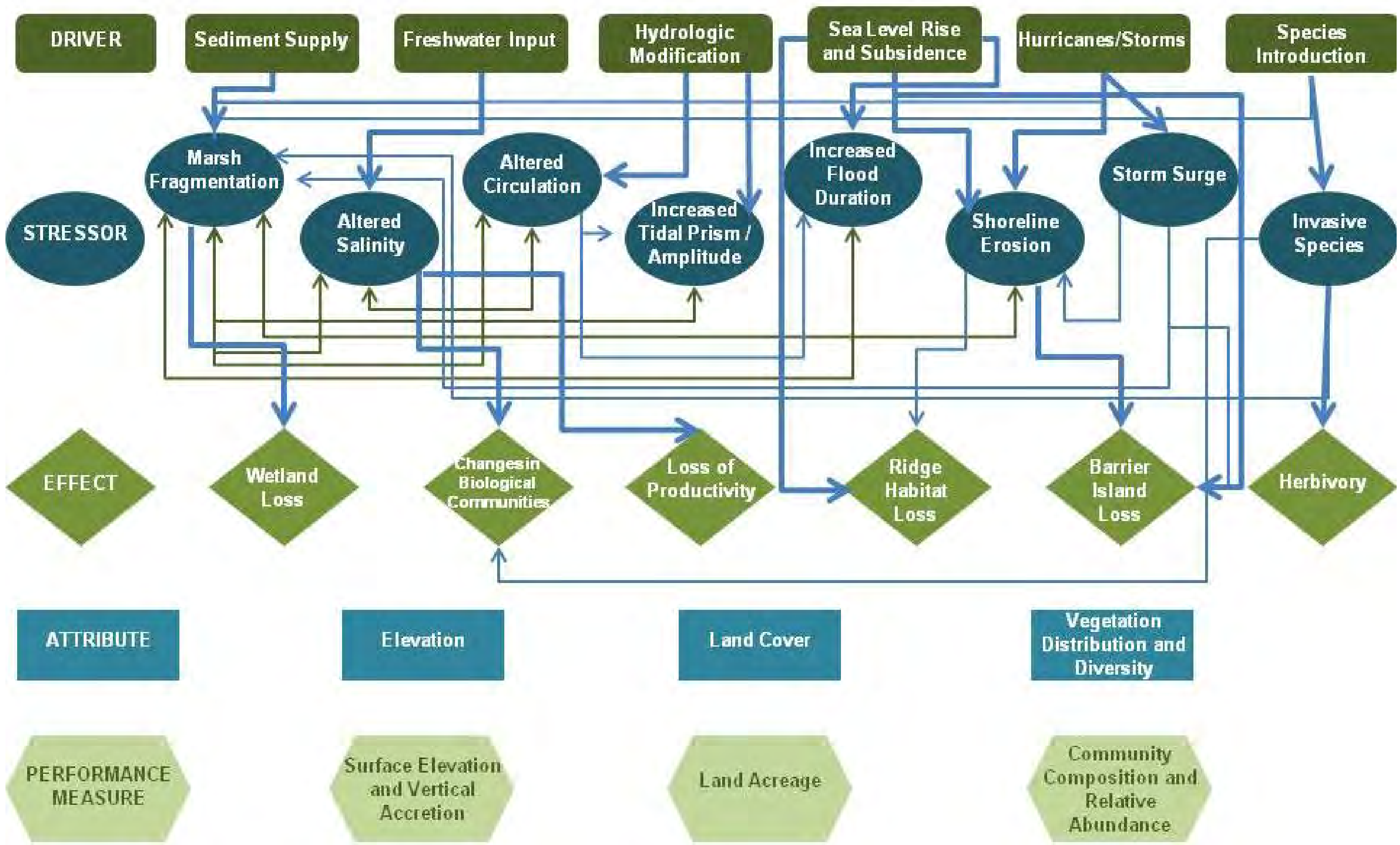


Figure 2-10. Conceptual Ecological Model

Coastal Land Loss

As previously described in the sections on existing and FWOP conditions, perhaps the most serious and complex problem in the study area is land loss. Land loss is a critical problem not only because of ecosystem degradation but also because of its role in increasing susceptibility of coastal communities to storm surge. Relative sea level rise, tropical storms, shoreline erosion, modification of natural hydrology, and other factors contribute to land loss in the study area. Coastal ecosystem sustainability is threatened by the inability of many wetlands to maintain their surface elevation. Alterations which allow marsh soils to be excessively waterlogged cause soil chemical changes stressing even the most resilient marsh plants. Plant stress can lead to mortality. Once plants die, roots no longer provide structure and integrity to hold marsh soils, and land loss results.

Bank/Shoreline Erosion

Tropical storms and wind driven waves cause erosion. Navigation channels subject inland areas to more dramatic tidal forces and wave action, increasing erosion. Rims of firmer soil around lakes, bays, and natural ridges along waterways are susceptible to wind-induced erosion. When these firmer soils are eroded away, organic marsh soils are directly exposed to open water wave attack.

Figure 2-11. Fragmented Marsh Separating Lake Borgne from the MRGO.

Fort Proctor (bottom left), an historic pre- Civil War era fort was originally constructed on land but is now surrounded by Lake Borgne.

Habitat Change and Loss

Habitat diversity is important for a healthy ecosystem. Erosion, storm surge inundation, and salinity changes from decreased freshwater inputs or saltwater intrusion can cause habitat changes and habitat loss (Figure 2-12). In some areas (such as the Central Wetlands), loss of habitats with high friction factors, such as swamp forests, can lead to higher storm surge risk.

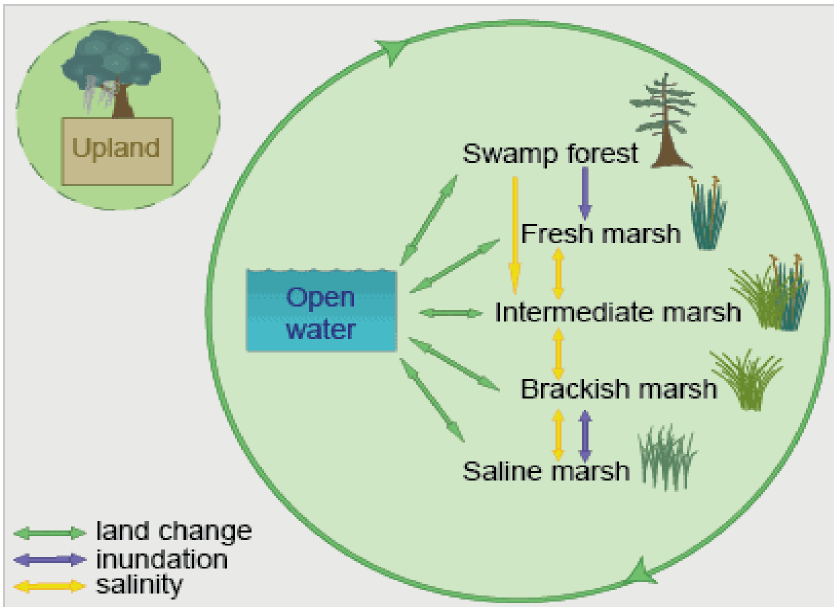
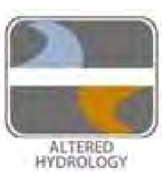


Figure 2-12. Potential Pathways of Change among Habitats and the Associated Driving Forces (Source: CLEAR)



Modification of Natural Hydrology

Construction of levees, oil and gas canals and navigation channels has altered natural hydrology, affecting freshwater, sediment, and nutrient transport. Dredged material spoil banks block the movement of sediment re-suspended during storms. Hurricanes play a major role in sediment transport and sustaining land elevations in coastal wetlands (Reed et al. 1997). Hurricanes can also result in massive land loss. Channels and canals promote saltwater intrusion and increase tidal processes that impact the marsh by accelerating erosion. Canals impede sheetflow and cause ponding of water on the marsh. Because of the presence of dredged material banks, partially impounded areas experience fewer but longer periods of flooding and reduced water exchange when compared to unimpounded marshes (USACE 2004). This impoundment results in increased waterlogging and frequently in plant death.

Hypoxic/anoxic conditions (“dead zones”) occur in Lake Pontchartrain and the Gulf of Mexico. These conditions are caused primarily by excess nitrogen in combination with stratification of more saline waters. Due to the control of the Mississippi River, nutrients pass though the study area and into the northern gulf, rather than into adjacent wetlands, which would absorb these nutrients.

Decreased Freshwater, Sediment and Nutrient Inputs

The construction of levees along the Mississippi River and its distributaries has eliminated the periodic floods that provided vital freshwater, sediment and nutrients to the study area. These flood control measures have seriously altered hydrogeomorphic, biogeochemical, and ecological processes. Without inputs of freshwater, sediment and nutrients, coastal land loss is accelerated and natural subsidence is exacerbated.

Saltwater Intrusion

Saltwater intrusion changes salinity gradients in estuaries, resulting in habitat shifts. Salinity levels exist along a gradient, which declines as the saltwater moves inland from the Gulf of Mexico. A distinct zonation of plant communities, or vegetative habitat types, differing in salinity tolerance exists along that gradient, with the species diversity of those zones increasing from salt to fresh environments. Changes to the salinity gradient are caused by a number of factors, including: the construction of levees, channels and canals, and drainage systems. Tropical storms can introduce saltwater into fresher areas, damaging large amounts of habitat in a short period of time.

Retreating and Eroding Barrier Islands

The barrier islands in the Louisiana portion of the study area are the remains of an abandoned Mississippi River Delta lobe; and their degradation is the result of the natural deltaic processes. The formation of Cat Island in Mississippi was also influenced by this abandoned delta, and it is distinct from other Mississippi barrier islands (Schmid 2001). Barrier islands act as buffers to reduce the effects of ocean waves and currents on associated estuaries and wetlands. Louisiana's barrier islands are eroding at a rate of up to 66 feet per year. According to recent U.S. Geological Survey (USGS) estimates, several islands will disappear by the end of the century (USACE 2009). Although Cat Island has lost 39% of the land area it had in 1848, it is the most stable of the Mississippi barrier islands. Interior elevations and the orientation of Cat Island prevent breaching and overwash by storm waves except along spits of the eastern shore (Morton 2007).

Figure 2-13. Aerial view of Breton Island (2009)

Ridge Habitat Degradation and Destruction

Natural levees are ridges formed from sediments delivered over the banks of rivers and bayous during floods. These ridges assist in defining a watershed and in maintaining its natural hydrology. Ridges sustain upland shrubs and trees, providing unique habitat for certain plant and animal species, such as birds and mammals. Intact ridges prevent intrusion of saltwater into fresher marsh. Natural factors such as subsidence have contributed to the loss of the ridges. The construction of the MRGO directly affected the Bayou La Loutre ridge by cutting the channel through the ridge.

Invasive Species

The aggressive spread of invasive species decreases native plant communities, rapidly altering ecosystem function. For instance, Chinese tallowtree (*Triadica sebifera*, formerly *Sapium sebiferum*), an invasive species found in the study area, can establish self-replacing monocultures that provide less value to the foraging of migrating avian species. Disturbed ecosystems are more vulnerable to invasive species than stable ecosystems: therefore, invasive species are a severe threat to biodiversity and ecological function in the study area.

In the study area, water hyacinth (*Eichhornia crassipes*), alligator weed (*Alternanthera philoxeroides*), and hydrilla (*Hydrilla verticilata*), common salvinia (*Salvinia minima*), giant salvinia (*Salvinia molesta*), and variable-leaf milfoil (*Myriophyllum heterophylum*) are invasive aquatic vegetative species, displacing native aquatics and degrading water and habitat quality (USACE 2009). Chinese tallowtree and sea-side cedar (*Tamarix gallica*) interrupt natural succession of native prairie, scrub-shrub and woody species because of their tolerance to flooding and salt stress (USACE 2009). Cogongrass (*Imperata cylindrica*) is a fast-growing perennial grass that is infesting Gulf coast wetlands, savannas, and forests (USACE 2009).

Herbivory

During the 1930s, nutria (*Myocastor coypus*) were accidentally released into the coastal wetlands. Their population has rapidly expanded and their grazing and foraging for plant roots have been a major contributor to wetland losses (USACE 2009). Although native, rather than an introduced species, muskrat eat-outs may also result in significant local impacts to area marshes. Eat-outs may recover under some conditions, tropical storm impacts on an eat-out area may overnight convert such an area to permanent open water conditions (USGS 2000).

Increasing Susceptibility of Coastal Communities to Storm Surge

The levees and floodgates that allowed increased development in coastal areas also contribute to subsidence and wetland loss. Continued land loss and ecosystem degradation cause developed areas to become more susceptible to storm surge, threatening communities and valuable infrastructure.

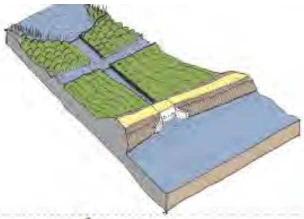
2.4.2 Study Area Opportunities

For each of the problems described in the previous section opportunities to improve future conditions were identified. Table 2-4 shows the linkages between study area problems and ecosystem restoration opportunities.

Table 2-4. System-Wide Study Area Problems and Opportunities

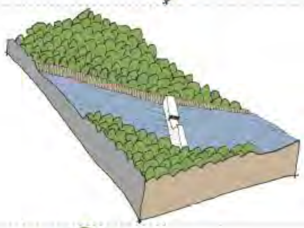
Problems	Opportunities
Decreased Freshwater, Sediment, and Nutrient Inputs	Increase sediment, freshwater, and nutrient inputs Increase organic deposition.
Modification of Natural Hydrology	Restore altered tidal circulation patterns and improve water quality.
Saltwater Intrusion	Prevent saltwater intrusion.
Wetland Loss	Create wetlands, nourish, and prevent the continued loss of wetlands.
Ridge Habitat Degradation and Destruction	Restore ridge habitat.
Bank/Shoreline Erosion	Prevent bank and shoreline erosion.
Habitat Changes and Loss	Restore habitat types such as swamps, ridges, submerged aquatic vegetation, oyster reefs, and barrier islands.
Invasive Species	Eliminate or reduce invasive species.
Herbivory	Prevent herbivory.
Retreating and Eroding Barrier Islands	Restore barrier islands.
Human Development Susceptible to Storm Surge	Reduce or prevent storm surge damage through restoration of natural ecosystem features.

Mississippi River Diversion



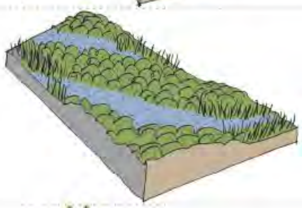
Diverting freshwater from the Mississippi River into the study area could nourish existing marshes to increase their productivity and build wetlands, maintain and restore salinity gradients, and reintroduce and distribute sediment and nutrients throughout the ecosystem.

Hydrologic Restoration



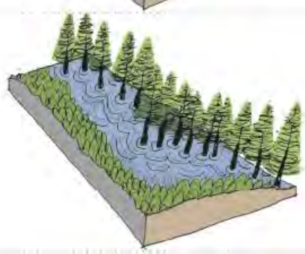
Several channels and canals within the Louisiana portion of the study area were identified during the scoping process for potential backfilling, plugging, installing water control structures (such as weirs and sills), or bank gapping.

Marsh Restoration and Nourishment



Marsh restoration involves the placement of dredged material in shallow openwater areas and extensively broken marsh to raise the area to marsh elevation. Following compaction and dewatering, the area is planted with marsh vegetation. Unlike marsh restoration features, no plantings are associated with marsh nourishment features.

Swamp Restoration and Nourishment



Swamp would be restored through the placement of dredged material, similar to marsh restoration features described above. Swamp restoration features would have a higher elevation than marsh restoration features to support cypress trees. Swamp nourishment is proposed for areas that are currently at marsh elevation, and consists of placing a thin layer of dredged material to nourish the area, raise elevation, and encourage the recruitment of cypress-tupelo community species.

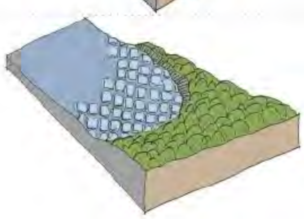
Shoreline Protection

Shoreline protection includes the placement of materials, such as sand, shell, or rock on-shore or off-shore. Construction methods included the establishment of artificial reefs and breakwaters off-shore as well as the placement of rock or sand on-shore. These measures dissipate wave energy and prevent shoreline erosion and land loss.

Ridge Restoration

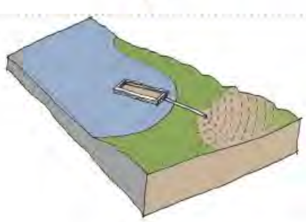
Historically, ridges were formed as natural levees of major and minor distributary channels that diverge from larger distributaries as they trend toward the outer coast. Ridge restoration would consist of the placement of dredged material to a height suitable for upland habitat. Various footprints were evaluated for several reaches of these historic ridges.

Artificial Oyster Reefs



Artificial oyster reefs were considered both for oyster production and shoreline protection purposes. Three alternative designs for artificial oyster reefs were evaluated as shoreline protection measures, i.e., a bio-engineered reef, using crushed stone, or incorporating a berm for oysters in addition to a traditional rock shoreline protection measure. These measures demonstrate the opportunity to incorporate benefits for oysters into shoreline protection designs.

Dredge and Place



Various sources for dredging and piping sediment exist throughout the study area. Barges could be used to bring material from other locations in the region; however, the cost of transporting material by barge generally costs about twice as much as pumping material via pipeline from a nearby source.

Figure 2-14: Study Area Potential Management Measures

2.4.3 Identification of Management Measures

A management measure is a feature (a structural element that requires construction or assembly on-site) or an activity (a nonstructural action) that can be combined with other management measures to form alternative plans. Management measures were developed to address study area problems and to capitalize upon study area opportunities. Management measures were derived from a variety of sources including prior studies, the NEPA public scoping process, and the multidisciplinary, interagency PDT. The structural management measures considered can be grouped into the following categories:

- Freshwater diversions
- Hydrologic restoration (e.g. plugs, fill, weirs, sills)
- Vegetative plantings
- Marsh restoration, marsh nourishment, and swamp restoration
- Shore protection
- Ridge restoration
- Restoration of forested habitat
- Barrier island restoration
- Submerged aquatic vegetation (SAV) restoration
- Oyster reef restoration

WRDA 2007 Section 7013 states that the study should undertake “efforts to integrate the recommendations of the report with the program authorized under section 7003 [LCA] and the analysis and design authorized by title I of the Energy and Water Development Appropriations Act, 2006 (119 Stat. 2247) [LACPR]”. Therefore, restoration features located in the study area proposed in LCA and LACPR were included in the initial evaluation of management measures.

In addition, the following nonstructural measures were considered: invasive species control; herbivory control; and buy-outs of developed areas for ecosystem restoration purposes. Invasive species control and herbivory control measures will be further considered in conjunction with structural measures as detailed designs and implementation plans are developed. Buy-outs of developed areas were not deemed necessary for the plan because of the large extent of non-developed areas available for restoration purposes.

2.4.4 Descriptions of Measures by Type

The section describes the types of measures that were identified to address study area problems and opportunities. The specific measures considered and the initial screening process as applied to each group of management measures is described in Section 2.6.2.

Freshwater Diversions

Freshwater diversion features could address the following study area problems: decreased freshwater, sediment, and nutrient inputs; modification of natural hydrology; saltwater intrusion; habitat changes and loss; wetland loss; and human development susceptible to storm surge. Diverting freshwater from the Mississippi River into the study area could nourish existing marshes to increase their productivity and build wetlands, maintain and restore salinity gradients, and reintroduce and distribute sediment and nutrients throughout the ecosystem. The benefits that diversions produce increase over time and continue as long as the diversion is operated and maintained. In addition, diversion operations can be adaptively managed to respond to environmental changes and optimize benefits. Figure 2-15 shows the Mississippi River Diversion at Caernarvon.

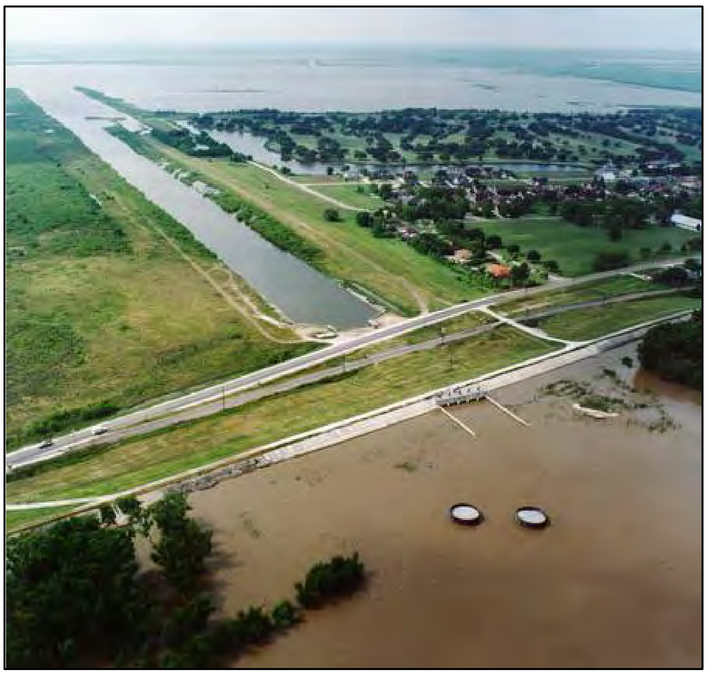


Figure 2-15. Caernarvon Freshwater Diversion

Hydrologic Restoration Measures

Hydrologic restoration measures could address the following study area problems: modification of natural hydrology; saltwater intrusion; and habitat changes and loss; and human development susceptible to storm surge. Hydrologic restoration can be achieved through backfilling, plugging, or creating gaps in the banks of canals and channels. The construction of water control structures, such as weirs and sills, can also restore natural hydrology. Several channels and canals within the Louisiana portion of the study area were identified during the scoping process for potential backfilling, plugging, installing water control structures (such as weirs and sills), or bank gapping. Bank gapping can be used to help restore natural hydrology and provide nutrients and sediment to facilitate organic deposition, improve biological productivity, and prevent further habitat deterioration (USACE 2004). Weirs and sills provide partial closure and aid sedimentation and salinity control. Backfilling can serve the dual purpose of water control and land building (depending upon the depth of fill). Plugging can be accomplished with lateral fill or full closure structures. Plugging methods are primarily water control structures and do not provide the land creation benefits of backfilling. Plugging, however, is usually a substantially less expensive option than backfilling.

Vegetative Planting

Vegetative planting features could address the following study area problems: habitat changes and loss; wetland loss; herbivory, invasive species; and human development susceptible to storm surge. One way to address habitat loss is through planting appropriate native species in areas that already have the necessary elevation to maintain a particular habitat. of restore and rebuild wetlands. Vegetated habitat will provide the following benefits: combat subsidence; reduce breaching and erosion; reduce wave fetch from open water areas; and allow for more vertical accumulation of vegetation.

Marsh Restoration and Marsh Nourishment

Marsh restoration and nourishment features could address the following study area problems: habitat changes and loss; wetland loss; herbivory, invasive species; and human development susceptible to storm surge. One way to address marsh loss is through the placement of dredged material to restore and rebuild wetlands. Marsh restoration involves the placement of dredged material in shallow open water areas and extensively broken marsh to raise the area to marsh elevation. Following compaction and dewatering, the area is planted with marsh vegetation. Retention dikes, deflection dikes, and/or closures may be used to contain material within the restoration area. Dredged material is allowed to overflow to nourish and consolidate existing marsh vegetation within the restoration area.

Marsh nourishment refers to the placement of a thin layer of dredged material into broken marsh. The placement of this material facilitates the recruitment and consolidation of marsh vegetation after dewatering. Unlike marsh restoration features, no plantings are associated with marsh nourishment features.

Newly restored or nourished marsh will provide the following benefits: add new sediment and nutrients to the system; combat subsidence; reduce breaching and erosion; reduce wave fetch from open water areas from previously broken marsh; and allow for more vertical accumulation of vegetation.

Figure 2-16. Dredge Material Placement for Marsh Restoration

Swamp Restoration and Swamp Nourishment

Swamp restoration and nourishment features could address the following study area problems: habitat changes and loss; wetland loss; herbivory, invasive species; and human development susceptible to storm surge. In addition to marsh restoration, there were additional suggestions to restore cypress swamp habitat in the study area. Swamp would be restored through the placement of dredged material, similar to marsh restoration features described above. Swamp restoration features would have a higher elevation than marsh restoration features to support cypress trees.

Swamp nourishment is proposed for areas that are currently at marsh elevation, and consists of placing a thin layer of dredged material to nourish the area, raise elevation, and encourage the recruitment of cypress-tupelo community species.

Figure 2-17. Dredge Piping Sediment from the Mississippi River to Restore Marsh

Shoreline Protection

Shoreline protection features could address the following study area problems: habitat changes and loss; wetland loss; and human development susceptible to storm surge. The prevention of shoreline erosion is essential to addressing the larger problem of coastal land loss. High water, wave action, wind induced currents, tidal flow, channel bathymetry, and tidal circulation can contribute to shoreline erosion.

Shoreline protection includes the placement of materials, such as sand, shell, or rock on-shore or off-shore. Construction methods included the establishment of artificial reefs and breakwaters off-shore as well as the placement of rock or sand on-shore. These measures dissipate wave energy and prevent shoreline erosion and land loss.

Figure 2-18. Example of Onshore Placement of Rock for Shoreline Protection

Figure 2-19. Example of Offshore Placement of Rock for Shoreline Protection

Ridge Restoration

Ridge restoration features could address the following study area problems: habitat changes and loss; wetland loss; herbivory, invasive species; human development susceptible to storm surge; and ridge habitat degradation and destruction. Historically, ridges were formed as natural levees of major and minor distributary channels that diverge from larger distributaries as they trend toward the outer coast. Deposits of mostly linear dredged material along the coast may also be considered ridges if they mimic natural levees. Natural ridges in the study area include the Bayou La Loutre ridge and the Bayou Terre aux Boeufs ridge. Several reaches of the Bayou La Loutre and Bayou Terre aux Boeufs ridges were proposed for restoration as part of the initial array of measures considered. Ridge restoration would consist of the placement of dredged material to a height suitable for upland habitat. Various footprints were evaluated for several reaches of these historic ridges.

Restoration of Forested Habitat

Restoration of forested habitat could address the following study area problems: habitat changes and loss; wetland loss; herbivory, invasive species; human development susceptible to storm surge; and ridge habitat degradation and destruction. Measures to restore forested habitat include planting woody vegetation. Vegetative planting measures were developed as standalone measures on existing spoil banks and in conjunction with other measures such as ridge restoration and swamp restoration. These measures may contribute to storm surge risk reduction.

Forests are an important resource in the study area and provide important habitat for resident and migratory birds. Wetland and upland forested habitat historically found in the study area has decreased. During public scoping meetings, measures to restore forest habitat were suggested.

Barrier Island Restoration

Barrier island restoration could address the following study area problems: retreating and eroding barrier islands; habitat changes and loss; and wetland loss. Barrier island restoration was considered for all barrier islands in the study area. These measures may contribute to storm surge risk reduction and salinity control. Barrier Islands in the study area consist of the Chandeleur Chain (including Chandeleur Island and Breton Island) and Cat Island (located between the Mississippi Sound and the Chandeleur Sound). Restoration of these islands was proposed as part of the initial array of measures considered.

Through LACPR and MsCIP, the contribution of surge reduction provided by the barrier islands, in their historic, existing, and altered states, has been subject to sensitivity analyses. The reports indicate that some surge reduction is realized by the barrier islands. Additional benefits were also predicted by creating longer and higher islands. It can only be speculated as to how much actual damage reduction the barrier islands provide, but the disappearance of the barrier islands provides the means for a dramatically increased wave climate, along the coasts of Mississippi and Louisiana.

Submerged Aquatic Vegetation (SAV) Pilot Projects

Submerged Aquatic Vegetation (SAV) restoration could address the habitat changes and loss problem in the study area. SAV beds improve water quality and provide other ecosystem function benefits such as increased habitat availability for critical fisheries resources. Worldwide, SAV coverage has been declining. For example, in 1969, an estimated 20,000 acres of SAV were documented in Mississippi Sound and coastal bays. As of 1998, only 2,000 acres were documented (Moncrieff et. al. 1998).

Submerged aquatic vegetation is an important component of the Lake Pontchartrain ecosystem. Presently, there are few areas where SAV is present, most of which are along the northshore (Cho and Poirrier 2005). Salinity level and water clarity have been determined to be two of the main factors that affect SAV in the Lake (Cho and Poirrier 2005).

During public scoping meetings, pilot projects to investigate various methods of SAV planting in the Mississippi Sound and in Lake Pontchartrain were suggested. SAV restoration measures are presented as pilot projects because of uncertainties surrounding the re-establishment of SAV beds. For example, it is unknown if efforts to create habitat conditions that are suitable for SAV are sufficient for restoration or if more targeted approaches, such as planting, would also be necessary to re-establish SAV beds.

Oyster Reef Restoration

Oyster reef restoration features could address the following study area problems: habitat changes and loss; wetland loss; and human development susceptible to storm surge. The establishment of oyster reefs in the Biloxi Marshes was suggested during public scoping meetings. Generally, oyster communities are a part of the Lake Borgne ecosystem and some reef designs could dissipate wave energy and thus prevent shoreline erosion or land loss and contribute to storm surge risk reduction.

Oyster reefs were considered both for oyster production and shoreline protection purposes. Three alternative designs for oyster reefs were evaluated as shoreline protection measures, i.e., a bio-engineered reef, using crushed stone, or incorporating a berm for oysters in addition to a traditional rock shoreline protection measure. These measures demonstrate the opportunity to incorporate benefits for oysters into shoreline protection designs.

2.4.4.1 Risk and Uncertainty Associated with Restoration Measure Types

All restoration measure types are subject to the general risks and uncertainties discussed in Section 2.5.4. Risk is considered to be the product of the likelihood of project failure and the consequences of that failure. Uncertainty is the lack of surety inherent in any future-oriented planning effort and is the result of incomplete and inadequate information about future conditions. The following section discusses specific risks for each restoration measure type.

Freshwater Diversion

The diversion of significant quantities of river water typically leads to unintended consequences, such as sedimentation and shoaling in the main river downstream of the diversion and sedimentation in interior distribution channels after the flow is diverted. The likelihood of shoaling and sedimentation is moderate. The consequences of shoaling and sedimentation are higher maintenance costs, which would decrease the cost effectiveness of the measure.

Specific risks and uncertainties associated with relative sea level rise in the formulation of freshwater diversion plans include a loss of benefits, changes in assumed conditions, and inadequate structure design. The consequences of inadequate structure design could be significant. To limit the likelihood of plan failure, increased relative sea level rise is incorporated into the design of freshwater diversion structures.

The SAND2 (Sediment and Nutrient Diversion) method uses sediment and nutrient inputs to predict accretion rates in areas affected by freshwater diversions. Ideally, sediment loads in the river at proposed diversion sites would be used in these calculations. Due to data limitations, the known data from the Tarbert's Landing was used in the analysis of these features. There is some uncertainty associated with not using site-specific data for the analysis. However the risk is minimal because the data being used came from a nearby station and the sites that were evaluated appear to occur in areas of higher sediment concentration in the Mississippi River.

SAND2 uses the average water depth of the project area along with the sediment load introduced into the area from the river to project future acres of marsh restored and nourished. If the assumed average water depth is greater or the introduced sediment load is less than what was assumed, a decrease in the projected benefits could occur.

The implementation of other authorized and planned freshwater diversions is uncertain. Freshwater diversion alternative plans will consider the potential impacts of other freshwater diversion, while being formulated to produce benefits independent of other diversions. It is very likely that the assumptions made in this study regarding other authorized and planned freshwater diversion projects will be inaccurate. However, by developing freshwater diversion alternatives that produce benefits independent of other plans, the consequences of this risk are decreased.

Uncertainties associated with river water constituents that may have unintended consequences include: increased total suspended sediments, turbidity, and organic/nutrient enrichment of the water column; disturbance and release of possible contaminants; decrease in water temperatures; and the possible release of oxygen depleting substances (organic or anaerobic sediments) as well as possibly decreasing dissolved oxygen (DO) levels. These impacts would be minimized to the extent practicable through the implementation of stormwater pollution prevention plans (SWPPPs), the ITM protocols, and other applicable best management practices (BMPs). The likelihood that river water constituents may have unintended effects is moderate. However, the consequences of these effects are likely to be temporary and localized in nature, and therefore are unlikely to significantly affect overall project success.

Hydrologic Restoration Measures

Restoration of hydrologic function can result in unexpected changes to circulation, salinity and water quality. Relative sea level rise could result in changes in assumed conditions, which could decrease the benefit of hydrologic restoration measures. The likelihood of failure associated with these risks is low, if sufficient analyses are conducted using accurate information.

Marsh Restoration and Marsh Nourishment

Marsh restoration and nourishment measures are susceptible to tropical storms, wind-driven erosion, the effects of increased relative sea level rise, saltwater intrusion, herbivory, invasive species, and lack of freshwater and nutrients. These problems contribute to the need for restoration, while posing the greatest risks to their success. Marsh restoration measures in interior areas are less susceptible to these risks than areas exposed to open water. However, without the restoration and protection of areas adjacent to open water, interior marshes will become increasingly exposed to these forces as the exterior marsh degrades.

It is very likely that one or more of these risk factors will affect project performance, with a moderate risk of project failure. The consequences of these risks can be complete or partial project failure and loss of investment. However, the consequences of failure must be considered on an individual project basis and include an analysis of the consequences of no action. The effects of these risks were minimized by incorporating lessons learned from previously constructed projects in the formulation of alternatives and incorporating these risk factors into the calculation of benefits.

Swamp Restoration and Swamp Nourishment

Saltwater intrusion and unsuitable water levels are the greatest risks associated with cypress swamp restoration. Therefore, these features were only planned for areas where salinity and water levels can be controlled to some extent (inside the levee system). The location of cypress swamp features inside of the levees significantly reduces the likelihood of failure.

Invasive species and herbivory are also a threat to cypress swamp restoration. Chinese tallow trees could out-compete native species and herbivory could destroy juvenile and newly established trees. Implementation methods for these features would incorporate controls to prevent loss of benefits from invasive species and herbivory.

Shoreline Protection

Subsidence, sea level rise, wave action, inaccurate or incomplete data, and design failures are the primary risks associated with shoreline protection features. Subsidence and wave energy are unavoidable, and therefore must be carefully considered in the design of alternative measures to avoid unacceptable consequences. Inaccurate or insufficient survey data or human error could result in design failures, reducing the effectiveness of these features. Appropriate maintenance and repair of these features contribute to project success. The likelihood that one or more of these factors will affect project performance is moderate. The consequences of failure could result in a significant or total loss of benefits.

Ridge Restoration

Lack of technical knowledge is a risk associated with ridge restoration features. Very few coastal ridge restoration projects have been constructed, and there is limited data to contribute to the successful design and implementation of these features. The lack of knowledge could jeopardize project success, and the consequences of failure could result in a significant or total loss of benefits.

In addition to the technical challenges of coastal ridge restoration, other factors threaten the success of these projects. Tropical storms, subsidence, sea level rise, saltwater intrusion, and invasive species are risks that can jeopardize the success of ridge restoration measures. The likelihood of failure due to these factors is moderate. The consequences of failure would be a partial or total loss of benefit. However, the consequences of failure must be considered on an individual project basis and include an analysis of the consequences of no action.

Restoration of Forested Habitat

Invasive species and herbivory are risks associated with forested habitat restoration. Chinese tallow trees could out-compete native species and herbivory can destroy juvenile and newly established trees. Implementation methods for these features would incorporate controls to prevent loss of benefits from invasive species and herbivory to reduce risk.

Barrier Island Restoration

The primary risk associated with barrier island restoration is significant loss of benefits due to erosion and tropical storm events. Because these measures are exposed to the open Gulf, losses to wave energy can be significant. These risks are unavoidable and are inherent to the changeable nature of these geographic features. The consequences of these risks can be complete project failure and loss of investment. Additionally, the opportunity cost of investing in a higher-risk restoration measure when a lower-risk measure could have been implemented must also be considered. However, the consequences of project failure must be balanced with a consideration of the consequences of no restoration.

Submerged Aquatic Vegetation (SAV) Pilot Projects

Lack of technical knowledge is a limiting factor for SAV features. Very few SAV restoration projects have been constructed, and there is limited data to contribute to the successful design and implementation. SAV are also fragile components of the ecosystem that are very susceptible to storm events. Given these limitations, the likelihood of failure is moderate to high. The consequences of failure are a partial or total loss of benefit and investment. The opportunity cost of investing in a higher-risk restoration measure when a lower-risk measure could have been implemented must be considered with the consequences of no action.

Oyster Reef Restoration

There is limited data on oyster reef restoration success as a means of shoreline stabilization and erosion prevention. The lack of data on oyster reef development for structural purposes is a risk to the successful design and implementation of these features. Climate change, saltwater intrusion, and over-freshening also present a risk to the successful implementation of oyster reef restoration. If habitat conditions are not conducive to the propagation of oysters, the measures would be ineffective. It is moderately likely that these risks will result in project failure, and the consequences would be a partial or total loss of benefit and investment.

2.4.5 Planning Subunits

For planning purposes, the study area has been divided into subunits as shown in Table 2-5 and Figure 2-20. Subunits classified as fastlands (agricultural, developed, and upland areas that do not have direct and significant impacts on coastal waters) do not function as part of the estuarine Lake Borgne ecosystem. These fastland areas are not targeted for ecosystem restoration in this study (LOSR 2002).

Table 2-5 also describes the relevance of each subunit to the MRGO study and how problems and opportunities were addressed in each subunit. Problems are further described in Table 2-6 for those subunits in which initial plan features were developed.

The initial determination whether restoration features should be developed in a subunit were based on the study authority. The study authority indicates that the plan would “physically modify the Mississippi River-Gulf Outlet and restore the areas affected by the navigation channel”. Therefore, if a subunit was adjacent to the MRGO or considered potentially affected by the construction, operation, or maintenance of the channel, problems and opportunities were identified in those subunits.

The study authority also mandates the development of “a plan to restore natural features of the ecosystem that will reduce or prevent damage from storm surge”. To address this portion of the authority, if a subunit was identified as a critical landscape feature in LACPR and was located in either the areas potentially affected by the MRGO or the Lake Borgne ecosystem, management measures were developed in those subunits.

The study area was interpreted to include the greater Lake Borgne ecosystem, because the authority also states that the plan should include: “consideration of…diversions of fresh water to restore the Lake Borgne ecosystem”. This interpretation is consistent with the study Implementation Guidance dated 28 April 2009. The Lake Borgne ecosystem was defined as areas hydrologically connected to Lake Borgne. Table 2-5 describes the relevance of each geographic subunit to the MRGO Ecosystem Restoration Plan.

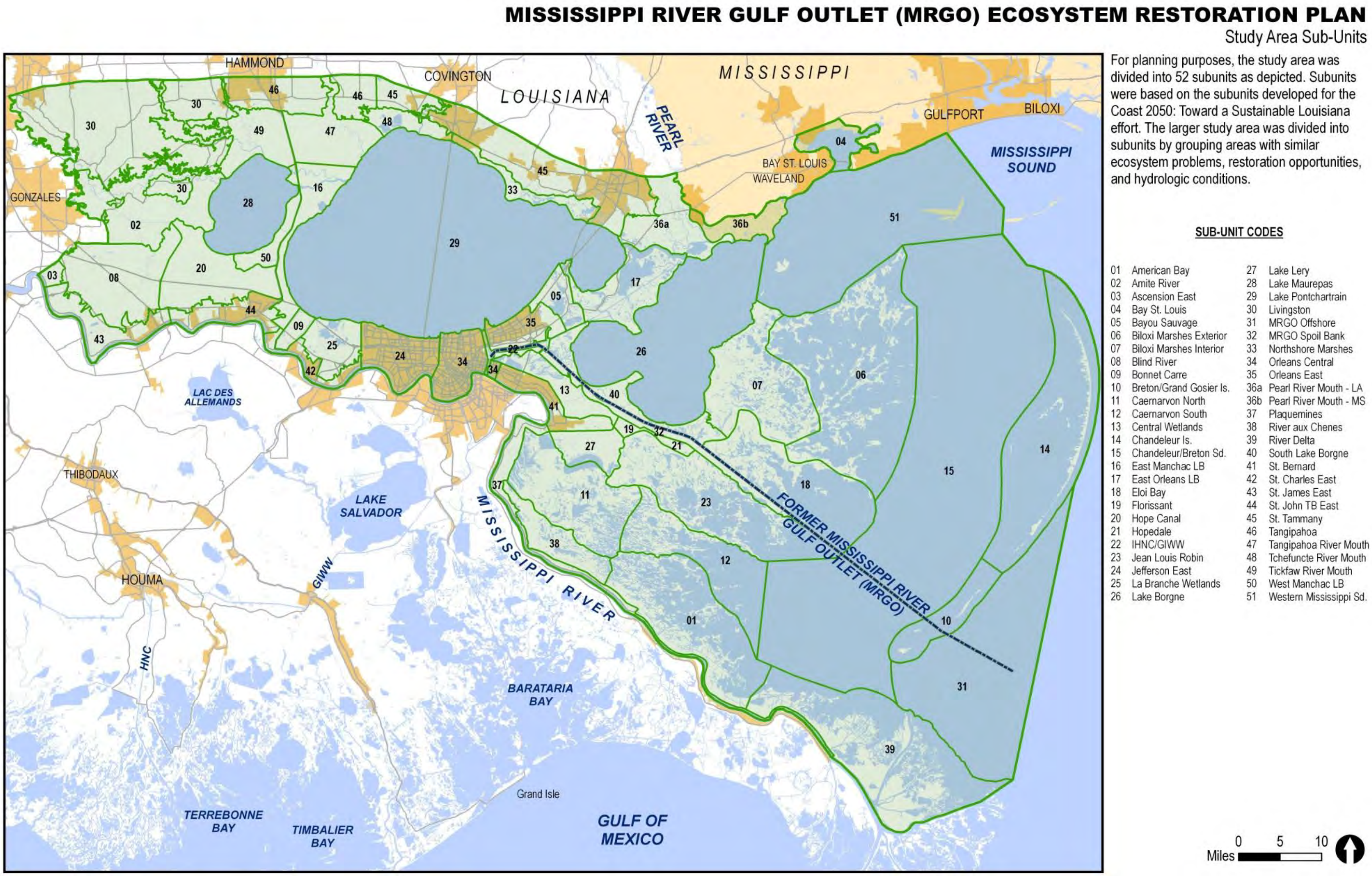


Figure 2-20. Study Area Subunit

Table 2-5. Subunits by Geographic Area and Their Relevance to the MRGO Ecosystem Restoration Plan

(ID) Subunit Name	Relevance of Subunit to MRGO Plan
Lake Maurepas and North Lake Pontchartrain	
(16) East Lake Maurepas	Identified as a critical landscape feature for storm surge risk reduction in LACPR. Measures were initially developed to address ecosystem restoration problems but were screened out because initial investigations indicated that the benefits of these features were minimal based on historic shoreline erosion and land loss rates. Habitat changed from cypress swamp to intermediate marsh on the Eastern Lake Maurepas Landbridge can be attributed to increased salinity caused by the MRGO. However, because these areas have relatively low land loss rates, the benefits of restoration in this area are comparatively low.
(50) West Lake Maurepas Landbridge	
(48) Tchefuncte River Mouth	Tate et al. 2002 indicates that the MRGO contributed to salinity increases as far west as Pass Manchac. Therefore, the MRGO may have contributed to increased salinity in areas hydrologically linked to Lake Maurepas. MRGO effects related to saltwater intrusion are partially addressed by the MRGO closures and are anticipated to be fully addressed by other authorized projects (Convent/Blind, Amite and Hope Canal/Maurepas Swamp freshwater reintroductions).
(47) Tangipahoa River Mouth	
(49) Tickfaw River Mouth	
(28) Lake Maurepas	
(02) Amite River	
(08) Blind River	
(20) Hope Canal	
(09) Bonnet Carré	
(25) LaBranche Wetlands	
(33) Northshore Marshes	
(29) Lake Pontchartrain	Lake Pontchartrain was affected by saltwater intrusion caused by the MRGO. Salinity effects are being addressed by the MRGO closures. Because it is an open water body, any problems, opportunities, or measures in the lake are linked to the nearest subunit. For example, Submerged Aquatic Vegetation Restoration in Lake Pontchartrain is linked to the (05) Bayou Sauvage subunit.
East Orleans Landbridge and South Lake Borgne	
(36a) Pearl River Mouth – LA	Subunits 36a, 17, and 05 are part of the Lake Borgne Ecosystem and are recognized as critical landscape features in LACPR. Subunit 40 was directly and indirectly impacted by the MRGO. Subunit 26 was indirectly affected by the MRGO. Because it is an open water body, any problems, opportunities, or measures in the lake are linked to the nearest subunit. The spatial integrity of the MRGO/Lake Borgne Landbridge was compromised by the construction of the channel. The maintenance of the form of the lake rim is needed to restore the estuary. Measures were developed to address subunit problems and opportunities.
(17) East Orleans Landbridge	
(05) Bayou Sauvage	
(26) Lake Borgne	
(40) S. Lake Borgne	
Central Wetlands	
(13) Central Wetlands	Subunit 13 was directly and indirectly impacted by the MRGO. The channel was cut through the eastern portion of the subunit. Measures were developed to address subunit problems and opportunities.
IHNC/GIWW	

Table 2-5. Subunits by Geographic Area and Their Relevance to the MRGO Ecosystem Restoration Plan

(ID) Subunit Name	Relevance of Subunit to MRGO Plan
(22) IHNC/GIWW	More saline water entered these navigation channels via the MRGO. These areas are being considered as potential borrow sites.
MRGO	
(32) MRGO Spoil Bank	Subunit 32 was directly affected by the dredging and placement of material during the construction of the channel.
(31) MRGO Offshore	MRGO effects addressed by deauthorization of channel, natural shoaling.
Biloxi Marsh	
(07) Biloxi Marshes Interior	Subunits 07 and 18 were directly and indirectly impacted by the MRGO. Subunit 06 is adjacent to the Lake Borgne ecosystem and the offshore portion of the MRGO was dredged in the vicinity. Measures were developed to address subunit problems and opportunities.
(06) Biloxi Marshes Exterior	
(18) Eloi Bay	
Barrier Islands	
(14) Chandeleur Islands	Subunits 14 and 15 are adjacent to the Lake Borgne ecosystem and the offshore portion of the MRGO was dredged in the vicinity. Potential borrow sites. An offshore portion of the MRGO was dredged in subunit 10. Impacts of MRGO are addressed by deauthorization of channel and natural shoaling.
(15) Chandeleur/Breton Sound	
(10) Breton/Grand Gossier Islands	
Florissant	
(19) Florissant	Subunit 19 was indirectly impacted by the MRGO through the placement of spoil material and hydrologic changes. Measures were developed to address subunit problems and opportunities.
Terre aux Boeufs, Hopedale	
(21) Hopedale	Subunits 21 and 23 were indirectly impacted by the MRGO through the placement of spoil material and hydrologic changes. Measures were developed to address subunit problems and opportunities.
(23) Jean Louis Robin	
Mississippi Sound	
(04) Bay St. Louis	Part of the Lake Borgne ecosystem. Problems and opportunities addressed by MsCIP.
(36b) Pearl River Mouth (Mississippi)	
(51) Western Mississippi Sound	Part of the Lake Borgne ecosystem. Problems and opportunities addressed by MsCIP. Potential borrow area.
Caernarvon	
(11) Caernarvon North	Insufficient nexus to Lake Borgne ecosystem or MRGO.
(38) River aux Chenes	
(12) Caernarvon South	
River Delta	
(01) American Bay	Insufficient nexus to Lake Borgne ecosystem or MRGO.
(39) River Delta	

Figure 2-21 illustrates the subunits that were affected by the MRGO and subunits in the Lake Borgne ecosystem.

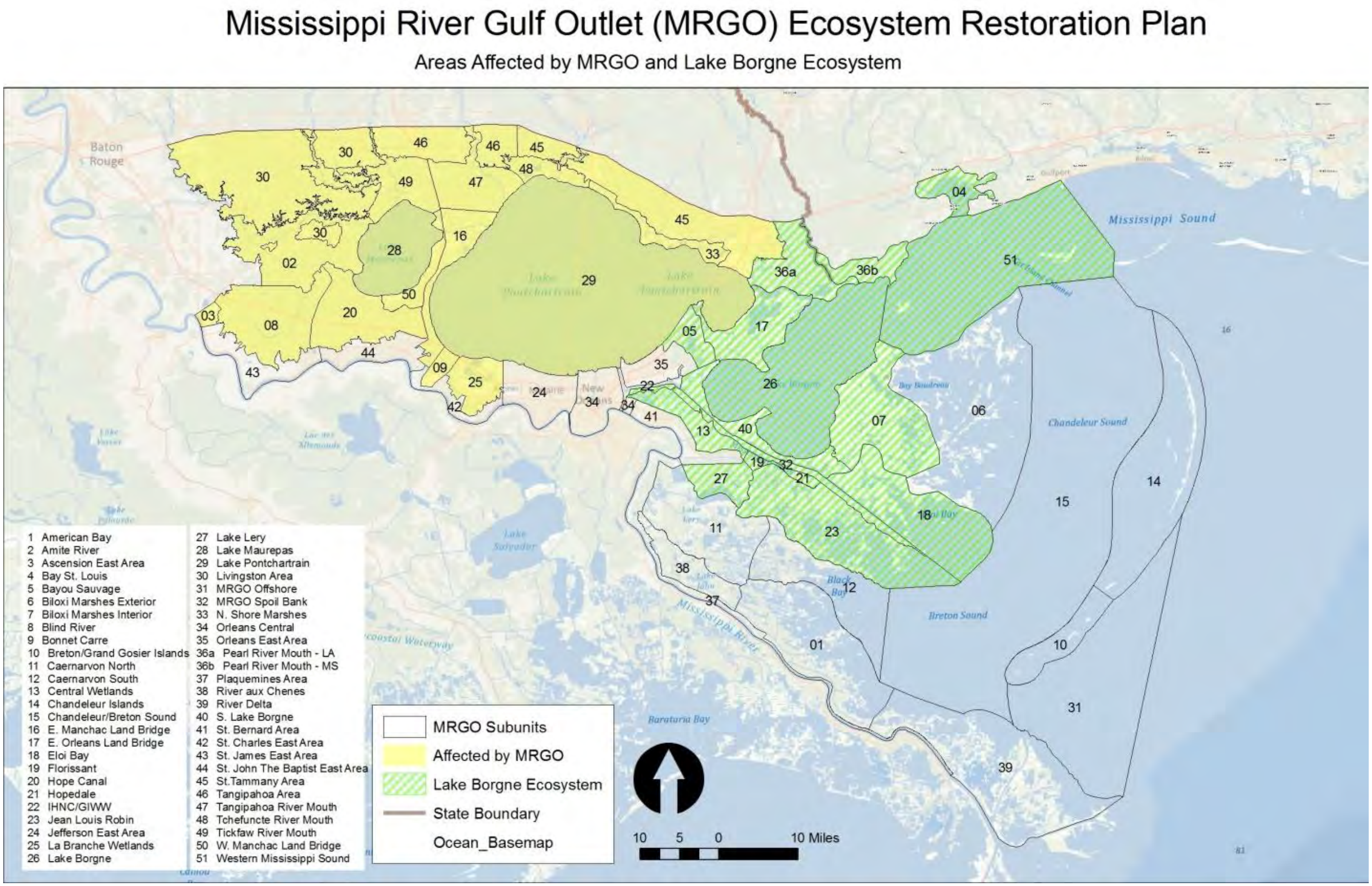


Figure 2-21. Areas Affected by the MRGO and Lake Borgne Ecosystem Subunits

Table 2-6.Problems in Initial Feature Subunits

	Problems								
	Decreased Freshwater, Sediment and Nutrient Inputs	Hydrologic Modification	Saltwater Intrusion	Wetland Loss	Ridge Habitat Degradation and Destruction	Bank and Shoreline Erosion	Habitat Change and Land Loss	Invasive Species and Herbivory	Retreating and Eroding Barrier Islands
Lake Maurepas and North Lake Pontchartrain									
(16) East and (50) Lake Maurepas Landbridge	X	X	X	X		X	X	X	
East Orleans Landbridge									
(36a) Pearl River Mouth – LA, (17) East Orleans Landbridge, and (05) Bayou Sauvage	X	X	X	X		X	X	X	
South Lake Borgne									
(40) South Lake Borgne	X	X	X	X	X	X	X	X	
Central Wetlands									
(13) Central Wetlands	X	X	X	X			X	X	
Biloxi Marsh									
(07) Biloxi Marshes Interior and (18) Eloi Bay	X	X	X	X	X	X	X	X	
(06) Biloxi Marshes Exterior	X	X	X	X		X	X	X	
Barrier Islands									
(10) Breton/Grand Gossier Islands	X	X							X
(14) Chandeleur Islands	X	X							X
Florissant									
(19) Florissant	X	X	X	X	X	X	X	X	
Terre aux Boeufs, Hopedale									
(23) Jean Louis Robin	X	X	X	X	X				
(21) Hopedale	X	X	X	X	X	X	X	X	

The problem of the susceptibility of coastal communities to storm surge does not appear in the table because development in the study area generally occurs in the subunits classified as fastlands. The problems of invasive species and herbivory are combined in the table because both of those problems generally occur in the same subunits.

2.5 STUDY GOALS, CONSTRAINTS, AND OBJECTIVES

Study goals, objectives, and constraints were developed to comply with the study authority and to respond to study area problems and opportunities.

> *The planning team develops objectives and constraints based on those problems and opportunities. An objective is a statement of what an alternative plan should try to achieve, while a constraint is basically a restriction that the alternative plan should avoid. Objectives, as well as constraints, are written statements that should generally include the following four types of information: effect (the verb that expresses the intent to bring about an objective and not to violate a constraint); subject (what is to be changed for the better through meeting the objective or not changed through avoiding a constraint); location (often the study area, which defines where the objective is to be achieved); and timing and duration (often the study period of analysis, which define when and how long the objective is to be achieved or the constraint to be avoided). Developing specific, flexible, measurable, realistic, attainable, and acceptable objectives and constraints is critical to the success of the entire planning process. Objectives and constraints are used to guide information gathering, to help identify solutions and formulate alternative plans, to identify which plan effects will be evaluated, to compare the relative effectiveness of alternative plans, to assist in plan selection, and ultimately, in gauging the success of the plan implemented (ER 1105-2-100, E-3.a).*

2.5.1 Goals

The overarching goals of the MRGO Ecosystem Restoration Plan are as follows:

1. Restore the Lake Borgne ecosystem and the areas affected by the MRGO navigation channel.
2. Restore natural ecosystem features that reduce or prevent storm surge.
3. Achieve ecosystem sustainability to the greatest degree possible.

2.5.2 Constraints

Planning constraints include legal and policy constraints that are applicable to all Federal water resources planning efforts, as well as study-specific constraints.

- Avoid or minimize negative impacts to threatened and endangered species to the extent practicable.
- Avoid or minimize impacts to critical habitat to the extent practicable.
- Do not diminish the level of protection provided by authorized flood risk reduction projects and hurricane storm damage risk reduction projects.
- Avoid actions that negatively affect the ability of authorized navigation projects to continue to fulfill their purpose to the extent practicable.
- Minimize impacts to commercial fisheries (such as oysters).

- Avoid or minimize contributions to low dissolved oxygen concentrations or conditions that could result in detrimental algal blooms.

2.5.3 Challenges Associated with Limited Resources

2.5.3.1 Sediment Replenishment and Borrow Source Suitability

The majority of the study area is situated within the abandoned St. Bernard Delta of the Mississippi River. Active sedimentation related to delta growth ceased in this area over 1000 years ago. Since delta abandonment, the processes of erosion and relative subsidence have dominated the landscape resulting in land loss and habitat switching. More recently, the construction of levees along the Mississippi River has eliminated the periodic floods that provided freshwater, sediment and nutrients to the study area. In addition, upstream reservoirs, changes in agricultural practices and land uses, and bank stabilization measures have reduced average sediment loads in the lower Mississippi River by approximately 67 percent since the 1950s (Kesel 1988). Sediments in the Mississippi River that could be used to build land in critical areas are lost from the system once the River reaches the Gulf of Mexico.

The surface and shallow subsurface of the study area is composed mainly of organic clay and clay. Coarser sediments are confined mainly to the Mississippi River and the Chandeleur Islands chain. As land areas erode, much of the material is oxidized or transported away via suspension. The remaining sediment is distributed throughout the marshes, bays, and lakes. Detailed investigations to quantify the distribution of eroded and transported sediments over this extensive study area have not been conducted to date. However, there are no significant land areas being formed within the study area from deposition of eroded marsh sediments indicating a net loss of material from the system.

The USACE has developed a conceptual sediment study to determine the amount of sediment available for restoration efforts throughout coastal Louisiana. The purpose of this initial effort is to document what is known about present-day sediment transport processes and pathways, coastal and nearshore volume changes, and sources and sinks of sediment for the Louisiana coast. In the study area, the primary focus areas include the Mississippi River, Chandeleur Sound, portions of Breton Sound, and the Mississippi River birdsfoot delta.

In addition to the Louisiana conceptual sediment study, USACE completed an initial study and comprehensive database of measured suspended solids in the lower Mississippi River (Thorne et al. 2008). This report indicates that the average annual load over the period 1963 to 2005 at one representative site on the lower river was approximately 150 million tons, varying between a minimum of 70 million tons and a maximum of 230 million tons. Further study of sediment loads in the lower Mississippi River is needed due to variation between sampling frequency and methods at various sites.

2.5.3.2 Potential Borrow Sources

Potential borrow sources for swamp and marsh restoration features include the Mississippi River, the IHNC/GIWW, the MRGO, Lake Pontchartrain, Lake Lery, Lake Borgne, Breton Sound, and offshore sources including the MRGO offshore dredged material disposal site (ODMDS). Barges could be used to bring material from other locations in the region; however, the cost of transporting material by barge generally costs about twice as much as pumping material via pipeline from a nearby source. Other sources of material from outside of the study area were not considered a practicable option due to the costs associated with obtaining, transporting, and stockpiling the needed volume of material.

Lake Borgne

Lake Borgne is a viable borrow source for most of the areas evaluated for restoration in this study. Lake Borgne is designated critical habitat for Gulf sturgeon, and therefore no actions should be undertaken that may adversely impact this resource. Lake Borgne includes some sandy bottoms that are the preferred foraging habitat for this species. These areas were surveyed and excluded from consideration as potential borrow sources.

Lake Pontchartrain

Lake Pontchartrain is a viable borrow source for features located on the East Orleans Landbridge. Like Lake Borgne, the portion of Lake Pontchartrain closest to these features is designated critical habitat for Gulf sturgeon. However, the sandy bottoms of Lake Pontchartrain were identified as preferred foraging habitat for this species. Therefore this borrow source was not considered further as other sources that are not preferred foraging habitat were identified closer to proposed restoration features.

MRGO Channel

Public preference for filling in the channel and restoring the area to historic conditions is documented in the Scoping Report for this study and numerous other public documents:

- The Final Environmental Impact Statement (EIS) for the Mississippi River-Gulf Outlet (MRGO), Louisiana, and Lake Borgne – Wetland Creation and Shoreline Protection Project, a USACE document, states that "use of the MRGO channel as a borrow source was considered to be contrary to the Congressional intent, as described in House Report No. 109-359, that funds provided in P.L. 109-148 for authorized operation and maintenance activities along the MRGO not be used to conduct any dredging of the MRGO channel." This reasoning may have limited applicability to the MRGO ecosystem restoration plan.

- Louisiana House Concurrent Resolution 34 (2005) to "suspend any current appropriations or authorizations for expenditure of funds to dredge the Mississippi River Gulf Outlet, to direct the United States Army Corps of Engineers not to engage in any dredging activities on the Mississippi River Gulf Outlet, and to begin the necessary process to return the waterway to wetlands marsh status as close as possible to what it was prior to establishment of the canal."

- "MRGO Must Go A Guide for the Army Corps Congressionally-Directed Closure of the Mississippi River Gulf Outlet" (Endorsed by LSU, Coalition to Restore Coastal Louisiana, Lake Pontchartrain Basin Foundation, Environmental Defense Fund, Gulf Restoration Network, National Wildlife Federation, Louisiana Wildlife Federation, American Rivers, and St. Bernard Parish).

Dredging the MRGO to obtain borrow material for wetland restoration is a potentially unacceptable alternative. However, because Lake Borgne (the closest available borrow source) is critical habitat for Gulf sturgeon, all viable alternatives must be investigated to avoid and minimize potential impacts to critical habitat to the extent practicable.

The MRGO was analyzed as a borrow option for marsh restoration features. Using the channel could supply <10% of the identified 150+ million cubic yards of sediment need for the entire FIP. Dredging the channel would provide some cost savings (estimated at ~$20 million in October 2010 Price Levels) over the Lake Borgne option. As illustrated above, MRGO dredging for borrow is a publicly sensitive issue that was adamantly opposed in some scoping comments.

Since Lake Borgne dredging raises issues because it is designated critical habitat for the threatened Gulf sturgeon, a trade off analysis has been conducted. Due to the public acceptability factor, the lake is the preferred choice while recognizing some higher costs and environmental impacts. Consultation with NMFS has resulted in a plan that minimizes impacts to critical habitat.

Analyses were conducted for using the MRGO as a potential borrow source between the closures at Bayou Bienvenue (IHNC Surge Barrier) and Bayou La Loutre. Assuming dredging to -40' by 500' with a 1' over-depth, approximately 15.5 million cubic yards of material would be available for use in restoration projects.

The practicability and acceptability of the use of the MRGO must also be considered. “An alternative is practicable if it is available and capable of being done after taking into consideration cost, existing technology, and logistics *in light of overall project purposes*” (40 CFR 230.10 emphasis added). One purpose of the study is to restore areas affected by the MRGO. The area that was dredged to create the channel is the most directly affected area.

Degrading the MRGO spoil banks south of the Chalmette Loop Levee to marsh elevation was considered as a restoration feature that would also provide material. This alternative was rejected because the spoil bank provides more storm surge protection than it would as marsh.

Mississippi River

The cost per unit associated with moving sediments from the river to restoration areas is significantly higher than using sediments from the nearest source. All things being equal, using river sediment for a restoration area with an average pumping distance of 20,000 feet (3.8 miles) would cost approximately 25 to 30 percent more than using material from Lake Borgne. Dredging costs are positively correlated to distance: the cost of transporting material via pipeline for an average distance of 50,000 feet is about twice as much for an average distance of 20,000 feet. Because dredging at depths greater than 70 feet necessitates costly modifications to dredging equipment, it is not always feasible to dredge the nearest location on the river. It is possible to load dredged river sediment onto barges and transport it to a restoration site. However, this process costs considerably more than dredging and distributing via pipeline. Other factors influencing the feasibility of using Mississippi River sediment include considerations for laying pipe across levees, land, and roads rather than water, and potential impacts to navigation. Table 2-7 provides a rough cost comparison of dredging from Lake Borgne and the Mississippi River.

Table 2-7. Cost Comparison of Dredging and Piping Material from Different Borrow Sources (October 2010 Price Levels)

Average Pumping Distance	Unit Cost of Dredging and Transporting via Pipeline	
	Source: Lake Borgne	Source: Mississippi River
20,000 lf	$4.50	$5.75
30,000 lf	$5.80	$6.75
40,000 lf	$7.25	$10.00
50,000 lf	$9.75	$10.25
60,000 lf	$11.00	$15.00

Notes: Very rough comparison of costs based on recent projects. Estimates for 5 million cubic yards of material per cubic yard. Assumes the same project from different sediment borrow sources with all other factors being equal.

Lake Lery

Lake Lery is a viable borrow source for features in the vicinity of Bayou Terre aux Boeufs. However, a number of other restoration plans currently under development are considering Lake Lery, and it is uncertain if it will be available for use in the implementation of this plan.

GIWW/Michoud Canal

Features in the Central Wetlands could utilize sediment from the adjacent GIWW channel between miles 66 and 60. The channel would be dredged to its authorized depth to provide material for restoration features. The Michoud Canal is another potential source of sediment for use in this vicinity.

MRGO Offshore Dredged Material Disposal Site (ODMDS)

The MRGO ODMDS is located off of Breton Island and was used as a disposal site for material dredged for the MRGO navigation channel. This location would be considered as a borrow source for barrier island restoration. This site is not a practicable site for inland marsh and swamp restoration features, because it is located between 30 miles to 70 miles away from these features.

Sand Deposits at Chandeleur and Breton Islands

There are sand deposits at the northern end of Chandeleur Island and the southern end of Breton Island that could provide a source of material for barrier island restoration. These deposits were described in a report by Coastal Planning and Engineering, Inc. and the Pontchartrain Institute for Environmental Sciences. Mining at these sites would have minimal impact with regard to littoral sediment transport because these sands are at the terminus of the littoral system and there are no downdrift features that would be impacted.

2.5.4 Environmental Planning Guiding Principles

Several of the guiding principles established in the LACPR Technical Report, Coastal Restoration Appendix that were applicable to this study area were adopted. The overarching principle of the guiding principles is that sustaining the integrity of the estuarine environments in coastal Louisiana, including various landscape features that make up those environments is critical to the ecological health, social and economic welfare of the region. Model analysis conducted for the LACPR of storm surge levels and wave magnitudes demonstrate the value of coastal features to lowering storm risks (USACE 2009). While the models show benefits from additional marsh, island and landbridge habitat, the effects of allowing existing features to degrade are even more pronounced. These guiding principles are consistent with the strategic approach developed by the Louisiana-Mississippi Gulf Coast Ecosystem Restoration Working Group's *Roadmap for Restoring Ecosystem Resiliency and Sustainability*.

Guiding principles include:

- Relatively intact estuarine ecosystems are a key attribute in coastal Louisiana, and alternatives should seek to enhance the resilience and self-sustainability of the estuarine environments, including protection of existing high-quality estuaries.
- Restoration of key processes and dynamics are critical to the long-term health of the ecosystem.
- Freshwater diversions must be carefully sited to maximize sediment retention within the coastal ecosystem and avoid sediment loss to the Gulf because of reduced Mississippi River sediment loads. Therefore, measures and alternatives must seek to maximize the combined benefits of diversions that seek to restore natural processes with mechanical marsh creation measures.
- Additional sources of sediments should be sought where feasible; recognizing that such measures should not contribute to ecosystem degradation in the source area.
- Measures should be combined synergistically to maximize possible cumulative benefits. Thus, the position of features within the landscape has a direct influence on the potential benefits derived.
- Capacity to assess and quantify benefits and impacts from various measure combinations may be limited due to the state-of-the-science, uncertainty with future development, relative sea level rise and other factors. Flexibility is required in project design and implementation to permit adaptive management as conditions change and more is learned.
- A concerted monitoring and adaptive management program should be a component of the restoration plan.

These principles support the goals and objectives developed for the study, particularly in terms of sustainability, geographic integrity, and restoration in a systems context. The development of alternative plans was influenced by these principles by seeking to maximize the combined benefits of features. Compliance with these principles was used in the evaluation, comparison, and selection of plans.

2.5.5 Risk-Informed Planning Framework

There are numerous risks and uncertainties associated with ecosystem restoration that must be considered in the planning process. Sources of risk and uncertainties fall into two general categories: errors in analysis and the variability of natural, social, and economic situations.

Future conditions are inherently uncertain. The forecast of future conditions is limited by existing science and technology. Future conditions described in this study are based on an analysis of historic trends and the best available information. Some variation between forecast conditions and reality is certain. The degree to which these variations would affect planning decisions made in this study can be limited by recognizing risks and uncertainties in the decision-making process.

Large uncertainties affect future conditions in the study area, including: climate change; sea level rise rates; subsidence rates; timing of tropical storm events; changes in frequency and intensity of tropical storm events; and/or changes in drought conditions. All of these factors could contribute to the acceleration of degradation of the study area, changing forecast conditions and the effectiveness of restoration plans.

There are also significant economic and social uncertainties that could affect planning for this study. The timing and availability of financial resources for implementation is a major uncertainty that must be considered.

Therefore, planning for this study will address the risks and uncertainties associated with all alternatives throughout the study process. The MRGO Ecosystem Restoration Plan Feasibility Study will be conducted within a risk-informed framework, aware of the challenges that risks and uncertainties present to the development, evaluation, and implementation of alternatives.

2.5.6 Value Engineering

In January 2009, Value Management Strategies, Inc. conducted a Value Engineering (VE) workshop with the PDT on the MRGO Ecosystem Restoration Study. The workshop was conducted at the Draft Feasibility Scoping Meeting Report/Preliminary Draft EIS phase, an early stage of plan formulation. The purpose of the VE study was to help the USACE better formulate plans to carry forward into the next phase of development. The VE team documented their findings in a March 2009 VE Study Report. This section evaluates the primary suggestions developed by the VE Team and how those suggestions were incorporated into the plan formulation process.

Project Development Process/Plan Formulation

The VE Team was concerned that the alternative measures were too expansive and unsustainable. The team recommended that additional reduced scope alternative strategies be developed. Three specific recommended measures were:

- Develop alternative strategies based on limited resources; stabilize East Orleans Landbridge and Lake Borgne shorelines and contiguous marsh areas only.

- Develop a long term sustainable project alternative based on sediment capture.

A phased implementation plan was developed considering land loss rates and the importance of measures to overall ecosystem form and function. Based on these factors, shoreline protection features, and features with the highest land loss rates are proposed to be constructed first.

The challenges associated with limited resources are not treated as absolute planning constraints, but are strongly taken into consideration. All of the plans in the final array would require phased implementation and large amounts of sediment.

Sediment Provisions

Land creation and ridge restoration measures would require an enormous quantity of sediment. In addition, new land will continue to be lost due to subsidence and relative sea level rise. Therefore, the VE Team recommended long-term land creation strategies, such as:

- A Mississippi River sediment delivery system using permanent trunk sediment pipelines; sediment traps via sill dams or over-dredging; and adding dredged material to diversions from the Mississippi River.
- Investigation of various sediment sources, such as:
- – Mine only from mid-depth water bottoms;
- – Dredge the MRGO channel;
- – Dredge the original MRGO spoils in Black Bay and Breton Sound;
- – Use MRGO south spoil bank to fill in the MRGO channel;
- – Dredge sediment from Lake Pontchartrain and transfer to marsh creation areas;
- – Trap sediment near the mouth of the Mississippi River; and
- – For nearshore sources, consider continuous re-dredging of perimeter inverted breakwaters or develop specified borrow locations (e.g., Lake Borgne) with identified mitigation measures.

At this point in the plan formulation process, feasibility level measures are being evaluated, not the specific methods of implementing those measures. However, all of the alternative sediment sources were considered and are discussed in Section 2.5.3.1.

Shoreline Protection

The VE team suggested inverted breakwaters as a method of shoreline protection. The concept of inverted breakwaters is to excavate near-shore trenches parallel to marsh area open shorelines for two main purposes: 1) to slow the water and reduce erosion rates and 2) to drop sediment close to the shore as a partial source of marsh creation and maintenance material.

The New Orleans District has previously tested this concept near Grand Isle and the results were not favorable. Also, the use of inverted breakwaters would not reduce transportation and dredging costs, since many shoreline locations are removed from interior marsh creation and nourishment sites. Therefore, at this time rock placement is considered the most effective means of foreshore protection. Similar to the inverted breakwater concept, offshore placement of rock structures may also benefit marsh by capturing sediments behind the shoreline protection feature.

Habitat Restoration

The VE team made the following habitat restoration recommendations:

- Consider utilizing wave attenuation devices to reduce (non-storm or hurricane) wave energy for the purpose of improving vegetation success.
- Consider temporary attenuation devices to reduce wind velocities to protect vegetation installations, providing a better environment for initial establishment and expediting the natural restoration processes.
- Utilize the proposed cypress swamp restoration area to biofilter stormwater and treated wastewater effluent, in lieu of dumping directly into Lake Borgne or the Mississippi River, to improve water quality and to add nutrients to the biotic system.
- Expand the submerged aquatic vegetation (SAV) pilot program to include consideration of SAV restoration in the marsh areas as well as the lakes.
- Consider soil bioengineering measures for the ridge restoration.

The VE team‘s habitat restoration recommendations would be taken into consideration in the detailed design of the federally identified plan.

2.5.7 Trade-Off Analysis

Decision-making for this study requires choices to be made from alternative options. These choices often entail trade-offs; choosing more of one thing simultaneously means choosing less of something else. Generally, stakeholders agree that restoration is needed in the study area. However, there are varying opinions among stakeholders as to where restoration should be sited, what restoration efforts are most important, and how it will be achieved. Planning for this study requires the evaluation of trade-offs and the consideration of competing interests.

In the screening process, it was determined which component measures would be retained, and which components would be eliminated from further consideration. Criteria were established to screen measures as described in Section 2.6. This step in the study process was a large-scale trade-off analysis. For example, it was determined that the area to the west of Bayou Terre aux Boeufs was not significantly affected by the MRGO. This area was identified as a good location for restoration: the marsh was significantly degraded by Hurricane Katrina, it is located adjacent to development, and restoration would have synergy with the Caernarvon Freshwater Diversion. However, recommending restoration in this area under this plan could potentially result in less restoration in areas that were more directly affected by the navigation channel. Therefore, Caernarvon area restoration was removed from consideration in favor of restoration in areas directly affected by the navigation channel.

The location of borrow sites is also a significant trade-off that was considered in the formulation of alternatives. Ideally, the restoration features would utilize sediments from outside of the area to increase the net amount of sediment in the system. Transporting materials via barge, truck, or rail is significantly more costly than transporting materials via pipeline from within the system. The Mississippi River was identified as the best source for material for restoration features in the study area. The sediment is transported from upstream, and therefore represents a net increase of sediment in the system. The material is also silty-sand, which is more stackable than the material available from area lake bottoms.

Despite the identification of the Mississippi River as the ideal source of material for restoration projects, only two features in the FIP would utilize these materials. All things being equal, using river sediment for a restoration area with an average pumping distance of 20,000 feet (3.8 miles) would cost approximately 25 to 30 percent more than using material from Lake Borgne. However, all of the proposed marsh and swamp restoration features are significantly farther away from point bar deposits of river sediment than the nearest borrow source. Because dredging at depths greater than 70 feet necessitates costly modifications to dredging equipment, it is not feasible to dredge the nearest location on the river. It is possible to load dredged river sediment onto barges and transport it to a restoration site. However, this process costs at least twice as much as dredging and distributing via pipeline. Other factors influencing the feasibility of using Mississippi River sediment include considerations for laying pipe across levees and land, rather than water, and potential impacts to navigation.

Lake Borgne water bottoms were determined to be the most cost-effective and feasible borrow source for construction of the majority of restoration features requiring sediment. However, the water bottoms of Lake Borgne are critical habitat for the endangered gulf sturgeon. To limit potential impacts to critical habitat, areas determined to have shell or hard bottoms were removed from consideration as borrow sites. Lake Pontchartrain is the closest site for a few marsh restoration features. However, the portion of Lake Pontchartrain in the study area is also designated critical habitat for gulf sturgeon. Due to the sandy composition of Lake Pontchartrain bottoms in the vicinity, these areas are considered prime habitat, and were removed from consideration. The location of borrow sites in Lake Borgne is the result of a significant trade-off. Some impacts to gulf sturgeon critical habitat are an unavoidable trade-off of achieving the benefits of the proposed action in a manner that is not cost-prohibitive. Continued coordination with NMFS and other stakeholders to avoid and minimize these impacts will be conducted in the design and implementation of these features.

There are also several trade-offs associated with the plan selection process. The alternative plans selected for the final array represent scales of trade-offs. The no-action alternative does not have any associated construction costs, but the disbenefits of no action to the ecosystem, region, and nation involve different kinds of costs. The results of no action are not an acceptable trade-off for the monetary savings, as evidenced by the Congressional mandate associated with the study. However, once it has been determined that no action is not an acceptable alternative for implementation, the action alternative selected for recommendations must balance costs and benefits.

Specific, measurable study objectives were developed to evaluate plans. The extent to which these plans achieved the identified objectives was used to determine which plan would be chosen for tentative recommendation. This evaluation is discussed in Section 2.7.3. Ultimately, the first Best Buy Plan that achieved all of the objectives and reasonably maximized benefits for the least cost was recommended as the FIP.

2.5.8 Objectives Found to be Unattainable

Developing realistic and attainable objectives is critical to the success of the entire planning process. The following objectives were found to be unrealistic and unattainable based on the constraints and challenges discussed in the previous sections:

- Restore the ecosystem to pre-Mississippi River and Tributaries (1928) conditions.
- Restore the ecosystem to pre-MRGO (1958) conditions.
- Maintain existing wetland acreage in the entire study area.

The following paragraphs describe the reasons for not pursuing the above restoration approaches.

2.5.8.1 Restoration to pre-Mississippi River and Tributaries (1928) Conditions

Reversing the alteration of the marsh landscape since 1928 would require removing levees and other hydrologic constraints, backfilling in the extensive network of artificial channels, and letting the unconstrained physical processes re-create the wetlands, ridges and other features over time. Even if these measures were implemented, it is unlikely that the system would return to 1928 form. The findings of the LCA and LACPR studies, however, suggest that complete restoration to a historic level is not feasible or cost-effective.

1. The physical processes that formed the marsh are quite different than those operating now. For example, sediment loads in the Mississippi River and other tributaries are much lower now than in recent history and relative sea level rise is greater and projected to increase with global climate change.
2. There are significant human constraints that limit the ability to restore natural processes. These include land development, flood risk reduction projects, and the presence of public infrastructure and travel corridors (including navigation channels and canals) within the study area.
3. The economic investment in restoration is usually directed towards achieving restoration goals within a quick timeframe. Conversely, recovery through the restoration of key natural processes may require decades or even centuries to fully realize benefits at significant costs. This may also mean trade-offs between created/restored landscape features that increase or accelerate system sustainability versus the significant implementation required for unconstrained ―natural" evolution.

2.5.8.2 Restoration to pre-MRGO (1958) Conditions

Full restoration to pre-MRGO conditions would require infilling the entire MRGO channel, restoring all land lost in the study area between 1958 and the present (wetlands, natural ridges, and barrier islands), planting the area with vegetation types present prior to the construction of the MRGO, and eradication of invasive species that have appeared since 1958. Restoration to pre-MRGO conditions was eliminated from further consideration due to: 1) the inefficiency involved with backfilling the MRGO channel and 2) the length of time required for implementation. For example:

1. It is estimated that it would require approximately 250–350 million cubic yards of dredged material to fill the channel from mile 60 to mile 25 at a cost of about $2.8 billion based on October 2006 price levels, and could take from 15 to 44 years to completely fill the channel (USACE 2008a). Backfilling the channel would replace the land lost from the direct impacts of construction and prevent saltwater intrusion into the channel. Backfilling the entire channel is not seen as an efficient measure, because the resources required could be used in other ways to produce greater benefits in less time.
2. Human constraints, such as the Lake Pontchartrain and Vicinity project, limit the ability to restore natural processes. Land use practices and other related factors throughout the entire Mississippi River drainage area may also effectively constrain opportunities.

2.5.8.3 Maintain Existing Wetland Acreage in the Entire Study Area

Both the LCA and LACPR reports set out to develop plans for maintaining the existing acres of wetlands across the coast. In the case of LCA, the purpose was for ecosystem function, and in the case of LACPR, for storm surge risk reduction. In the MRGO study area, the LACPR Final Technical Report indicates that preserving the quantity and configuration of existing wetlands in the study area is important for sustaining current levels of storm risk reduction. In peer review of the LCA and LACPR reports, however, the National Research Council of the National Academies expressed doubts about the feasibility of sustaining wetlands into the future. The 2006 NRC publication *Drawing Louisiana's New Map: Addressing Land Loss in Coastal Louisiana* states the following:

> *Full restoration of past Louisiana wetland cover and function will not be possible. The natural and anthropogenic processes contributing to net land loss in coastal Louisiana are significant and pervasive, and they have been operating for decades. Achieving no net loss is not a feasible objective because the social, political, and economic impediments are extensive; the sediment supply is limited; and the affected area is large. Louisiana's coastal restoration plans must acknowledge these limitations prominently and adjust goals and public expectations accordingly.*

2.5.9 Study Objectives and Metrics

Study objectives were developed as specific targets to guide the development of measures and gauge the extent that plans meet the overarching study goals. Metrics are used to measure how plans meet those specific targets. Study objectives include targets for salinity, habitat diversity, and landscape features critical to storm surge risk reduction. Salinity targets are based on ecosystem health and oyster production. Habitat targets are based on the direct and indirect habitat impacts of the MRGO navigation channel as described in Section 1.4. Critical landscape targets for storm surge risk reduction are based on features identified in the LACPR Final Technical Report. Table 2-8 identifies the study goals and objectives, the portion of the study authority related to those objectives, problems and opportunities associated with the objectives, the management measure types identified to address specific objectives, and metrics for evaluation of alternatives.

Table 2-8. Goals, Objectives, Metrics, and Measures

WRDA 2007 Authority	Goal(s)	Objective	Problem	Management Measures	Metric
- Sec. 7013 a(3)B(i) - Sec. 7013 a(3)B(ii) - Sec. 7013 a(3)B(iii) - Sec. 7013 a(3)B(iv) - Sec. 7013 a(3)B(v)(II) - Sec. 3083 (a) and (b) to be studied under Sec. 7013 as per WRDA 2007 implementation guidance	1. Achieve ecosystem sustainability to the greatest degree possible. 2. Restore habitat in the Lake Borgne ecosystem and the areas affected by the MRGO navigation channel.	1. Restore historic salinity conditions in the study area to re-establish and maintain historic habitat types; optimize ecosystem services; and decrease stress to vegetation as measured by the monthly salinity targets in the Biloxi Marsh (as identified by Chatry et al. 1983) each month of the year, for at least four years out of every ten year period.	- Land loss - Habitat change and loss - Modification of natural hydrology - Decreased freshwater, sediment, and nutrient inputs - Saltwater intrusion	Freshwater Diversion, Hydrologic Modification	Percentage of years target can be met over the period of analysis.
- Sec. 7013 a(3)B(i) - Sec. 7013 a(3)B(ii) - Sec. 7013 a(3)B(iv) - Sec. 7013 a(3)B(v)(I)	1. Achieve ecosystem sustainability to the greatest degree possible. 2. Restore habitat in the Lake Borgne ecosystem and the areas affected by the MRGO navigation channel. 3. Restore	2. Restore native habitat acreages impacted by the MRGO and their ecosystem functions. a. Increase the year round spatial coverage of cypress swamp habitat in the Central Wetlands by at least 9,500 acres by 2065. b. Increase the year round spatial coverage of fresh/intermediate marsh in the Central Wetlands, Golden Triangle, MRGO, and South Lake Borgne by at least 6,800 acres by 2065. c. Increase the year round spatial coverage of brackish marsh in Bayou Terre aux Boeufs, the Biloxi Marsh, and the East Orleans Landbridge by approximately 18,100 acres by 2065. d. Increase the year round spatial	- Land loss - Habitat change and loss - Invasive species - Increasing susceptibility of coastal communities to storm surge	Swamp Restoration and Nourishment Marsh Restoration and Nourishment, Shoreline Protection, Freshwater Diversion, Ridge Restoration, SAV Restoration, Oyster Reef Restoration, Buy-outs, Vegetative Plantings, Invasive Species control, Herbivory control, Barrier Island Restoration.	1. Number of Acres restored or nourished 2. Number of Net Acres at the end of the period of analysis

Table 2-8. Goals, Objectives, Metrics, and Measures

WRDA 2007 Authority	Goal(s)	Objective	Problem	Management Measures	Metric
	natural features of the ecosystem that will reduce or prevent damage from storm surge.	coverage of vegetated wetlands in areas adjacent to the channel lost to increased tides and salinity by at least 3,900 acres by 2065. e. Increase the year round spatial coverage of ridge habitat along Bayou La Loutre by 2065.			
- Sec. 7013 a(3)B(i) - Sec. 7013 a(3)B(ii) - Sec. 7013 a(3)B(iv) - Sec. 7013 a(3)B(v)(I)	3. Restore natural features of the ecosystem that will reduce or prevent damage from storm surge.	3. Increase the year round spatial coverage of critical landscape features that provide hurricane and storm damage risk reduction in the study area (i.e. areas located in the Biloxi Marshes, the East Orleans Landbridge, and forested habitats).		Marsh Restoration and Nourishment, Shoreline Protection, Ridge Restoration, Freshwater Diversion, Oyster Reef Restoration, Vegetative Plantings, Invasive Species control, Herbivory control,	In critical landscape areas and forested habitat: 1. Number of AAHUs in critical areas 2. Number of Critical Acres restored or nourished 3. Number of Net Critical Acres at the end of the period of analysis
- Sec. 7013 a(3)B(i)	2. Restore habitat in the Lake Borgne ecosystem and the areas affected by the MRGO navigation channel.	4. Increase awareness and understanding of the significance of resources in the study area through increased recreational and educational opportunities.	- Land loss - Habitat change and loss - Modification of natural hydrology - Increasing susceptibility of coastal communities to storm surge	Recreation and education enhancements to ecosystem restoration features.	1. Number of restoration features including recreation components.

Objective 1 – Salinity Targets

The first objective is to Restore historic salinity conditions in the study area to re-establish and maintain historic habitat types; optimize ecosystem services; and decrease stress to vegetation as measured by the monthly salinity targets in the Biloxi Marsh (as identified by Chatry et al. 1983) each month of the year, for at least four years out of every ten year period.

The Salinity Working Group for the MRGO Ecosystem Restoration Plan confirmed the validity of the salinity targets presented in the Mississippi and Louisiana Estuarine Areas Freshwater Diversion from Lake Pontchartrain Basin to Mississippi Sound Feasibility Study (also referred to as the Bonnet Carré study) for ecosystem restoration (USACE 1984). The salinity targets are based on mean monthly averages and are graphically presented in Figure 2-22 and Table 2-9.

The salinity targets were originally developed and adopted by an ad hoc group consisting of representatives from USACE, LDWF, NMFS, St. Bernard Parish, LDNR and the Mississippi Bureau of Marine Resources for the 1984 report to enhance fish and wildlife resources in the Pontchartrain basin and re-establish a desirable salinity regime in the historic oyster reefs on the seaward fringe of the Biloxi Marsh (USACE 1984). The group determined that salinity should mimic historical conditions when the Mississippi River over-flowed its banks in the early part of the year. The targets were developed using ten years of data (1971-1981) from Louisiana's most productive oyster seed grounds. Oysters are an important commercial species but are also the best indicator species to determine the optimum salinity range for the Louisiana commercial fishery (LPBF 2006b). Oysters directly contribute to the larger ecosystem by filtering water and providing reef surface for other organisms. The Salinity Working Group noted that a target line and frequency need to be established in order to design a freshwater diversion, but that adaptive management should also be a component of freshwater reintroduction plans. Therefore, the metric for achieving this study objective is whether salinity falls within the optimal range each month, at least forty percent of the time, as described in Chatry et al. 1983. The Chatry targets are a way to measure the restoration of historic salinity regimes.

Table 2-9. Monthly Salinity Targets at the Chatry Line

Month	Mean Optimal Salinity	Standard Deviation
January	16.4	1.04
February	14.4	0.79
March	11.6	1.02
April	8.0	1.27
May	7.0	0.92
June	12.5	0.80
July	12.7	0.57
August	15.7	0.80
September	17.0	1.06
October	16.8	0.87
November	16.1	0.82
December	15.7	0.52

Figure 2-22. Salinity Target Line Identified by Chatry et al. 1983

Objective 2 – Habitat Targets

The target acres for each habitat type were developed using the direct and indirect habitat impacts of the construction and operation of the MRGO between 1956 and 2008 as described in Section 1.4. The numbers of acres presented in these objectives are considered the minimum restoration targets to address the study authority (Table 2-10).

Table 2-10. Habitat Targets

Habitat Type	Direct Loss	Indirect Loss	Indirect Gain	Net	Target
Fresh / Intermediate	-3,400	-3,400		-6,800	6,800
Brackish	-10,300	-19,200	11,400	-18,100	18,100
Saline	-4,200		19,200	+15,000	0
Cypress	-1,500	-8,000		-9,500	9,500
Shallows	-4,800		4,800*	0+*	0
Additional**	-500	-3,400		-3,900	3,900
Total	-24,700	-34,000		-23,300	38,300

*Shallow water increases are difficult to quantify. Increases of this habitat type offset losses, and net gain is likely due to marsh loss.

**Additional marsh includes areas adjacent to the channel lost due to increased salinity and tides.

Although the impacts of the MRGO to the habitat of the Bayou La Loutre Ridge are not quantified, the channel made a 500 foot cut through the ridge, destroying upland habitat and a natural salinity barrier. To address this effect of the construction of the MRGO channel, the study evaluated measures to improve and increase ridge habitat.

The MRGO was dredged at an existing tidal inlet between Grand Gossier and Breton Islands, and may have interrupted sediment transport to Breton Island. To address this potential effect of the construction of the MRGO channel, the study evaluated measures to improve and increase barrier island habitat.

Objective 3 – Critical Landscape Features for Storm Damage Risk Reduction

Features that have been identified as critical landscape features for providing hurricane and storm damage risk reduction in the study area include:

- The Biloxi Marsh, the East Orleans Landbridge and the Lake Maurepas Landbridge.
- Forested habitats within the Lake Borgne ecosystem.

All of these geographic locations were affected by increased salinity attributable to the MRGO, although it is noted in the planning assumptions for this study that the restoration of the Lake Maurepas area would be achieved through authorized LCA and CWPPRA projects. Portions of the channel were excavated through the Biloxi Marsh, and habitats in this area were affected by erosion along the channel and increased salinity due to saltwater intrusion from the channel. The affects of the MRGO channel on the East Orleans Landbridge are related to saltwater intrusion. Tate et al. 2002 notes that pre- and post-channel water quality monitoring and analysis indicate that salinity in the vicinity of Chef Menteur Pass increased by 2.3 ppt. Therefore, restoration in these areas is connected to portions of the study authority related to the restoration of habitats affected by the MRGO and areas that will reduce or prevent damage from storm surge.

The connection between these features and storm surge is based on the geographic structure of the estuary. The Biloxi Marsh separates Lake Borgne from the Chandeleur Sound and the Gulf of Mexico. If the Biloxi Marsh did not exist, Lake Borgne would merge with Chandeleur Sound, and the ―speed bump” the marsh creates for storm surge would be removed. Similarly, if the East Orleans Landbridge disappeared, Lakes Pontchartrain and Borgne would merge to form one large lake and there would be no natural barrier to storm surge between these two bodies of water. The affect would be compounded if both landscape features were to disappear.

These landscape features are technically recognized as significant in terms of scarcity and connectivity. The continuing disappearance of wetland barriers in the study area is well documented (Morgan and Larrimore 1957, Penland and Boyd 1981, Day and Templet 1989, Kesel, 1989, Gagliano 1998, USACE 2004, LPBF, 2006a, Lopez 2006, USGS 2007). Burkett et al. 2002 describes the importance of these areas and forested habitat as a barrier contributing to the reduction of flooding levels in the Greater New Orleans area. Restoration of the Biloxi Marsh and the East Orleans Landbridge is identified as measures that can ―potentially reduce the loss of life and property due to flooding” (Burkett et al. 2002).

A sensitivity analysis was performed for the LACPR Technical Report to assess the impact of barrier island and marsh features on storm surge and wave energy. Hydrodynamic modeling evaluated future scenarios for degraded and restored coastal conditions. The model was adjusted to account for changes to bathymetry and frictional resistance associated with the presence or absence of various landscape features.

The findings of the LACPR analysis indicate that the effect of coastal features on storm surge and wave energy depends on a variety of factors, including the physical characteristics of the storm, coastal geomorphic setting, and the track of a storm when it makes landfall. The complex, dynamic nature of the interaction of various factors precludes the application of constant attenuation rates, i.e. it cannot be stated that a given acreage of marsh will produce a given amount of surge reduction.

While the models show benefits from additional marsh, island, and landbridge habitat in some areas, the effects of allowing existing features to degrade in these areas are even more pronounced (USACE 2009). Therefore, the MRGO Ecosystem Restoration Plan will address the storm damage risk reduction objective by evaluating alternatives to sustain the integrity of the study area, particularly areas identified as critical landscape features. The Maurepas Landbridge, the Pontchartrain Landbridge (East Orleans Landbridge), and the Biloxi Marshes were identified in the LACPR Technical Report as critical landscape features having significant effects on surge, based on model results. Forested habitats were also considered to have different frictional coefficients in the LACPR hydrodynamic modeling, and therefore some benefit with regard to hurricane storm damage risk reduction.

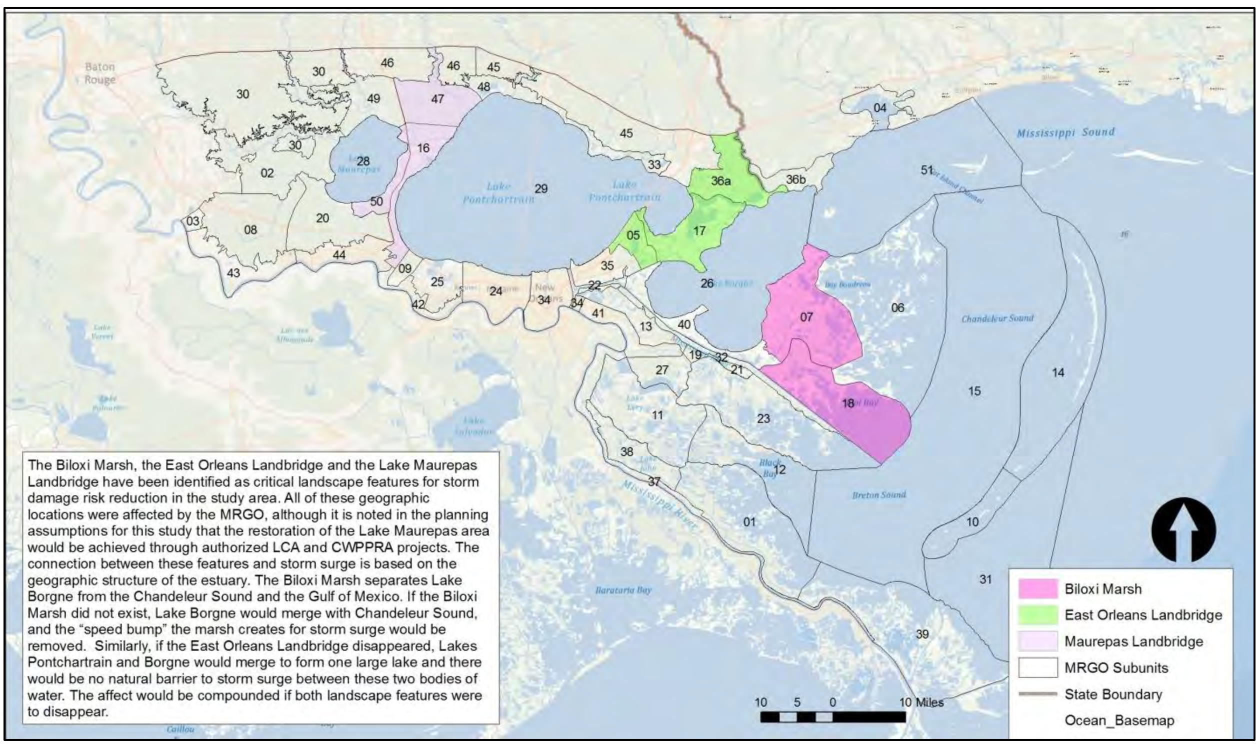


Figure 2-23. Critical Landscape Features for Storm Surge Damage Risk Reduction

The Multiple Lines of Defense strategy incorporates coastal ecosystem restoration as a ―first line of defense" in comprehensive hurricane storm damage risk reduction plans (Lopez 2006). In the Multiple Lines of Defense strategy, natural landscape features complement engineered structures, such as levees, to decrease hurricane storm damage risk. However, hurricane storm damage risk reduction systems cannot rely significantly on coastal landscape features because of the vulnerability of these features to single storm events.

The MRGO Ecosystem Restoration study did not undertake an analysis to assign monetary benefits in terms of storm damage risk reduction to restoration features. The monetary benefits of coastal landscape features with respect to storm damage risk reduction are difficult to empirically quantify due to the complex interaction of dynamic variables. However, the general effect of coastal marshes on storm surge is well documented (USGS 1994, Walmsley et al. 2009, Howes et al. 2010, Shepard et al. 2011)

The extent to which plans achieve the storm surge damage objective was measured by comparing the extent of restoration proposed for identified critical landscape features. Restoration of forested habitat was also considered in the evaluation of this objective.

Figure 2-24. Multiple Lines of Defense Strategy (Source: Lopez 2006)

EO 11990 recognizes the impact of wetlands to flood and storm hazards, demonstrating the institutional significance of these areas. The East Orleans Landbridge and Biloxi Marsh are also significant in terms of the function of the estuary, because they act as geomorphic barriers to saltwater intrusion from the Gulf of Mexico. The significance of these resources is recognized by the Estuary Protection Act.

The Biloxi Marsh and East Orleans Landbridge are critical landscape features that contribute to the maintenance of significant resources and storm surge reduction. Therefore, restoration in these areas was considered to contribute to the achievement of both the habitat and storm surge risk reduction objectives.

Objective 4 – Increase awareness and understanding of the significance of resources in the study area through increased recreational and educational opportunities.

The landscape and habitat impacts of the construction and operation of the MRGO since 1956 have changed recreational opportunities in the study area. This objective was developed to increase opportunities for citizens to enjoy and understand the significance of the resources this study seeks to restore.

Louisiana is known as ―Sportsman's Paradise" as a tribute to the wildlife and the hunting, trapping and fishing resources of the state. This nickname demonstrates the public significance of the recreational value of the study area‘s unique natural resources. The five species of fish most landed in recreation fishing activities in Louisiana are red drum, black drum, speckled sea trout, Atlantic croaker, and sand sea trout (Pattillo et al. 1997). These species rely on transitional habitat between estuarine and marine environments for nursery, foraging, spawning, and other life requirements that would be restored and protected through the implementation of this plan.

Involving the public in the restoration activities and increasing awareness of the problems and opportunities in the study area could contribute to the acceptability and overall success of the plan. Providing the public with increased opportunities to interact with the ecosystem and learn about environmental principles, processes and native habitat in general could create a sense of public ownership in the restoration plan. Citizens that are more aware of the impacts of human activities to the natural environment would be more likely to support actions that restore, protect, and sustain these significant resources.

2.6 IDENTIFICATION AND SCREENING OF MANAGEMENT MEASURES

Several hundred conceptual features were initially considered. These features came from previous plans and reports, as well as the public scoping process. The following provides a list of conceptual features initially considered for inclusion in this study.

Levees, Floodgates, and other Risk Reduction Features

- Construct five floodgates at Seabrook, the GIWW, MRGO near Bayou Bienvenue, Bayou Dupre, and MRGO near Verret
- New levee connecting the five floodgates on the GIWW and MRGO to levees on the SW shore of MRGO to +17 feet
- Raise levee that is parallel to the SW shoreline of MRGO to +17.5 feet and other levees in St. Bernard Parish to +20 feet.
- Construct new levee at +17.5 feet connecting the levees in St. Bernard Parish to levees on the Mississippi River.
- Continue construction of 40 Arpent Levee through Verret.
- Raise Mississippi River Levees.
- Construct new river floodgate at Bohemia.
- Sector gates at Seabrook, GIWW, MRGO and leaky levee at MRGO to GIWW gates.
- Raise and armor existing MRGO levees.
- A new levee on the eastern shore of MRGO or barriers across Lake Borgne.
- Storm breakwaters from Golden Triangle to Bayou St. Malo.
- A levee from approximately Verret to the GIWW protecting the land in the Golden Triangle.
- No gate constructed across the MRGO/GIWW at Paris Road.

Freshwater Diversion

- Freshwater diversion at or near Violet
- Introduction of freshwater into the system at the existing Violet Canal
- Bayou Bienvenue Diversion
- Bayou LaLoutre Diversion
- Bayou Terre aux Boeufs Diversion
- American/California Bay Diversion
- Bohemia Mississippi River Reintroduction
- Diversion N. of Fort St. Phillip
- Fort Jackson Sediment Diversion
- Grand Bay Diversion
- Bayou Lamoque Diversion
- White Ditch Diversion
- Benney's Bay Diversion
- Adaptive Management through Maintenance of Existing Crevasses and Construction of New Crevasses
- Diversion at Hope Canal
- Diversion at Blind River or Convent/Blind
- Caernarvon Diversion Modification
- Bonnet Carrè Freshwater / Sediment Introduction or Opportunistic use of Bonnet Carrè Spillway
- La Branche Diversion
- Violet Spillway
- Effluent from Waste Water Treatment Plant

Hydrologic Modification and Restoration

- Fill MRGO
- Fill Hopedale
- Fill Florissant
- Fill Back Dike Canal
- Identify sustainable methods to benefit Bayou St. John water quality
- South Slough Hydrologic Restoration
- Lock Replacement
- Total closure of Alabama Bayou at MRGO
- Remove Old Grand Prairie Levee.
- Dredge and maintain Baptiste Collette Bayou.
- Construct new channel from Baptiste Collette Bayou to Gulfport Ship Channel
- Do not construct closures at Rigolets and Chef Pass
- Constriction of Bayou Dupre at Lake Borgne
- A sill at Seabrook
- Water control structures on MRGO
- Biloxi Marsh water control structures
- Channel severance or constriction on MRGO in four or more additional locations
- Allow natural infill of the south reach of MRGO channel
- Sediment Delivery by Pipeline at Central Wetlands
- Sediment Pipeline at Golden Triangle
- Bayou La Loutre Water Control Features
- Create Channel (Bayou Restoration)
- Constrict opening between Lake Borgne and MRGO
- MRGO sill

Marsh Restoration

- Biloxi Marsh marsh restoration
- Restoration and maintenance of the narrow land between Lake Borgne and the MRGO
- Ensure that the MRGO remains isolated from Lake Borgne
- Central Wetlands marsh restoration
- Golden Triangle marsh restoration
- Lake Borgne marsh restoration
- New Orleans East Landbridge marsh restoration
- Breton Landbridge marsh restoration
- South Lake Borgne marsh restoration
- Caernarvon area marsh restoration
- Grand Bay Marsh Restoration
- La Branche Wetlands Marsh Restoration
- Fort St. Phillip Marsh Restoration
- St. Tammany Marsh Restoration
- Jefferson Parish fringe marsh buffer
- Small Marsh Restoration at Outfall Canals
- Bayou Terre aux Boeufs Marsh Restoration
- North Lake Lery Marsh Restoration
- Marsh Restoration South of Lake Lery

Swamp Restoration

- Central Wetlands cypress restoration
- Florissant cypress restoration
- Hopedale cypress restoration

Shoreline Protection

- New bank line stabilization on the entire shore of Lake Borgne
- Breakwaters in Lake Borgne
- Breakwaters to protect Chandeleur Islands.
- Armor eroding shorelines on the north bank of MRGO and on Lake Borgne.
- Armor MRGO banks to stop erosion.
- Armor both sides of the La Loutre Ridge bank
- Shoreline protection in the Biloxi Marsh
- Biloxi Marsh northeastern outlying islands bank armament
- Jetties in the offshore segments of the channel in Breton and Chandeleur Sounds
- Foreshore protection segments along the portion of the Chalmette Loop Levee fronting the MRGO
- Foreshore protection in various locations on the north bank of the channel fronting wetlands areas
- Shore protection from Golden Triangle to Bayou St. Malo.
- Restoration/rehabilitation of bank lines along MRGO
- La Branche Wetlands shoreline protection
- Sink Ships for Breakwater/Oyster Reef
- Lake Maurepas shoreline protection
- St. Tammany shoreline protection
- Lake Lery shoreline protection

Ridge Restoration

- Restore La Loutre Ridge to +8 feet
- Rebuild La Loutre Landbridge

- Restore Bayou La Loutre Ridge east of the MRGO to Christmas Camp Lake
- Bayou Terre aux Boeuf ridge restoration

Vegetative Planting

- Plant MRGO spoil banks with trees
- Plant trees in front of levees

Barrier Island Restoration

- Restore Breton and Chandeleur Island Chain
- Biloxi Marsh northeastern outlying islands marsh restoration
- Cat Island restoration

SAV Restoration

- SAV restoration in the study area

Oyster Reef Restoration

- Oyster reef restoration in the Biloxi Marsh

Recreation Features

- USACE provide a boat launch immediately south of the proposed closure structure on the right descending bank of the MRGO
- Bienvenue Triangle recreation feature
- Violet Diversion recreation feature
- Shell Beach monument recreation improvements
- Bayou St. John recreation improvemen

2.6.1 Initial Formulation and Screening Process

The following section provides a summary of the initial formulation and screening of measures.

Step 1 –Proposed measures that did not serve the primary purpose of ecosystem restoration (e.g., levees, floodwalls) were eliminated as not in compliance with the goals and objectives of the study. Recreation features were deferred for development in conjunction with the selected plan.

Step 2 – Conceptual measures were defined spatially and input into a Geographic Information System (GIS) database. In some cases, several specific proposed marsh, swamp, or ridge restoration measures in the same area were combined into one larger measure, while other larger, more conceptual measures were segmented into smaller geographic components.

Step 3 – Once measures were geographically defined, they were screened based on their spatial effects by determining if they met one of two of the following criteria: 1) the measure addressed restoration of the Lake Borgne Ecosystem, 2) the measure addressed a MRGO ecosystem effect. Measures that did not meet one of these two criteria were eliminated from further consideration.

Step 4 – The remaining measures were then screened based on additional criteria specific to the type of measure as described in the following sections. During this portion of the screening process, measures were only compared to like measures, for example, marsh restoration measures were only compared to other marsh restoration measures.

The following sections describe the initial screening by measure type.

2.6.1.1 Freshwater Diversions Initial Screening

The MRGO study authority calls for considering the diversion of freshwater from the Mississippi River for restoring the Lake Borgne ecosystem. Delivering river water to the Lake Borgne area could be achieved at a number of different locations along the east bank of the Mississippi River. Several alternative locations and sizes for freshwater diversions had been proposed in previous reports such as LCA and LACPR, which were incorporated into the initial measures to be evaluated as part of this study. Twenty-two freshwater diversion sites along the east bank of the Mississippi River between Convent in St. James Parish and Baptiste Collette Bayou in Plaquemines Parish were evaluated. This set of initial sites for evaluation was developed from existing reports, public input, and interagency collaboration. If sites had previously specified sizes, specific multiple sizes at these sites were considered. If previous studies had not identified discharge rates for a site, consideration of the size of the diversion was deferred. Freshwater diversion measures were initially screened from further consideration based upon two criteria. If diversion measures and sites were determined to have an influence area lying entirely outside the Lake Borgne ecosystem or outside of the areas potentially affected by the MRGO, they were screened from further evaluation as detailed below.

Ten potential sites on the river‘s east bank below Caernarvon were identified in the initial planning phase. It was determined that these areas were outside of the Lake Borgne ecosystem. Therefore, potential diversion locations on the river below the existing Caernarvon Diversion were removed from further consideration. This initial screening reduced the original 43 measures to a total of 23 conceptual measures at 12 sites (see Table 12-11).

The location of a freshwater diversion is constrained by existing development, infrastructure, and river conditions as illustrated in Figure 2-25. A freshwater diversion at Bonnet Carrè was the selected plan in the 1984 *Mississippi and Louisiana Estuarine Areas Feasibility Study Freshwater Diversion to Lake Pontchartrain and Mississippi Sound Feasibility Study* (USACE 1984). The State of Louisiana has expressed opposition to a large diversion of freshwater into Lake Pontchartrain due to water quality concerns. A re-evaluation of this study was performed in 1996, and a Finding of No Significant Impact (FONSI) for an Environmental Assessment evaluating water quality impacts to Lake Pontchartrain was signed in July 1996. In an official reply, the State of Louisiana in July 1996, declined to participate further in the project. WRDA 2007 Section 3083 authorizes the achievement of the benefits described in *Mississippi and Louisiana Estuarine Areas Freshwater Diversion to Lake Pontchartrain and Mississippi Sound Feasibility Study* through the design and implementation of a freshwater diversion at or near Violet, LA. Modification to the Bonnet Carrè is still an authorized project and could be considered as part of that effort. Because it would be inefficient to build a new structure at a location where an existing structure could be modified to achieve the same benefits, a new structure at or near the Bonnet Carrè Spillway was removed from further consideration, including a new diversion in the vicinity of the La Branche Wetlands.

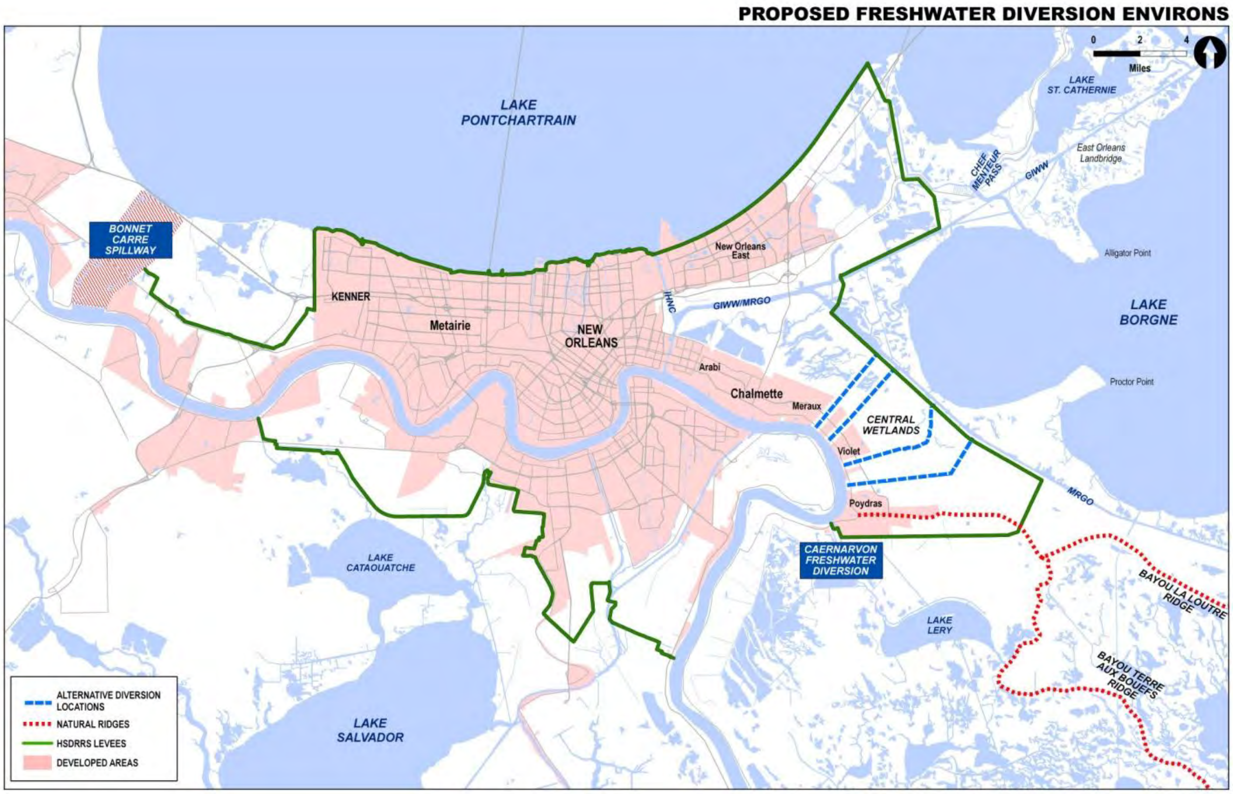


Figure 2-25. Freshwater Diversion Location Constraints

A freshwater diversion could not be located between the La Branche Wetlands and the Inner Harbor Navigation Canal without impacting existing suburban and urban development in Orleans and Jefferson Parishes. Developing a plan to locate a diversion in a densely developed community without open land corridors between the river and estuary would require substantial relocation of homes, businesses, and public infrastructure. There are no existing open land corridors between the river and lake in either Jefferson Parish or Orleans Parish. Therefore, no locations in Jefferson Parish or in Orleans Parish were evaluated.

There are four open land corridors in St. Bernard Parish between the communities of Chalmette and Poydras where freshwater could be diverted from the Mississippi River for distribution in the Lake Borgne ecosystem.

South of Poydras, there are opportunities to divert river water in the vicinity of Bayou Terre aux Boeufs and at the existing Caernarvon Diversion. The Bayou Terre aux Boeufs ridge in St. Bernard Parish forms a hydrologic barrier that would inhibit the movement of freshwater to the areas targeted for restoration in the MRGO study. Bayou Terre aux Boeufs flows through the communities of St. Bernard, Toca, Kenilworth and Verret. A freshwater diversion at this location was proposed in LACPR to benefit the marshes located between the MRGO and Bayou Terre aux Boeufs. As noted in LACPR, the construction of a freshwater diversion at this location would require construction of a leveed conveyance channel approximately 7.16 miles in length to influence the area between Bayou Terre aux Boeufs and the MRGO. To distribute freshwater to this area would require widening and deepening the existing bayou, and adjacent residential, commercial, and industrial development would be impacted. Additional channels would be needed outside of the Chalmette Loop Levee to influence the greater Lake Borgne ecosystem. Because the Mississippi River is farther away from Lake Borgne in this location, it would be less efficient to distribute freshwater through Bayou Terre aux Boeufs than at a location where the river is closer to the lake. A freshwater diversion at Bayou Terre aux Boeufs would not provide freshwater to the Central Wetlands, Golden Triangle, and northern Lake Borgne/MRGO Landbridge, and therefore would not achieve the goals and objectives of this study. Due to concerns regarding efficiency, constructability, and potential impacts to development, diversion alternatives at Bayou Terre aux Boeufs were removed from further consideration.

Two existing LCA Caernarvon Diversion projects were being developed to maximize benefits at the Caernarvon Diversion, and the area targeted for restoration in the MRGO Ecosystem Restoration Study would be more efficiently served by a freshwater diversion that would not be impeded by the Bayou Terre aux Boeufs ridge and the MRGO spoil bank. This assessment reduced the number of potential diversion sites to four locations in the vicinity of Violet, LA in St. Bernard Parish.

Restoration of a freshwater system in the Central Wetlands may be needed to restore the swamp habitat affected by the MRGO, and sustain the restored marsh. To accomplish this restoration, a freshwater diversion is needed to establish the optimal salinity regime for the estuary. A river diversion at or near the existing Violet Canal was determined to be the best location to achieve the goals and objectives of the study. The MRGO was excavated through the eastern portion of the Central Wetlands and increased salinity in the area through salt water intrusion. The habitat of the Central Wetlands changed from a cypress swamp and fresh/intermediate marsh system to an entirely brackish system. Although salinity levels have decreased in the area due to the closure of the MRGO, a freshwater diversion may be needed to establish and maintain optimal salinity. In these preliminary analyses, a freshwater diversion located in the vicinity of Violet, LA was determined to be the most effective way to restore the Central Wetlands and the salinity regime in the estuary.

Table 2-11. Steps 3 and 4: Freshwater Diversion Measures

Measure Name	Addresses Restoration of Lake Borgne Ecosystem	Addresses a MRGO Ecosystem Effect	Other Criteria
American Bay Diversion	No	No	
California Bay Diversion	No	No	
Bohemia Mississippi River Reintroduction	No	No	
Delta Building Diversion N. of Fort St. Phillip	No	No	
Fort Jackson Sediment Diversion	No	No	
Grand Bay Diversion R1 and R2	No	No	

Table 2-11. Steps 3 and 4: Freshwater Diversion Measures			
Measure Name	Addresses Restoration of Lake Borgne Ecosystem	Addresses a MRGO Ecosystem Effect	Other Criteria
Bayou Lamoque Diversion R1, R2, R3, R4, and R5	No	No	
White Ditch Diversion R3 and R5	No	No	
Benney‘s Bay Diversion R3 and R4	No	No	
Adaptive Management through Maintenance of Existing Crevasses and Construction of New Crevasses	No	No	
Freshwater Diversion in the Vicinity of Violet	Yes	Yes	
Diversion at Hope Canal R1, R2, R3, R4, and R5	Yes	Yes	Addressed by LCA authorized project.
Diversion at Blind River R1, R2, R3, R4, and R5	Yes	Yes	Addressed by LCA authorized project.
Diversion Convent/Blind River R1, R2, R3, R4, and R5	Yes	Yes	Addressed by LCA authorized project.
Bayou Bienvenue Diversion R1 and R2	Yes	Yes	Concerns associated with constructability and impacts to existing infrastructure.
Bayou La Loutre Diversion R1 and R2	Yes	Yes	Concerns regarding efficiency, constructability, potential impacts to development, and the potential to influence the targeted areas.
Caernarvon Diversion Modification R1 and R2	Maybe	Maybe	Target influence area for MRGO Ecosystem Restoration could be served more efficiently from another location due to the hydrologic barriers formed by the bayou Terre aux Boeufs and MRGO spoil banks. Also addressed in the two authorized Caernarvon Diversion modification projects.
Bonnet Carrè Freshwater / Sediment Introduction or Opportunistic use of Bonnet Carrè Spillway	Yes	Yes	Project is already authorized and can be implemented by Congress; however WRDA 2007 Section 3083 mandates the achievement of the benefits of this diversion at or near Violet, LA. Modification to the Bonnet Carrè could be considered as part of that effort.
La Branche Diversion R1 and R2	Yes	Yes	The benefits of a diversion at this location could be achieved at Bonnet Carrè for considerably less cost.

Table 2-11. Steps 3 and 4: Freshwater Diversion Measures

Measure Name	Addresses Restoration of Lake Borgne Ecosystem	Addresses a MRGO Ecosystem Effect	Other Criteria
Bayou Terre aux Boeufs Diversion R1 and R2	Yes	Yes	Target influence area for MRGO Ecosystem Restoration could be served more efficiently from another location due to the hydrologic barriers formed by the bayou Terre aux Boeufs and MRGO spoil banks.
Violet Spillway	Yes	Yes	An uncontrolled diversion was ruled out because of the need to control flows at different times of the year in order to meet salinity targets, support cypress growth, avoid flooding, adaptively manage, etc.
Effluent from Waste Water Treatment Plant	Yes	Yes	Addressed by CIAP project. Flow capability insufficient to meet the objectives.
Note: Bold text indicates the measure was carried forward for further consideration.			

Alternatives that did not include a freshwater diversion were considered in the initial development of alternatives. These alternatives were ultimately eliminated from further study as inconsistent with the study goals and objectives and the –Guiding Principles”. A small freshwater diversion would not mimic periodic overbank flooding of the Mississippi River, a key process of the estuary that preliminary analyses indicate is needed to re-establish historic salinity gradients, habitat types, and increase self-sustainability in the system.

The forecast future without project salinity conditions suggest that salinity in the study area would be reduced by the closures on the MRGO and other authorized projects. However, additional inputs of freshwater may be necessary to fully restore the historic salinity regime.The restoration and maintenance of a cypress swamp and fresh/intermediate marsh in the Central Wetlands may require the introduction of freshwater into this area. Additionally, to restore the MRGO/Lake Borgne Landbridge to a condition favorable for the propagation of intermediate marsh species, the area may require further salinity reductions beyond the forecast future without project conditions.

The –Guiding Principles” reinforce the inclusion of a freshwater diversion for this study. The freshwater diversion proposed as part of the MRGO Ecosystem Restoration Plan would assist with realizing the following guiding principles:

- Restore key processes and dynamics in the estuary;
- Enhance the resilience and self-sustainability of the estuary;

- Maximize the combined benefits of freshwater diversions that seek to restore natural processes with mechanical marsh creation measures; and
- Combine measures synergistically to maximize possible cumulative benefits.

2.6.1.2 Hydrologic Restoration Initial Screening Results

Initially, 24 channel/canal backfilling measures were considered. After screening, six of the original fill measures were carried forward for further study. In addition, those associated with the distribution of freshwater from diversions were considered to be part of the diversion measure rather than a stand-alone measure. Some other proposed backfill areas were deemed impractical because of the cost of installing multiple retaining structures in a relatively small geographic area. Other canal backfilling features were screened out to maintain vessel access following the MRGO closure at Bayou La Loutre. The remaining six backfilling features were located within the footprint of the former navigation channel (see Table 2-12).

Initially, 26 water control measures were considered. After screening, no measures were carried forward. It was determined that water control measures would be examined in conjunction with individual marsh/swamp restoration features and freshwater diversions, rather than as stand-alone measures (see Table 2-12).

Table 2-12. Steps 3 and 4: Hydrologic Restoration Measures

Measure Name	Addresses Restoration of Lake Borgne Ecosystem	Addresses a MRGO Ecosystem Effect	Other Criteria
Florissant Fill and Plant with Trees	No	No	
Hopedale Fill and Plant with Trees	No	No	
Alabama Bayou Closure	No	No	
Identify sustainable methods to benefit Bayou St. John water quality, habitat management, recreational access, and educational opportunities	No	No	
South Slough Hydrologic Restoration 1-3	No	No	
Lock Replacement	No	No	
Multiple Closures in MRGO 1-3	No	No	
Fill parallel canal to Marsh Elevation (Back Canal Bienvenue to Dupre)	No	No	
Fill parallel canal to Marsh Elevation (Back Canal Between Dupre and Verret Levee)	Yes	Yes	Interferes with freshwater distribution. The benefits of creating marsh habitat in this location are less than the impacts to fisheries and access.

Table 2-12. Steps 3 and 4: Hydrologic Restoration Measures			
Measure Name	Addresses Restoration of Lake Borgne Ecosystem	Addresses a MRGO Ecosystem Effect	Other Criteria
Fill parallel canal to Marsh Elevation (Back Canal Between HPL at Verret to Yscloskey)	Yes	Yes	Interferes with freshwater distribution. The benefits of creating marsh habitat in this location are less than the impacts to fisheries and access.
Fill parallel canal to Marsh Elevation (Back Canal Between Bayous Yscloskey and La Loutre)	Yes	Yes	Interferes with freshwater distribution. The benefits of creating marsh habitat in this location are less than the impacts to fisheries and access. Access over pipelines is an issue.
Fill parallel canal to Marsh Elevation (Back Canal Between Bayous Yscloskey and La Loutre)	Yes	Yes	Interferes with freshwater distribution. The benefits of creating marsh habitat in this location are less than the impacts to fisheries and access.
Fill in MRGO to Bay Bottom (Between barrier islands to Mile 27)	Yes	Yes	Interferes with freshwater distribution. The benefits of creating marsh habitat in this location are less than the impacts to fisheries and access. NOTE: Approx 1360' of canal, in vicinity of MRGO mile 41.6, is filled in and does not require any further fill.
Fill parallel canal to Marsh Elevation (Bayou La Loutre to terminus)	Yes	Yes	Natural fill occurring; no land created.
Fill in MRGO to Marsh Elevation (GIWW to Bienvenue) Reach 1	Yes	Yes	Impractical: Three containment structures would be required in addition to IHNC surge barrier in distance of approx. 7000'.
Fill in MRGO to Marsh Elevation (GIWW to Bienvenue) Reach 2	Yes	Yes	
Fill parallel canal to Marsh Elevation (Bayou Bienvenue to Bayou Dupre inside levee)	Yes	Yes	Already filled in by previous MRGO O&M dredge disposal.
Fill parallel canal to Marsh Elevation (Bayou Dupre to Levee at Verret inside levee)	Yes	Yes	Already filled in by previous MRGO O&M dredge disposal.
Florissant Historic - Re-grade from ridge to marsh at edge of MRGO	Yes	Yes	Degrading spoil banks not seen as desirable because upland scrub-shrub provides habitat for migrating birds.
Hopedale Historic - Re-grade ridge to marsh at edge of MRGO	Yes	Yes	Degrading spoil banks not seen as desirable because upland scrub-shrub provides habitat for migrating birds.

Table 2-12. Steps 3 and 4: Hydrologic Restoration Measures			
Measure Name	Addresses Restoration of Lake Borgne Ecosystem	Addresses a MRGO Ecosystem Effect	Other Criteria
Sediment Delivery by Pipeline at Central Wetlands	Yes	Yes	Deferred as dependent on other diversion measures.
Sediment Delivery by Pipeline at Golden Triangle	Yes	Yes	Deferred as dependent on other diversion measures.
MRGO Sill (Water Control Structure 2-5			Deferred as dependent on other diversion measures.
Bayou La Loutre Water Control Features 1-6	Yes	Yes	Deferred as dependent on other diversion measures.
Create Channel (Bayou Restoration) 1-3	Yes	Yes	Concerns about increasing saltwater intrusion and tidal scour.
Constrict opening between Lake Borgne and MRGO	Yes	Yes	Addressed by shore protection measures along south shore of Lake Borgne and north bank of MRGO.
MRGO Sill (Water Control Structure - 1)	Yes	Yes	Channel filling in naturally.
Fill in MRGO to Marsh Elevation - A (Bienvenue to Dupre)	Yes	Yes	
Fill in MRGO to Marsh Elevation - C (Dupre to end of Levee Reach)	Yes	Yes	
Fill In MRGO to Marsh Elevation - I (Bayou LaLoutre to Lake Athanasio)	Yes	Yes	
Fill in MRGO to Marsh Elevation - G (Bayou Yscloskey to Bayou Doulluts)	Yes	Yes	
Fill in MRGO to Marsh Elevation - F (End of Leveed Reach to Bayou Yscloskey)	Yes	Yes	
Fill in MRGO to Marsh Elevation - H (Bayou Doulluts to Bayou LaLoutre)	Yes	Yes	
Note: Bold text indicates the measure was carried forward for further consideration.			

2.6.1.3 Marsh and Swamp Restoration Measures Initial Screening Results

Initially, approximately 42 marsh restoration and five swamp restoration areas were identified in Louisiana. For discussion of potential marsh restoration sites in Mississippi, see MsCIP. The sites in Louisiana were screened to remove areas that were not affected by the MRGO or were outside of the Lake Borgne ecosystem (see Table 2-13). After initial screening, 19 areas were identified for further refinement of marsh restoration and nourishment measures. Three areas in the Central Wetlands were retained for further study and refinement of swamp restoration and nourishment measures.

Table 2-13. Steps 3 and 4: Marsh and Swamp Restoration Measures

Measure Name	Addresses Restoration of Lake Borgne Ecosystem	Addresses a MRGO Ecosystem Effect	Other Criteria
Maintain Breton Landbridge - North	Yes	Yes	Adverse impact to hydrology in terms of freshwater.
Bayou Terre aux Boeufs Marsh Creation - B	Yes	Yes	
Caernarvon Area Marsh Creation - South	No	No	
Maintain and Restore Biloxi Landbridge and Barrier Reefs North B	No	No	
Maintain and Restore Biloxi Landbridge and Barrier Reefs South A	No	No	
Maintain and Restore Biloxi Landbridge and Barrier Reefs South B	No	No	
Maintain critical marsh shoreline and ridges of East Orleans Landbridge - B-C	Yes	Yes	
Maintain critical marsh shoreline and ridges of East Orleans Landbridge – D	Yes	Yes	Screened out as unnecessary due to existing dredge material disposal.
Maintain critical marsh shoreline and ridges of East Orleans Landbridge - A	Yes	Yes	
Maintain critical marsh shoreline and ridges of East Orleans Landbridge - E	Yes	No	
Maintain critical marsh shoreline and ridges of East Orleans Landbridge - F	Yes	No	
Maintain and Restore Biloxi Landbridge and Barrier Reefs North A	Yes	No	Marsh is intact and has not changed significantly since 1956.
Bayou Terre aux Boeufs Marsh Creation - A	No	No	
Golden Triangle Marsh Creation - East	Yes	Yes	
Maintain Lake Borgne Landbridge including Landbridge Shoreline Protection	Yes	Yes	
Maintain and Restore Biloxi Landbridge and Barrier Reefs South C	Yes	Maybe	
Biloxi Marshes - Marsh Creation Interior - C	Yes	Maybe	Marsh is intact and has not changed significantly since 1956.
Bayou Terre aux Boeufs Marsh Creation - C	No	No	
Maintain Breton Landbridge - South	No	No	
Caernarvon Area Marsh Creation - North	No	No	
Central Wetlands Swamp Creation - B	Yes	Yes	
Central Wetlands Swamp Creation - A	Yes	Yes	
Central Wetlands Swamp Creation - C	Yes	Yes	
Golden Triangle Marsh Creation - East	Yes	Yes	

Table 2-13. Steps 3 and 4: Marsh and Swamp Restoration Measures

Measure Name	Addresses Restoration of Lake Borgne Ecosystem	Addresses a MRGO Ecosystem Effect	Other Criteria
Biloxi Marshes - Marsh Creation Interior - B	No	No	
Biloxi Marshes - Marsh Creation Interior - A	No	No	
Biloxi Marshes - Marsh Creation Interior - D	Yes	Maybe	
Biloxi Marshes - Marsh Creation Interior - E	Yes	Maybe	Marsh is intact and has not changed significantly since 1956.
Biloxi Marshes Marsh Creation and Shoreline Protection – A	Yes	No	Marsh is intact and has not changed significantly since 1956.
Eloi Bay Marsh Creation/Nourishment	Yes	Yes	Marsh is intact and has not changed significantly since 1956.
North Lake Lery Marsh Creation	No	No	
Biloxi Marsh Marsh Nourishment	Yes	Yes	
Biloxi Marshes Marsh Creation and Shoreline Protection - B	Yes	No	Marsh is intact and has not changed significantly since 1956.
Skiff Lake Marsh Creation	Yes	Maybe	Marsh is intact and has not changed significantly since 1956.
Morgan Harbor Marsh Creation	Yes	Yes	Removed from consideration due to concerns regarding impacts to oyster reefs and seed grounds.
Breton Marsh Creation - A (See Note 2)	Yes	Yes	Marsh is intact and has not changed significantly since 1956.
Breton Marsh Creation - C (See Note 2)	Yes	Yes	Marsh is intact and has not changed significantly since 1956.
Florissant Swamp Restoration	Yes	Yes	Area not historically cypress; conditions not suitable for the development of a sustainable cypress swamp.
Hopedale Swamp restoration	Yes	Yes	Area not historically cypress; conditions not suitable for the development of a sustainable cypress swamp.
Hopedale Marsh Restoration	Yes	Yes	
Florissant Marsh Restoration	Yes	Yes	
Biloxi Marshes Marsh Creation - Lake Athanasio.	Yes	Yes	Marsh is intact and has not changed significantly since 1956.
Marsh Creation South of Lake Lery	No	No	
Marsh Creation east of Lake Calebass	Yes	Yes	Removed from consideration due to concerns regarding impacts to
Marsh Creation near St. Helena Bay	Yes	Yes	

Table 2-13. Steps 3 and 4: Marsh and Swamp Restoration Measures			
Measure Name	Addresses Restoration of Lake Borgne Ecosystem	Addresses a MRGO Ecosystem Effect	Other Criteria
Marsh Creation West of Lake Jean Louis Robin	Yes	Yes	oyster reefs and seed grounds.
Marsh Creation West of Lake Calebass	Yes	Yes	
Note: Bold text indicates the measure was carried forward for further consideration.			

2.6.1.4 Shoreline Protection Measures Initial Screening Results

Initially, 58 shoreline protection measures were considered. Various shore protection alignments were initially screened to eliminate those deemed to be outside the Lake Borgne ecosystem or outside areas potentially affected by the MRGO. Breakwaters were screened out in Lake Borgne and Biloxi Marshes because they are less effective than foreshore protection. After screening, 26 shoreline protection measures were carried forward for further study (see Table 2-14).

Table 2-14. Steps 3 and 4: Shoreline Protection Measures			
Measure Name	Addresses Restoration of Lake Borgne Ecosystem	Addresses a MRGO Ecosystem Effect	Other Criteria
Maintain Shoreline East Orleans Landbridge – C	Yes	No	
Biloxi Marshes Shoreline Protection – A	No	No	Would only protect a small area at a high cost due to water depth and geographic constraints.
Biloxi Marshes Shore Protection Interior A	Yes	No	Off-shore protection deemed less effective than near shore protection for erosion prevention.
Biloxi Marshes Shore Protection Interior C	No	No	
Biloxi Marshes Shore Protection - South C	Yes	No	
Biloxi Marshes Shore Protection Interior B	Yes	No	Off-shore protection deemed less effective than near shore protection for erosion prevention.
Biloxi Marshes Shore Protection - South A	Yes	No	Would only protect a small area at a high cost due to water depth and geographic constraints.
Skiff Lake Shoreline Protection	No	No	Would only protect a small area at a high cost due to water depth and geographic constraints.

Table 2-14. Steps 3 and 4: Shoreline Protection Measures

Measure Name	Addresses Restoration of Lake Borgne Ecosystem	Addresses a MRGO Ecosystem Effect	Other Criteria
Maintain Lake Borgne Shoreline - B	Yes	No	State will build with surplus funds. Part of FWOP.
Maintain Shoreline East Orleans Landbridge – A	Yes	No	
Lake Borgne Shoreline Protection - B	Yes	No	State will build with surplus funds. Part of FWOP.
Shoreline Protection (Potential Creation of SAV Habitat)	Yes	No	
MRGO North Bank (MRGO Mile 23.2-20.8) O&M	Yes	Yes	Removed as inefficient. Does not protect any land, could prevent natural filling in the channel.
Maintain Shoreline East Orleans Landbridge – B	Yes	No	
Lake Borgne Shoreline Protection - A	Yes	No	State will build with surplus funds. Part of FWOP.
Biloxi Marshes Shore Protection - South B	No	No	
Biloxi Marshes Shore Protection - North A	Yes	No	
Maurepas Shoreline Protection - East	Yes	No	Marsh is intact and has not changed significantly since 1956.
Lake Borgne Shoreline Protection – C	Yes	No	
MRGO North Bank (MRGO Mile 33.8-32.6) O&M	Yes	Yes	
Morgan Harbor Shoreline Protection	Yes	No	
MRGO Shoreline Protection - H O&M	Yes	Yes	
MRGO Shoreline Protection - G	Yes	Yes	
Maurepas Shoreline Protection – West	Yes	Maybe	Removed due to low benefit numbers from initial WVA and high cost.
Eloi Bay Shoreline Protection	Yes	No	
Oyster Reef Development in Biloxi Marshes C (Foreshore Dike with 35 ' Berm for Reef)	Yes	Maybe	Reefs in area already in good condition.
Biloxi Marshes Shore Protection - North B	No	No	

Table 2-14. Steps 3 and 4: Shoreline Protection Measures

Measure Name	Addresses Restoration of Lake Borgne Ecosystem	Addresses a MRGO Ecosystem Effect	Other Criteria
MRGO Shoreline Protection - C O&M	Yes	Yes	
MRGO Shoreline Protection - D O&M	Yes	Yes	
MRGO South Bank (MRGO Mile 59-47) O&M	Yes	Yes	Screened out because WVA assigned very few benefits.
Golden Triangle Shoreline Protection	Yes	Yes	Covered by CIAP project.
MRGO Shoreline Protection - F O&M	Yes	Yes	
Bayou Dupre/Lake Borgne Shoreline Protection	Yes	Yes	Covered by USACE project.
West of Shell Beach Shoreline Protection	Yes	Yes	Covered by USACE project.
Biloxi Marshes Shoreline Protection – B	Yes	No	Would only protect a small area at a high cost due to water depth and geographic constraints.
MRGO Shoreline Protection - B	Yes	Yes	
Maintain Lake Borgne Shoreline – A	Yes	No	
MRGO Shoreline Protection - E	Yes	Yes	
MRGO South Bank (MRGO Mile 23.2-20.8) O&M	Yes	Yes	Removed as inefficient. Does not protect any land, could prevent natural filling in the channel.
MRGO South Bank (MRGO Mile 37.3-36.5) O&M	Yes	Yes	Existing Articulated Concrete Mattress in good condition.
MRGO South Bank (MRGO Mile 38.9-38.5) O&M	Yes	Yes	Existing Articulated Concrete Mattress in good condition.
MRGO South Bank (MRGO Mile 60-59) O&M	Yes	Yes	Screened out because WVA assigned very few benefits.
Jean Louis Robin Shoreline Protection	Yes	Yes	
West Lake Lery Shoreline Protection	No	No	
South Lake Lery Shoreline Restoration	No	No	
MRGO Shoreline Protection - A	Yes	Yes	In authorized part of the GIWW channel, O&M covered.

Table 2-14. Steps 3 and 4: Shoreline Protection Measures

Measure Name	Addresses Restoration of Lake Borgne Ecosystem	Addresses a MRGO Ecosystem Effect	Other Criteria
Oyster Reef Development in Biloxi Marshes A (Via Crushed Stone)	Yes	Maybe	Not as effective for shoreline protection purpose as measure #98 - Oyster Reef Development in Biloxi Marshes C (Foreshore Dike with 35' Berm for Reef)
Breakwaters along Lake Borgne Shoreline	Yes	No	Not as cost effective as nearshore shoreline protection measures
Oyster Reef Development in Biloxi Marshes B (Bio-Engineered Reef)	Yes	Maybe	Not as effective for shoreline protection purpose as measure #98 - Oyster Reef Development in Biloxi Marshes C (Foreshore Dike with 35' Berm for Reef)
Biloxi Marshes Shoreline Protection - Offshore Artificial Reef	No	No	Not as cost effective as nearshore shoreline protection measures
LaBranche Wetlands Shoreline Protection	No	No	
Sink Ships for Breakwater/Artificial Reef	No	No	
Lake Maurepas Shoreline Protection – A	No	No	
Lake Maurepas Shoreline Protection – B	No	No	
St. Tammany Shoreline Protection	No	No	
Bay Boudreau Shoreline Protection	Yes	No	Duplicative with #98 Shoreline Protection

Note: Bold text indicates the measure was carried forward for further consideration.

2.6.1.5 Ridge Restoration Measures Initial Screening Results

Initially, 55 ridge restoration measures were considered. The 55 measures were developed by combining five different sized ridges (historic, 50 ft, 100 ft, 150 ft, and 200 ft footprints) at 11 locations. After screening, only two ridge restoration locations on the Bayou La Loutre Ridge were carried forward for further study (see Table 2-15).

Ridge restoration consists of stacking sediment to a height conducive to the propagation of upland habitat. In areas where natural ridges are above marsh elevation and currently support upland habitat, ridge restoration would bury existing vegetation and replace it with vegetation considered to have greater habitat value. It was determined that the benefits derived from the higher habitat value would not justify the costs associated with raising the elevation and planting these features.

Similarly, in areas where the ridges have subsided to marsh elevation, ridge restoration would result in adverse impacts to marsh that must be considered in the calculation of benefits. The Bayou Terre aux Boeufs Ridge was removed from further consideration because it was determined that the negative impacts to existing upland and marsh habitats were greater than the ecosystem benefits of ridge restoration in this location.

Portions of the south side of the Bayou La Loutre Ridge were identified that were above marsh elevation but did not have existing upland vegetation: these sections were retained for further evaluation. Ridge restoration designs were developed that minimized impacts to adjacent wetlands while providing suitable crown widths and slopes for establishing ridge species.

Table 2-15. Steps 3 and 4: Ridge Restoration Measures

Measure Name	Addresses Restoration of Lake Borgne Ecosystem	Addresses a MRGO Ecosystem Effect	Other Criteria
Bayou La Loutre Ridge Restoration East - South Bank A 200ft	Yes	Yes	
Bayou La Loutre Ridge Restoration East - South Bank A 50ft	Yes	Yes	Crown width and slope not suitable for establishing oak ridge species.
Bayou La Loutre Ridge Restoration East - South Bank A 100ft	Yes	Yes	Crown width and slope not suitable for establishing oak ridge species.
Bayou La Loutre Ridge Restoration East - South Bank A 150ft	Yes	Yes	Crown width and slope not suitable for establishing oak ridge species.
Bayou La Loutre Ridge Restoration East - South Bank A historic width	Yes	Yes	Removed due to potential negative impacts to existing vegetation and marsh.
Bayou La Loutre Ridge Restoration East - South Bank B 50ft, 100 ft, 150 ft, 200 ft, and historic width	Yes	Yes	Removed due to potential negative impacts to existing vegetation and marsh.
Bayou La Loutre Ridge Restoration East - North Bank A: 50ft., 100 ft., 150 ft., 200ft., and historic width	Yes	Yes	Removed due to potential negative impacts to existing vegetation and marsh.
Bayou La Loutre Ridge Restoration East - North Bank B: 50ft., 100 ft., 150 ft., 200ft., and historic width	Yes	Yes	Removed due to potential negative impacts to existing vegetation and marsh.
Bayou La Loutre Ridge Restoration West - North Bank A: 50ft., 100 ft., 150 ft., 200ft., and historic width	Yes	Yes	Removed due to potential negative impacts to existing vegetation and marsh.
Bayou La Loutre Ridge Restoration West - South Bank A: 50ft., 100 ft., 150 ft., 200ft., and historic width	Yes	Yes	Removed due to potential negative impacts to existing vegetation and marsh.
Bayou Terre aux Boeufs West Ridge Restoration A: 50ft., 100 ft., 150 ft., 200ft., and historic width	Yes	Yes	Removed due to potential negative impacts to existing vegetation and marsh.

Table 2-15. Steps 3 and 4: Ridge Restoration Measures

Measure Name	Addresses Restoration of Lake Borgne Ecosystem	Addresses a MRGO Ecosystem Effect	Other Criteria
Bayou Terre aux Boeufs West Ridge Restoration B: 50ft., 100 ft., 150 ft., 200ft., and historic width	Maybe	Maybe	Removed due to potential negative impacts to existing vegetation and marsh.
Bayou Terre aux Boeufs West Ridge Restoration C: 50ft., 100 ft., 150 ft., 200ft., and historic width	Maybe	Maybe	Removed due to potential negative impacts to existing vegetation and marsh.
Bayou Terre aux Boeufs East Ridge Restoration A: 50ft., 100 ft., 150 ft., 200ft., and historic width	Maybe	Maybe	Removed due to potential negative impacts to existing vegetation and marsh.
Bayou Terre aux Boeufs East Ridge Restoration B: 50ft., 100 ft., 150 ft., 200ft., and historic width	Maybe	Maybe	Removed due to potential negative impacts to existing vegetation and marsh.
Note: Bold text indicates the measure was carried forward for further consideration.			

2.6.1.6 Vegetative Planting Measures Initial Screening Results

Initially, 11 stand-alone vegetative planting measures were considered, which involved planting trees on the banks of the MRGO navigation channel. All of these measures were screened out (see Table 2-16). Measures to plant trees on the north bank of the MRGO were screened out because tree planting in that location is inconsistent with both the existing and historic marsh habitat. Measures to plant trees in front of the levee were screened out because they could potentially affect the structural integrity of the levee. Measures to plant trees on the spoil bank were screened out because the spoil banks are already well vegetated.

Additional vegetative planting measures are being carried forward as integral components of other measures such as marsh, swamp, and ridge restoration.

Table 2-16. Steps 3 and 4: Vegetative Planting Measures

Measure Name	Addresses Restoration of Lake Borgne Ecosystem	Addresses a MRGO Ecosystem Effect	Other Criteria
Plant Trees in Front of Levee (Mile 59 - 47)	Yes	Yes	Would violate maintenance criteria for levees.
Plant Trees on Spoil Bank – A	Yes	Yes	Disposal areas are already well vegetated and will likely develop into mature stands that could serve basically the same function as
Plant Trees on Spoil Bank – C	Yes	Yes	
Plant Trees on Spoil Bank – D	Yes	Yes	

Table 2-16. Steps 3 and 4: Vegetative Planting Measures

Measure Name	Addresses Restoration of Lake Borgne Ecosystem	Addresses a MRGO Ecosystem Effect	Other Criteria
Plant Trees on Spoil Bank – E	Yes	Yes	more desirable tree species.
Plant Trees on Spoil Bank – B	Yes	Yes	
Plant Trees on Spoil Bank – F	Yes	Yes	
Vegetative Planting Trees North Bank of MRGO – A	No	No	
Vegetative Planting Trees North Bank of MRGO – B	No	No	
Vegetative Planting Trees North Bank of MRGO – C	No	No	
Vegetative Planting Trees North Bank of MRGO – D	No	No	
Note: Bold text indicates the measure was carried forward for further consideration.			

2.6.1.7 Barrier Island Restoration Measures Initial Screening Results

Initially, three barrier island restoration measures were considered. After screening, two barrier island restoration measures were carried forward for further study and several variations of these alternatives were developed (see Table 2-17). Cat Island was eliminated from further study because it is part of MsCIP. The MRGO channel was dredged between Breton and Grand Gossier Islands in the Chandeleur Islands Chain, and some scientists contend that the former navigation channel disrupted sediment transport to Breton Island. However, the impact to the islands from the MRGO, if any, is difficult to quantify with any degree of certainty because the erosion and migration patterns in place since the late 1800s were still operating in 2005, with no obvious change after construction of the MRGO (Britsch 2009). Barrier islands were not identified as critical landscape features with respect to storm surge risk reduction in the LACPR ADCIRC analyses (USACE 2009). Barrier island restoration was ultimately eliminated for implementation under this authority because of the insufficient nexus to MRGO effects, the Lake Borgne ecosystem, or storm surge damage risk reduction. Restoration of the barrier islands would not directly benefit the area targeted for restoration under this authority. Alternative barrier island restoration measures on the Chandeleur Island chain require further study to determine how to maximize benefits while minimizing risks to project performance. Further study of alternative barrier island restoration techniques should be conducted to protect and restore this significant coastal habitat.

Table 2-17. Steps 3 and 4: Barrier Island Measures			
Measure Name	Addresses Restoration of Lake Borgne Ecosystem	Addresses a MRGO Ecosystem Effect	Other Criteria
Cat Island Restoration Study	Yes	No	Would violate maintenance criteria for levees.
Chandeleur Islands (Not Breton & Grand Gossier)	No	No	
Breton and Grand Gossier Island Restoration	No	Maybe	No documented MRGO effect to the islands; channel between the islands is addressed under "Channel Filling Measures"

2.6.1.8 SAV Demonstration Projects Initial Screening Results

Initially, two SAV demonstration projects were considered — one in Louisiana and one in Mississippi. The Louisiana SAV project was replaced with a breakwater/shoreline protection measure to allow expansion of established SAV on Lake Pontchartrain. The Mississippi project was screened out because it is recommended by the MsCIP report (see Table 2-18).

Table 2-18. Steps 3 and 4: SAV Measures			
Measure Name	Addresses Restoration of Lake Borgne Ecosystem	Addresses a MRGO Ecosystem Effect	Other Criteria
Mississippi SAV DEMO	No	No	
Louisiana SAV DEMO	Yes	Maybe	Replaced with breakwater to provide calming to allow expansion of established SAV on south shore of Lake Pontchartrain.

2.6.1.9 Artificial Oyster Reef Measures Initial Screening Results

Initially, one artificial oyster reef measure was considered. This artificial oyster reef measure is not being carried forward to the final array of alternatives because the area identified is already in acceptable condition regarding oysters; however, various oyster reef designs were evaluated under shoreline protection (see Table 2-19).

Table 2-19. Steps 3 and 4: Oyster Reef Measures			
Measure Name	Addresses Restoration of Lake Borgne Ecosystem	Addresses a MRGO Ecosystem Effect	Other Criteria
Oyster Reef Development in the Biloxi Marsh	Maybe	Maybe	Area identified already in acceptable condition regarding oysters, oyster reef designs evaluated as shoreline protection measures.

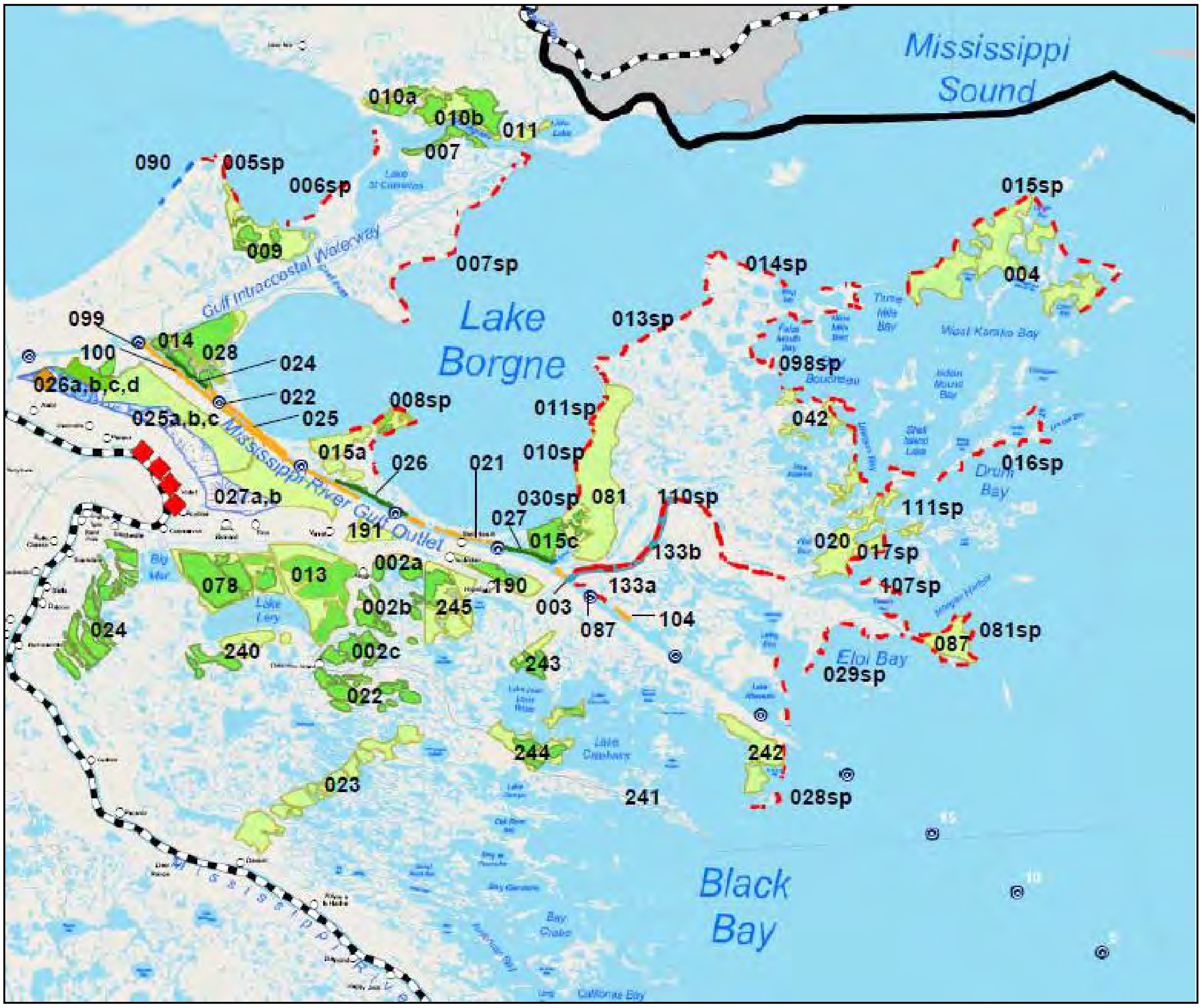


Figure 2-26. Preliminary Features Evaluated

2.6.2 Summary of Initial Screening Results

Screening the measures proposed in the initial array resulted in the elimination of 240 measures and the retention of 59 measures to be carried forward for refinement and detailed evaluation. The measures that were carried forward for further evaluation were further refined to produce more detailed designs, cost estimates, and quantification of outputs.

2.7 ALTERNATIVE PLAN FORMULATION

Alternative plans are combinations of management measures that collectively meet study goals and objectives within the defined study constraints. Alternative plans and their component management measures were assessed relative to the Federal objective of National Ecosystem Restoration (NER).

A GIS database was utilized to catalogue study information including individual management measures, existing and authorized water projects, and study area existing conditions. The GIS enables the visual display and manipulation of information across the large study area. Additionally, the system allows the building and testing of various alternative combinations of management measures during the course of plan formulation. Thus, GIS serves as a decision support tool.

2.7.1 Preliminary Evaluation of Measures

Measures are compared against one another and assembled into alternative plans using performance outputs (benefits) and costs.

Outputs (Benefits)

Environmental outputs were measured using the Wetland Value Assessment (WVA) methodology (certified for this use by the USACE Ecosystem Planning Center of Expertise). The WVA quantifies changes in fish and wildlife habitat quality and quantity that are expected to result from a proposed wetland restoration project. The results of the WVA, measured in Average Annual Habitat Units (AAHUs), can be combined with cost data to provide a measure of the effectiveness of a proposed project in terms of annualized cost per AAHU gained. In addition, the WVA methodology provides an estimate of the number of acres benefited or enhanced by the project and the net acres of habitat protected/restored. The results of the WVAs (in AAHUs) were compared with annual costs in IWR-PLAN to develop alternative plans.

The WVA model was used to determine the most effective measures for each habitat type identified for restoration in the study planning objectives. The WVA methodology uses different models for each habitat type, which facilitates the comparison of restoration measures by type. The WVA model does not assign different values to different types of habitat. An AAHU of brackish marsh has the same benefit as an AAHU of ridge habitat in the WVA model, although coastal ridge habitat is extremely scarce and brackish marsh is relatively abundant. Therefore, other important considerations, such as habitat type scarcity, contribution to overall ecosystem function, whether a measure addresses a direct effect of the MRGO, and contribution to restoration of critical landscape features were evaluated qualitatively for alternative plan combinations developed by IWR-PLAN.

WVA requires estimates of FWP and FWOP marsh acreages. Wetland acreage data (1985 through 2006) was obtained from the USGS for each of the study area subunits. FWOP subunit wetland acreages were determined via a linear trendline through those data (Figure 2-27). Where applicable, annual net acreage benefits associated with pre-existing or soon to be constructed restoration projects were added to the base subunit FWOP acreages to obtain revised FWOP subunit acreages.

The SAND2 method was used to predict accretion rates in areas benefitted by freshwater diversions. This model is an Engineering Research and Development Center (ERDC) revision of the SAND1 (Boustany-ERDC spreadsheet model) used in the Louisiana Coastal Protection and Restoration Final Technical Report (LACPR). The WVA model used this engineering input to assess benefits.

Given the great uncertainties regarding future subsidence rate changes, sea-level rise changes, and many other factors that might affect future wetland loss rates over the project life, there is considerable uncertainty regarding the accuracy of the predicted river diversion benefits. However, the SAND2 model provides an objective means for comparing alternative measures and plans.

Utilizing the predicted FWOP wetland acreage as a basis, the SAND2 model calculates FWP benefits (in acres) via the accretion of suspended sediments (land building) together with the effects of nitrogen additions. The nitrogen benefits (in acres) are calculated as the grams of nitrogen required to produce a wetland acre multiplied by the grams of introduced nitrogen (less nitrogen lost to denitrification), which equals wetland acres restored/supported via introduced nitrogen.

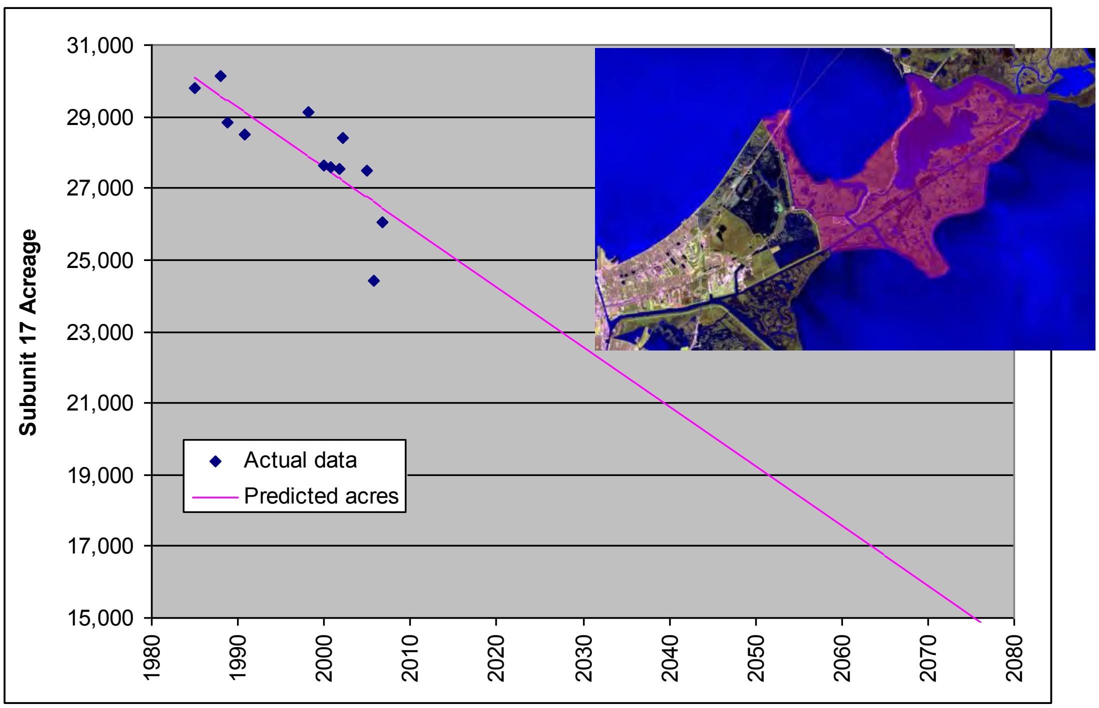


Figure 2-27. Actual and Predicted Acreage for Subunit 17.

Sustainability

The benefits analysis utilized for the MRGO Ecosystem Restoration Plan considers sustainability inherently. Because the WVA methodology utilizes historic land loss rates in the calculation of benefits, areas that have historically been more susceptible to risks such as tropical storms, subsidence, and sea level rise, will have fewer AAHUs than areas that have not been as susceptible to these factors. The SAND2 methodology accounts for the greater sustainability of features nourished by the freshwater diversion by assigning more AHHUs to features in the diversion influence area. Additionally, the WVA methodology assigns greater benefits to features that include natural vertical accretion than protection features like shoreline protection that require maintenance.

The initial WVA analysis was conducted for each feature individually and did not consider synergies with other restoration projects proposed as part of this plan. The initial WVAs did consider existing, authorized and planned projects that were included in the FWOP condition. The Violet, Louisiana Freshwater Diversion was assumed to be operational in 2015 in the analysis.

Costs

Preliminary costs were developed for measures remaining after initial screening. Material quantities were developed for each measure based on assumptions about existing land elevations, required containment dikes and interior weirs, access channels, borrow sources and shoreline protection sections. Further information on these assumptions can be found in the Engineering Appendix.

The preliminary cost estimates for the MRGO Ecosystem Restoration Plan Feasibility Study were prepared based on readily available New Orleans District data and quantities provided by Waterways Section, Civil Branch. The estimated costs were based upon an analysis of each line item evaluating quantity, production rate, and time, together with the appropriate equipment, labor, and material costs or the costs were based on in-house knowledge and experience by New Orleans District cost engineers who estimated similar projects. Cost Estimates were developed using historical data, CEDEP, and Mii estimating software.

The project consists of various combinations of marsh restoration, marsh nourishment, ridge restoration, swamp nourishment and shoreline protection. The marsh restoration, marsh nourishment, and swamp nourishment were constructed using typical dredge and fill techniques from nearby borrow sources such as interior bays, Lake Borgne, Lake Lery, Breton Sound, and the Mississippi River. It is anticipated that cutterhead pipeline dredges would excavate the native material and pump it to the project sites. The largest dredge that could do the work was typically chosen given the large quantities and long pump distances. Dredge size was limited by the available depth in the access route and the proposed borrow areas (24-inch to 30-inch dredge sizes assumed). Nourishment and restoration areas included earthen retention dikes, weirs, and earth and sheetpile closure structures as required. Given the remote locations of the projects, all work is assumed to be marine based. All materials for the shoreline protection alternatives will be delivered by barge. All features were estimated based on standard construction methods all of which are common to the New Orleans District and South Louisiana.

The estimates assumed access was available to proposed areas unless otherwise stated. Following preliminary planning, further investigations were made to verify accessibility assumptions. Each measure cost was developed independently and assumed equipment availability is not an issue. Contingencies of 20 to 30 percent were added to all cost estimates based on the level of uncertainty to produce conservative worst-case scenario costs for planning purposes while detailed engineering information was collected and analyzed. E&D of 4% and S&A of 6% were also added to each estimate. The initial costs developed for planning purposes reflected only construction costs and did not include real estate, OMRR&R, or adaptive management. Some costs changed when site specific geotechnical and survey data were applied. The cost-effectiveness of features was re-evaluated when detailed information became available. Costs were developed with October 2009 price levels using a four percent discount rate and 0.04655 amortization factor. The detailed cost-estimates did not significantly alter the cost-effectiveness of any plan feature.

Table 2-20 provides the costs and benefits generated for the formulation and analysis of plans.

Table 2-20. Measures Retained for Plan Formulation

Geographic Area	Measure Label	Total AAHU	Annual Cost*
E. Orleans Landbridge	010a	147	1,318,785
E. Orleans Landbridge	010b	578	7,610,542
E. Orleans Landbridge	011	156	648,743
E. Orleans Landbridge	007	89	1,889,288
E. Orleans Landbridge	009	500	2,385,457
E. Orleans Landbridge	005sp	74	758,201
E. Orleans Landbridge	006sp	77	958,944
E. Orleans Landbridge	007sp	188	3,012,971
E. Orleans Landbridge	090	15	330,464
S. Lake Borgne	028	84	1,236,516
S. Lake Borgne	014	832	5,911,103
S. Lake Borgne	015a	551	2,348,644
S. Lake Borgne	008sp	128	1,979,597
S. Lake Borgne	015c	569	1,965,753
S. Lake Borgne	030sp	7	130,898
S. Lake Borgne	Fill in MRGO[1]	1,932	159,995,564
MRGO Channel	099	0.01	143,223
MRGO Channel	100	0.02	813,422
MRGO Channel	024	22	1,400,723
MRGO Channel	021	20	340,306
MRGO Channel	022	20	326,590
MRGO Channel	025	7	175,561
MRGO Channel	027	32	1,770,019
MRGO Channel	026	40	2,736,228
MRGO Channel	087	5	316,098
MRGO Channel	104	3	104,483
Central Wetlands	025a	271	6,207,018
Central Wetlands	025b	134	3,283,973
Central Wetlands	026a	158	5,020,967
Central Wetlands	026b	303	2,856,953
Central Wetlands	026c	136	1,446,291
Central Wetlands	026d	33	1,350,766
Central Wetlands	026e	196	14,406,107
Central Wetlands	027a	369	7,055,378
Central Wetlands	027b	384	8,860,530
Biloxi	081	373	5,873,225
Biloxi	042	73	6,446,604
Biloxi	020	159	4,796,356

Table 2-20. Measures Retained for Plan Formulation			
Geographic Area	**Measure Label**	**Total AAHU**	**Annual Cost***
Biloxi	010sp[2]	100	1,397,042
Biloxi	011sp[2]	91	566,508
Biloxi	013sp[2]	179	2,639,700
Biloxi	014sp	142	4,414,464
Biloxi	98asp	66	2,171,273
Biloxi	98bsp	120	4,863,397
Biloxi	111sp	58	1,901,045
Biloxi	017sp	31	1,239,152
Biloxi	107sp	35	1,223,905
Biloxi	029asp[3]	137	2,084,680
Biloxi	110	130	4,994,804
Bayou La Loutre Ridge	133a	8	865,399
Bayou La Loutre Ridge	133a + 133b	14	1,510,834
Terre aux Boeufs	002a	358	2,266,837
Terre aux Boeufs	002b	823	9,815,257
Terre aux Boeufs	002c	552	5,087,244
Terre aux Boeufs	245	1,545	4,829,628
Terre aux Boeufs	243[4]	425	1,354,619
Terre aux Boeufs	244[4]	984	4,217,112
Terre aux Boeufs	241[4]	1,051	5,186,676
Terre aux Boeufs	242[4]	972	2,066,854
Florissant	191	12	1,576,410
Hopedale	190	186	2,054,465
Jetty Realignment	029bsp + 028[5]	232	3,392,549

Notes:

* October 2009

[1] Exclusive of other MRGO measures.
[2] Subsequently removed from consideration as the State of Louisiana is planning to build these features with surplus funds.
[3] Due to survey findings that water depths are infeasible for traditional foreshore protection, measure was changed to oyster reef restoration.
[4] Subsequently removed due to impacts to oyster reefs and seed grounds.
[5] Due to survey findings, this measure was removed from further consideration.

Relative Sea Level Rise Considerations

Potential increases in RSLR, as noted in the future without project conditions, could impact the costs and benefits developed for these features. These potential impacts and associated OMRR&R and/or adaptive management actions were assessed for all of the features retained for plan formulation. OMRR&R actions were calculated as part of the project costs. Additional adaptive management measures associated with increased RSLR scenarios were also incorporated into the project costs.

The first O&M event for brackish marsh was determined by the calendar year of predicted marsh collapse used in the WVA. Marsh collapse is when the observed condition of a defined area loses a significant amount of marsh through erosion or inundation resulting in a ‗collapse' where the remaining marsh is lost at an accelerated rate. For the MRGO Ecosystem Restoration study under the medium RSLR condition, the predicted marsh collapse in brackish marsh habitat occurs in calendar year 2058 (or target year 44). For OMRR&R, target year 39 (calendar year 2053) is used to precede the predicted marsh collapse event in target year 44 for brackish marsh.

The amount of marsh lost that would need to be replaced during an O&M event was calculated by taking the difference of the peak amount of marsh created and or nourished and the amount of marsh left in a particular target year. For brackish marsh habitat, the target year 39 is used. For swamp habitat, target year 35 is used.

The 50 year land loss totals for the MRGO restoration project were calculated by USFWS using the three levels of RSLR. The total amount of land remaining for any single project feature at the end of 50 years for the low RSLR is no less than 83%. The total amount of land remaining for any single project feature at the end of 50 years for the medium RSLR is no less than 69%. OMRR&R and adaptive management measures would address risks and uncertainties.

Under the high sea level rise rate, all wetland restoration features lose significant amounts of land, and all shoreline protection features would require significant adaptive management actions. The diminished output under the high RSLR scenario necessitates a systematic approach to assess and respond to the high RSLR. Sea level rise rates will be monitored in the pre-construction, construction, and post construction phases. Data will be evaluated at key decision points. An assessment of relative sea level rise trends would be made prior to partnership agreements, PED, construction award and any cost shared Adaptive Management actions. If at any time data indicate that the high level of RSLR is occurring, additional Federal investments in the plan would be re-assessed.

2.7.2 Cost Effectiveness/Incremental Cost Analysis

Cost effectiveness/Incremental Cost Analysis (CE/ICA) are two distinct analyses that must be conducted to evaluate the effects of alternative plans. First, it must be shown through cost effectiveness analysis that an alternative restoration plan's output cannot be produced more cost effectively by another alternative. ―Cost effective" means that, for a given level of non-monetary output, no other plan costs less, and no other plan yields more output for less money. Subsequently, through incremental cost analysis, a variety of implementable alternatives and various-sized alternatives are evaluated to arrive at a ―best" level of output within the limits of both the sponsor's and the Corps' capabilities.

The subset of cost effective plans are examined sequentially (by increasing scale and increment of output) to ascertain which plans are most efficient in the production of environmental benefits. Those most efficient plans are called ―Best Buys". They provide the greatest increase in output at the lowest average cost. ―Best Buys" have the lowest incremental costs per unit of output. In most analyses, there will be a series of Best Buy plans, in which the relationship between the quantity of outputs and the unit cost is evident. As the scale of Best Buy plans increases (in terms of output produced), average costs per unit of output and incremental costs per unit of output will increase as well. Usually, the incremental analysis by itself will not point to the selection of any single plan. The results of the incremental analysis must be synthesized with other decision-making criteria (for example, significance of outputs, completeness, effectiveness, acceptability, risk and uncertainty, reasonableness of costs) to support the selection and recommendation of a particular plan. The Corps' Institute for Water Resources (IWR) has developed procedures and software to assist in conducting CE/ICA. IWR-PLAN Decision Support Software was used to assist in performing CE/ICA for this study.

2.7.2.1 Minimum Planning Increment

Despite the use of AAHUs to describe the benefits for all habitat types, all AAHUs are not equivalent. The comparison of AAHU values across habitat types should be addressed qualitatively when planning in a systems-based context, because diverse habitats are needed to restore the function of the system as a whole. Additionally, ER 1105-2-100 notes that the concept of significance of outputs plays an especially important role in ecosystem restoration planning. Several measures were considered necessary components of a plan that addressed the study authority, considered the significance of ecosystem outputs, and adhered to the Guiding Principles developed for the study. A minimum planning increment was included in the plan formulation process to produce alternatives that would address the study authority and consider significance of outputs, completeness, effectiveness, and acceptability, prior to the evaluation of efficiency through CE/ICA analysis.

Cypress and Coastal Ridge Habitat

In an abstract evaluation of cost per AAHU, cypress and coastal ridge restoration measures are not as cost-effective as other types of measures. These restoration measures require more sediment and more time to achieve benefits than marsh restoration, and therefore have much higher costs compared to benefits. For example, if an existing site is at mean sea level, marsh restoration requires fill to be placed at a settled elevation of approximately 1.5 ft.; cypress swamp requires +2.0 ft; and ridge requires +8.0 ft. Therefore, swamp requires 33% more fill than marsh, and ridge requires 433% more fill than marsh, given the same site conditions. In addition, marsh restoration will be fully vegetated in a few years, whereas cypress and ridge require decades to mature.

Restoration of cypress and ridge habitat was considered necessary to fulfill the requirements of the study authority to ―restore the areas affected by the navigation channel," as documented in Habitat Impacts of the Construction of the MRGO and Louisiana Coastal Area Ecosystem Restoration Study (USACE 1999, 2004).

- The former navigation channel was cut through the Central Wetlands and the Bayou La Loutre ridge, directly impacting these areas.
- The Central Wetlands is the only area in the immediate vicinity of the MRGO that could support cypress swamp, a scarce habitat rich in biodiversity. Other locations are outside of the project area (Caernarvon) or far removed from the channel (LaBranche and Maurepas).

- The only remaining natural ridge in the immediate vicinity of the MRGO is the Bayou La Loutre ridge. This habitat is technically significant because of its scarcity, biodiversity, and function as a limiting habitat on which species of concern depend (Conner and Day 1988, Twedt and Portwood 1997, Barrow et al. 2000, USGS 2006, Barrow et al. 2006).

- Cypress swamp habitat is increasingly scarce and provides unique habitat and ecological functions, contributing to the technical significance of these resources (Lowery 1974, Conner and Toliver 1990, Messina and Conner 1998, Martin et al. 2002).

- The restoration of cypress swamp in the Central Wetlands is widely supported by the adjacent communities, NGOs, state and local government, and resource agencies, demonstrating its public significance (University of Wisconsin-Madison 2008 and 2009, SLFPA-E 2009, Day et al. 2006).

- The ecosystem services provided by these habitat types (e.g. avian and mammalian habitat) cannot be provided by other habitat types in the study area (Messina and Conner 1998, Barrow et al. 2000, USGS 2006, Barrow et al. 2006).

Cypress swamps and coastal ridge, once common habitats in the study area, are now increasingly scarce. In the immediate vicinity of the MRGO, 99% of cypress habitat has been converted to brackish marsh or open water since 1956 (USGS 2009). These habitats are technically significant because of their contribution to biodiversity; importance to species of concern; and contribution to the geographic form of the ecosystem. Cypress swamps provide critical nesting habitat for the bald eagle, the emblem of the United States. Fortunately, significant conservation actions have resulted in the removal of the bald eagle from the federally threatened species list. However, the national bird is protected by the Bald and Golden Eagle Protection Act of 1940, demonstrating the institutional significance of this species and its habitat. The institutional and public value of cypress swamps was recognized by the Louisiana government in 2005, when the findings of a technical task force that the state should ―place priority on conserving, restoring, and managing coastal wetland forests…to ensure that their functions and ecosystem services will be available to present and future citizens of Louisiana and the United States" were adopted (Chambers et al. 2005). Coastal forest habitats provide critical rookeries for seventeen species of wading birds that are known to regularly occur in Louisiana. Louisiana is believed to have the largest population of wading birds in the United States due to the biodiversity provided by its unique ecosystems (Fontenot and DeMay 2008) Millions of migratory birds depend upon Louisiana's coastal forests as wintering and stopover habitat (NWF 2011). The prothonotary warbler is one example of a species associated with cypress-tupelo stands that is listed as a Tier 1 priority species by Partners in Flight because of the dramatic loss of this habitat nationwide (Partners in Flight 2006). The cypress-tupelo forests of Louisiana are vital for the long-term survival of this, and many other, songbird species that use Louisiana's coastal wetland forests for breeding and/or wintering habitat (Lowery, 1974). The coastal forests of the study area are included as ―Important Bird Areas" designated by the Audubon Society as critical breeding, wintering, and stopover habitat for birds of conservation concern (Audubon 2011). The Important Bird Areas Program relies heavily on volunteer efforts, and citizen participation in state-wide data collection efforts such as Christmas Bird Counts, Breeding Bird Surveys, and the Louisiana Winter Bird Atlas demonstrates the public significance of these species and their habitat.

The restoration of these habitats was integral to the development of a complete, effective, efficient, and acceptable plan. By definition, the most effective and efficient plan would fully achieve the target objective. Therefore, IWR-PLAN formulation was developed to produce plans that include features to achieve these objectives. As the ridge habitat does not have a specified acreage amount, two scales of ridge restoration were developed, and the smaller feature closest to the channel was selected for inclusion in the minimum planning increment. Abstractly, any amount of ridge habitat would satisfy the objective. However, a smaller ridge restoration project would be less sustainable than the two scales of ridge restoration developed. The first increment of ridge that is included in the minimum planning increment starts at the restored hydrologic barrier created by the MRGO rock closure and extends to an existing canal. While this increment does not fully restore the ecological, hydrologic, surge reduction, and geographic functions of the historic Bayou La Loutre ridge, the feature was developed between two logical termini to produce a plan component with independent utility.

The addition of these features in a minimum planning increment provides 10,318 acres of cypress swamp restoration and 54 acres of ridge restoration, at a cost of approximately $845 million (October 2011 Price Levels).

Recommendations for MRGO Channel

Similarly, the inclusion of some features in the MRGO is required to address the LCA Near-Term Project described in Section 7006 (c)(1)(A) and the portion of the 7013 authority requiring ~~a~~ plan to physically modify the Mississippi River-Gulf Outlet", despite the relative cost-effectiveness of these features.

Bank reclamation and stabilization along the MRGO is important to prevent the further confluence of the MRGO and Lake Borgne and to maintain the MRGO/Lake Borgne Landbridge. A plan that did not include features in the MRGO would likely be unacceptable to the public and did not appear to meet the Congressional intent of the study. Stabilization of the MRGO banks would preserve estuarine wetlands and important structural features of the lake and marsh landscape. The MRGO features would prevent future land loss and restore previously degraded wetlands; stabilize and restore the endangered, critical Lake Borgne rim geomorphic structure; and protect vital socioeconomic resources, such as communities located adjacent to the MRGO.

The Lake Borgne estuarine complex is deteriorating and recent analysis indicates that the rate of wetland loss in the area is accelerating. Rapid action is required to protect the integrity of the southern Lake Borgne shoreline and to prevent continued erosion of the MRGO channel banks. Without action, critical landscape components that make up the Lake Borgne estuary would be lost and future efforts to restore other parts of the ecosystem would be much more difficult and expensive if not impossible.

The following previous studies have described the need for bank stabilization along the MRGO:

- EA #47, MRGO Foreshore Protection (1985); MRGO St. Bernard Parish, Louisiana, Reconnaissance Report (1988)
- EA #72, MRGO Breton Sound Jetty Repairs (1988)
- EA #152, MRGO St. Bernard Parish, LA, Bank Stabilization, Miles 50.5 to 55.0 (1991)
- EA #162, Mississippi River – Gulf Outlet, St. Bernard and Plaquemines Parishes, LA – Marsh Enhancement/Creation and Berm Construction (1992)
- EA #244, MRGO Back Dike (CWPPRA), Disposal Area Marsh Protection, Back Dike (1996)
- EA #247, MRGO St. Bernard Parish, LA, Bank Stabilization Miles 55.0 to 56.1 (1996); MRGO North Bank Foreshore Protection Evaluation (1996)
- EA #255, MRGO, LA, Wetland Creation, Miles 15.0 to 23.0, St. Bernard and Plaquemines Parish, LA (1997)
- EA #269, MRGO, LA, South of Lake Borgne Additional Disposal Areas, St. Bernard Parish, LA (1998)
- EA #274, MRGO, Additional Disposal Areas, Hopedale Marshes (1998)
- Coast 2050: Toward a Sustainable Coastal Louisiana (1998)
- EA #288, MRGO Mile 43 to Mile 41 North Bank Stabilization, St. Bernard Parish, LA (1999)
- EA #269-B, MRGO, South of Lake Borgne Additional Disposal Areas plus Deflection Dike and Floatation Channels, St. Bernard Parish, LA (2000)
- EA #277, MRGO, LA, Shell Beach Disposal Areas, St. Bernard Parish, LA (2001)
- MRGO Reevaluation Study (2002)
- EA #349, MRGO, Miles 32-27, Additional Disposal Areas – Hopedale Marshes, St. Bernard Parish, LA (2002)
- EA #355, MRGO Mile 27.0 to 0 (2003)
- EA #361, MRGO, LA, Test Installation of Articulated Concrete Mattressing, Miles 39.0 to 38.0 (2003)
- Lake Borgne and MRGO Shoreline Protection between Doulluts Canal and Lena Lagoon (CWPPRA 2003)
- EA #354, MRGO, Additional Disposal Area Designation Miles 66.0 to 49.0, St. Bernard Parish, LA (2004)
- EA #402Lake Borgne – MRGO, Shoreline Protection Project, St. Bernard Parish, LA (2004)
- EA #403 MRGO, Hopper Dredging Miles 27.0 To 66.0 (2004)
- EA #411, MRGO, Installation of Articulated Concrete Mattressing, Miles 37.4 to 36.5, St. Bernard Parish, Louisiana (2004)
- Ecological Review, Lake Borgne and MRGO Shoreline Protection (2005)
- LCA (2005)
- Louisiana Coastal Impact Assistance Program (2006)
- Environmental Assessment for the Lake Borgne Shoreline Protection Project (2006)
- LACPR (2006)
- Integrated Ecosystem Restoration and Hurricane Protection: Louisiana's Comprehensive Master Plan for a Sustainable Coast (2007)

Bank stabilization in the MRGO was identified as a critical near-term need in the LCA report. The implementation guidance for the MRGO Ecosystem Restoration Plan states that the Section 7006 project “shall be held in abeyance until the tentatively selected plan for ecosystem restoration, authorized by Section 7013 of WRDA 2007, is identified.” The implementation guidance also states that the feasibility report and EIS for Section 7013 of WRDA 2007 will include recommendations regarding the Section 7006 project.

Shoreline protection features on the south shore of the MRGO were determined to have limited ecosystem restoration benefits because the areas protected are levees or spoil banks. Maintenance of shoreline protection features adjacent to levees will be conducted as needed as part of levee maintenance. Channel back-filling measures were determined to be among the least cost effective features evaluated in the plan, due to the depth of the MRGO and the amount of sediment required. Maintenance of existing shoreline protection features and channel narrowing features on the north shore of the channel produced more habitat benefits and were more cost effective than other features proposed in the MRGO. However, when compared to features in other areas, the MRGO features were less cost-effective.

Although the MRGO features were determined to be less cost-effective than other restoration features considered, it was determined that the most cost-effective MRGO features should be included in the recommendations for this study. The inclusion of the most cost effective MRGO features in the recommendations for the study serves to “integrate the recommendations of the report with the program authorized under section 7003” as noted in the study authority.

Maintaining existing bank stabilization features along the north shore of the MRGO are the lowest cost features evaluated for this study. Maintenance of these features has ceased since the deauthorization of the channel. At this time, these features will not be maintained unless a non-federal sponsor is identified and funds are appropriated for implementation of these features. These features are less cost effective than other shoreline protection features because of the way WVA benefits are calculated. Because there are existing bank stabilization features in these locations, the projected erosion and land loss is less than in areas where there is no existing shoreline protection. Benefits are calculated by comparing the future without project condition to the future with project condition; therefore, maintenance of existing structures produces fewer benefits than construction of new features, despite the increased costs. Existing shoreline protection features in the MRGO are anticipated to become submerged within the period of analysis if they are not maintained. A first maintenance event for the existing foreshore protection in the MRGO was added to all of the alternatives in the final array to maintain the existing bankline and prevent land loss along the MRGO/Lake Borgne Landbridge. Any subsequent OMRR&R would be the non-Federal sponsor‘s responsibility. In addition, new shoreline protection is proposed for the area south of Bayou La Loutre in the vicinity of the closure structure and three channel narrowing features are proposed as part of the final array of alternatives.

Protection and restoration of the south Lake Borgne/MRGO landbridge is technically and institutionally significant because these wetlands are specifically targeted for protection and restoration in WRDA 2007 Section 7006 and 7013 and the documents cited above. These features are also publicly significant as demonstrated by significant public comment to restore the area to a pre-construction condition; the actions and publications of the MRGO Must Go

Coalition; and Louisiana House Concurrent Resolution 34 (2005) to ―…direct the United States Army Corps of Engineers not to engage in any dredging activities on the Mississippi River Gulf Outlet, and to begin the necessary process to return the waterway to wetlands marsh status as close as possible to what it was prior to establishment of the canal.”

The most cost-effective measures for the MRGO were included in all plans in the final array. These seven measures provide 26.5 miles of shoreline protection and restore and protect 1,171 acres of intermediate marsh at a cost of approximately $120 million (October 2011 Price Levels). An additional increment provides 6 miles of shoreline protection using vinyl sheetpile wall for bank reclamation and containment for fill to restore and protect 360 acres of intermediate marsh at a cost of approximately $53 million (October 2011 Price Levels).

Violet, Louisiana Freshwater Diversion

Alternatives that did not include a freshwater diversion were considered in the initial development of alternatives. These alternatives were ultimately eliminated from further study as inconsistent with the study goals and objectives and the ―Guiding Principles”. A small freshwater diversion would not mimic periodic overbank flooding of the Mississippi River, a key process of the estuary that preliminary analyses indicate is needed to fully re-establish historic salinity gradients, habitat types, and increase self-sustainability in the system.

The Violet, Louisiana Freshwater Diversion is technically significant because the man-made separation of the Mississippi River from the wetlands has decreased biodiversity and increased the scarcity of native marsh habitats. These effects were exacerbated by the construction of the MRGO and the resultant saltwater intrusion (USACE 1999). A freshwater diversion would restore this connection and increase marsh productivity and vertical accretion (DeLaune et al. 2003).

The Violet, Louisiana Freshwater Diversion is institutionally significant because it is included in federal, state and local plans (Louisiana Master Plan, CIAP, and CWPPRA). The public significance of the diversion is demonstrated by support from regional NGOs (LPBF 2006b, Day et al. 2006, Lopez et al. 2010).

Violet, Louisiana Freshwater Diversion Recommendations

The restoration of historic salinity conditions is a key system driver. The Violet, Louisiana Freshwater Diversion, as authorized for design and implementation in WRDA 2007 Section 3083, would fully restore salinity conditions, mimic natural processes, and enhance the sustainability of the system through the input of freshwater, nutrients and sediment. Full restoration of historic habitat types in the area is dependent upon salinity conditions.

Additional study is needed to improve decisions about where, when, and how to divert Mississippi River flows in a systems context. The ongoing Mississippi River Hydrodynamic and Delta Management Study will evaluate ecosystem restoration alternatives in concert with dynamic flood risk management and navigation; multipurpose management scenarios of the river; and dynamic conditions in a comprehensive systems context. The information gained from this study will improve decision-making for the Violet, Louisiana Freshwater Diversion. Therefore, the final recommendations for the MRGO Ecosystem Restoration Plan include additional analysis, design and implementation of the Violet, Louisiana Freshwater Diversion as authorized by WRDA 2007 Section 3083.

Summary of Minimum Planning Increment

The following measures were included as a minimum increment for further plan formulation.

- 10,318 acres of cypress swamp restoration and 54 acres of ridge restoration at a cost of approximately $845 million (October 2011 Price Levels).
- Seven MRGO measures that provide 18 miles of shoreline protection and restore and protect 764 acres of intermediate marsh at a cost of approximately $120 million (October 2011 Price Levels). An additional increment provides 6 miles of shoreline protection using vinyl sheetpile wall for bank reclamation and containment for fill to restore and protect 360 acres of intermediate marsh at a cost of approximately $53 million (October 2011 Price Levels).
- The Violet, Louisiana Freshwater Diversion to restore and maintain the salinity regime of the estuary, mimic natural historic processes, and increase the sustainability of the area.

These measures are considered critical for the formulation of a plan that addresses the study authority and achieves the goals and objectives. These features are the basis for the formulation of a complete, effective, efficient, and acceptable plan through the CE/ICA process.

IWR-PLAN Steps

The Corps' Institute for Water Resources (IWR) has developed procedures and software to assist in conducting CE/ICA. IWR-PLAN Decision Support Software was used to assist in performing CE/ICA. Given the computational limitations of the IWR-PLAN software, the over 50 individual measures could not be run in IWR-PLAN simultaneously (all measures are combinable). Therefore, separate runs were made in each major geographic area to limit the number of possible combinations.

Some scale of restoration in these geographic areas was considered necessary to address the study authority to ―restore the areas affected by the navigation channel" and ―restore natural features of the ecosystem that will reduce or prevent damage from storm surge."

The Biloxi Marsh geographic area consists of Subunits 07 - Biloxi Marshes Interior, and 18 - Eloi Bay. These subunits compose a unique geomorphologic feature that has been identified as a critical landscape feature for storm surge damage risk reduction and is technically significant, in terms of scarcity and connectivity, as a geologic barrier for storm surge reduction (USGS 1994, USACE 2009, Walmsley et al. 2009, Howes et al. 2010, Shepard et al. 2011). The Biloxi Marsh also supports oyster reef habitat, which is arguably the most imperiled marine habitat on earth (Beck et al. 2011). This area is institutionally significant because it is protected by significant legislation promoting the conservation of the nation's wetlands and estuaries in general, and the significance of the Gulf of Mexico ecosystem as recognized by President Obama's administration in particular (EPA et al. 2011). This area is publically significant because of its recreational value and importance as an area that can potentially reduce the loss of life and property due to flooding" (Burkett et al. 2002). The primary problems in this area are the lack of freshwater and sediment, and wind driven shoreline erosion. Unlike other subunits, this area has relatively low subsidence rates due to its unique geomorphology. The Bayou La Loutre Ridge is located in the Biloxi Marsh subarea; however, because it was determined that some scale of ridge needed to be included in the plan, these restoration features were evaluated in IWR-PLAN separately.

The East Orleans/South Lake Borgne geographic area is composed of Subunits 36a - Pearl River Mouth – LA, 17 - East Orleans Landbridge, 05 - Bayou Sauvage, 40 - South Lake Borgne and 26 - Lake Borgne. Subunits 36a, 17, and 05 form the East Orleans Landbridge area. This area is recognized as a critical landscape feature with respect to storm surge damage risk reduction (USGS 1994, USACE 2009, Walmsley et al. 2009, Howes et al. 2010, Shepard et al. 2011). Subunit 40 - South Lake Borgne covers the MRGO/Lake Borgne Landbridge, the strip of marsh separating the MRGO from the lake. The spatial integrity of the MRGO/Lake Borgne Landbridge was compromised by the construction of the channel. South Lake Borgne is considered a critical landscape feature to protect the form and function of the estuary, which is recognized as an institutionally significant resource by President Obama's administration. These subunits were grouped together because the areas are contiguous and create a structural framework for the estuary. This landscape feature is publically important because of its role in the potential reduction loss of life and property due to flooding and recreational value. There are numerous state, local, and NGO plans for restoration that demonstrate this significance (LPBF 2006, Lopez 2006, Day et al. 2006, Lopez et al. 2010). Because these areas are important to the overall integrity of the estuary, IWR-PLAN was used to facilitate the development of the most cost-effective combination of measures for all components of the area.

The Terre aux Boeufs/Hopedale geographic area is composed of Subunits 23 - Jean Louis Robin, and 21 - Hopedale. These subunits are south of the MRGO and have been primarily affected by the channel through the placement of spoil material and hydrologic changes. Bayou Terre aux Boeufs forms the boundary of Subunit 23, and is considered to be the southeast boundary of the hydrologic impacts of the channel. This area is technically significant because it contributes to the spatial integrity of the ecosystem (USGS 1994, USACE 2009, Walmsley et al. 2009, Howes et al. 2010, Shepard et al. 2011). This area also supports imperiled oyster reef habitat (Beck et al. 2011). The significant legislation protecting estuarine and wetland resources, President Obama's and previous Presidential administration's commitments to this ecosystem demonstrate it is an institutionally important resource. The area's public importance is recognized by its inclusion in several Federal, state, and local restoration plans.

The Central Wetlands (Subunit 13) is isolated from the rest of the study area by levees and floodgates, and was considered a separate geographic area for this reason. Additionally, the Central Wetlands presents a unique set of problems and opportunities because of its proximity to the Mississippi River and the containment provided by the levees. Similarly, Florissant (Subunit 19) is isolated from other portions of the study area, and was evaluated separately.

The restoration of the Central Wetlands is important to achieve the goals and objectives of this study because of the magnitude of the effects of the channel in this area and the significant resources it historically supported. The channel was excavated and spoil material was placed on the northeastern border of this subunit. Saltwater intrusion resulted in the mortality of the remaining cypress forest and fresh marsh in the area. Fresh marsh is ranked as imperiled by the Louisiana Natural Heritage Program because it has undergone the largest reduction in acreage of any of the marsh types in the state over the past 20 years due to saltwater intrusion, demonstrating its technical, institutional and public significance (LDWF 2011).

The following describes the steps that were taken to identify the most cost efficient plans.

Step 1 –CE/ICA were run in IWR-PLAN for each of the following geographic areas:

1. **Biloxi Marsh** (3 marsh areas; 10 shoreline segments)
2. **MRGO Channel** (8 narrowing/shoreline features)
3. **East Orleans/South Lake Borgne** (9 marsh areas; 4 shoreline segments; SAV measure)
4. **Terre aux Boeufs/Hopedale** (5 marsh areas and 1 shoreline protection feature)

Step 2 – The incremental cost box graphs (incremental cost per unit vs. output) for the above areas were evaluated and a subset of Best Buy plans for each geographic area were selected to run as scales in a combined IWR run. Scales were selected as follows:

- **Minimum scales** – Selected Best Buy plans containing at least two or more measures. The Best Buy plan containing only one measure was not selected as a scale because it would not produce a complete, effective, or acceptable plan for a geographic area.
- **Intermediate scales** – Selected one or more Best Buy plans based on cost effective increments, i.e. where high outputs could be gained for minimal additional cost.
- **Maximum scales** – To develop the full cost effectiveness curve, always selected the largest Best Buy Plan, i.e. the plan that contained all measures in that group.

Step 3 – Repeated the CE/ICA using scales of alternatives as described below:

- **Biloxi Marsh** – 4 scales selected based on Steps 1 and 2.
- **MRGO Channel** – 5 scales based on Steps 1 and 2; in addition, backfilling in the MRGO channel between Bayou Bienvenue and Bayou La Loutre was added as a scale for a total of 6 scales. MRGO 1-7 was included in the minimum planning increment.
- **East Orleans/South Lake Borgne** – 5 scales based on Steps 1 and 2.
- **Terre aux Boeufs/Hopedale** – 3 scales based on Steps 1 and 2.
- **Ridge** – Partial ridge vs. full ridge – 2 scales. The partial ridge was included in the minimum planning increment.

- **Florissant** – 1 scale.
- **Central Wetlands** – Swamp only vs. swamp plus marsh – 2 scales.

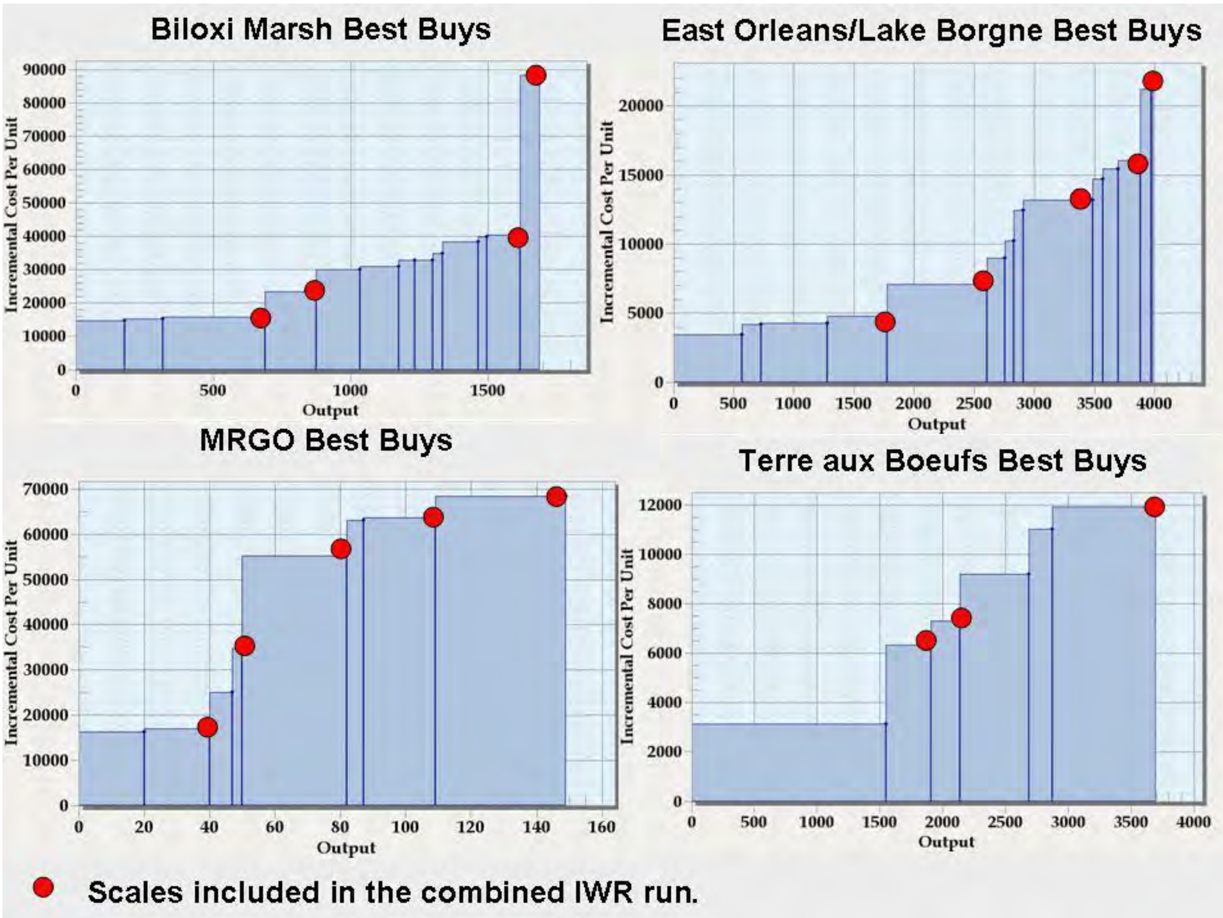
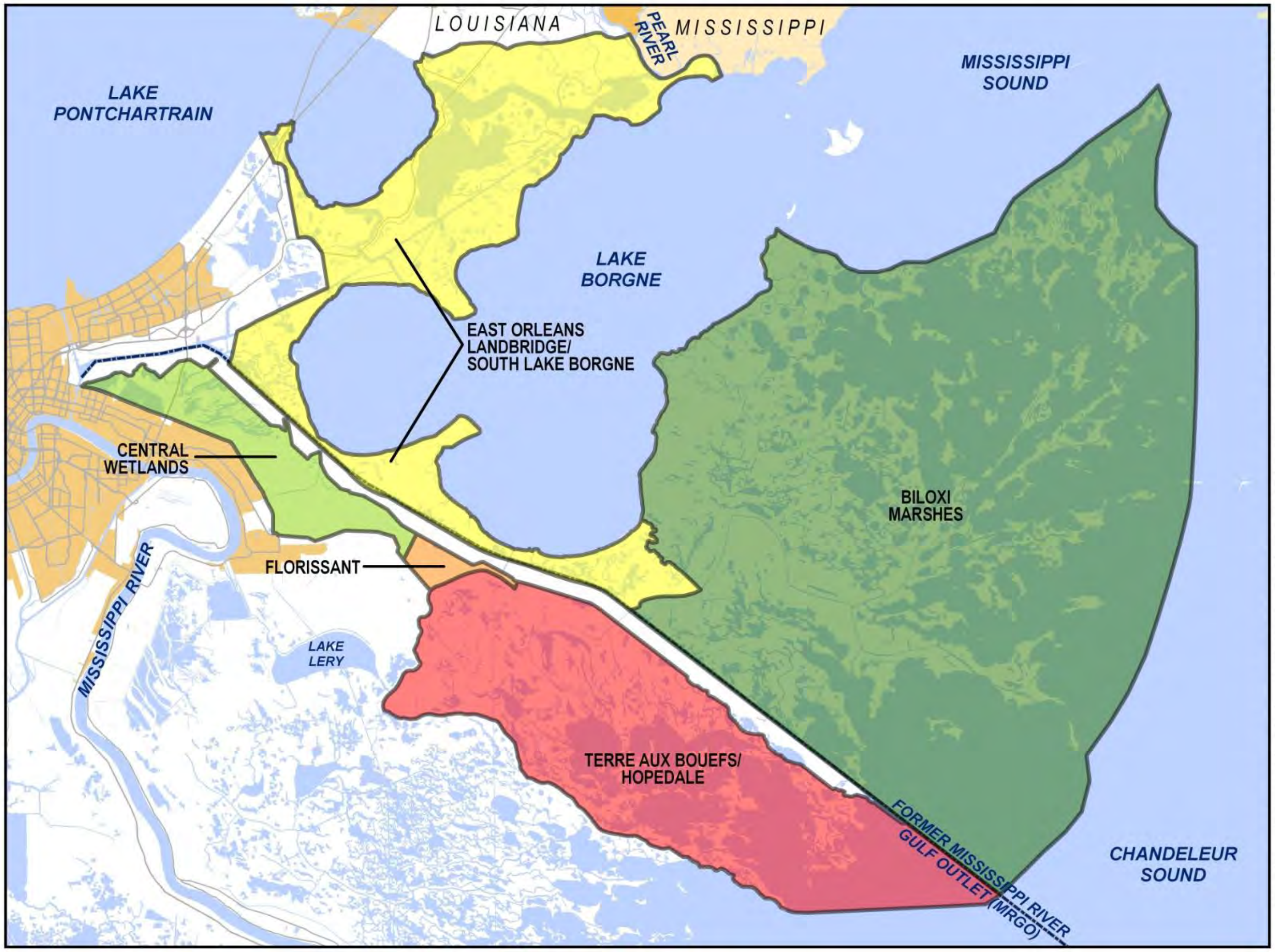


Figure 2-28. Sub-Area Best Buys

MISSISSIPPI RIVER GULF OUTLET (MRGO) ECOSYSTEM RESTORATION PLAN

Geographic Sub-Areas



The Corps' Institute for Water Resources (IWR) has developed procedures and software to assist in conducting Cost-Effectiveness/ Incremental Cost Analyses (CE/ICA). The IWR-PLAN Decision Support Software was used to assist in performing CE/ICA. Given the computational limitations of the IWR Plan software, not all of the individual measures could be run simultaneously (all measures are combinable). Therefore, separate runs were made in each major geographic area to limit the number of possible combinations.

The Biloxi Marsh area is a unique geomorphologic feature that has been identified as a critical landscape feature for storm surge damage risk reduction.

The East Orleans/South Lake Borgne geographic area is a critical area in need of restoration. The East Orleans Landbridge is recognized as a critical landscape feature with respect to storm surge damage risk reduction in LACPR. South Lake Borgne covers the MRGO/ Lake Borgne Landbridge, the strip of marsh separating the MRGO from the lake. South Lake Borgne is considered a critical landscape feature to protect the form and function of the estuary. These subunits were grouped together because the areas are contiguous and considered critical geomorphologic features.

The Terre aux Bouefs/Hopedale geographic area is south of the MRGO and have been primarily affected by the channel through the placement of spoil material and hydrologic changes.

The Central Wetlands is isolated from the rest of the study area by levees, and was considered a separate geographic area for this reason. Additionally, the Central Wetlands presents a unique set of problems and opportunities because of its proximity to the Mississippi River and the containment provided by the levees.

Similarly, the Florissant area (Subunit 19) is isolated from other portions of the study area, and was therefore evaluated in separately.

Miles 0 2.5 5

Figure 2-29. Geographic Subareas

All solutions were combinable. In Step 3 of the CE/ICA each plan was required to contain at least one scale of ridge, and one scale of Central Wetlands.

As noted previously, one limitation of the WVA model is that all habitat types are considered to have equal value. In an abstract evaluation of cost per AAHU, the restoration measures proposed for the Central Wetlands and the Bayou La Loutre ridge were not as effective as many of the measures. However, the inclusion of some restoration measure in these areas, as well as the MRGO channel, is considered necessary to fulfill the requirements of the study authority.

- The former navigation channel was cut through the Central Wetlands and the Bayou La Loutre ridge, directly impacting these areas.
- The Central Wetlands is the only area in the immediate vicinity of the MRGO that could support cypress swamp habitat.
- The Bayou La Loutre ridge is the only natural ridge in the immediate vicinity of the MRGO.
- Cypress swamp and coastal ridge habitat are increasingly scarce and provide unique habitat and ecological functions.
- The restoration of cypress swamp in the Central Wetlands is widely supported by the adjacent communities, NGOs, state and local government, and resource agencies.

The inclusion of some scale of restoration in these areas was integral to development of the plan. This constraint was added to the IWR-PLAN formulation process to ensure production of a wide range of alternatives meeting the study objectives.

IWR-PLAN Results

IWR-PLAN software generated 6,721 plan combinations. Including the No Action plan, there were 285 cost-effective plans and 19 Best Buy plans ranging in costs up to $6.5 billion (October 2009 Price Levels). A summary of the costs and benefits associated with the plans generated in IWR-PLAN is provided in Table 2-21.

The Best Buy plans that were generated in IWR-PLAN addressed the study goals and objectives of the study in varying degrees. The plans included for further consideration should be selected from the Best Buy plans, as all of these plans maximize restoration benefits for the associated costs. These plans are summarized in Table 2-22.

Table 2-21. Best Buy Plans

Plan#	Output (HU)	Annual Cost	Average Cost($/HU)	Incremental Cost ($)	Incremental Output (AAHU)	Incremental Cost per Output
1	0.00	0.00				
2	6,132	65,660,087	10,708	65,660,087	6,132	10,708
3	7,693	82,617,053	10,739	16,956,966	1,561	10,863
4	8,569	93,263,525	10,884	10,646,472	876	12,154
5	9,173	101,670,185	11,084	8,406,660	604	13,918
6	9,862	112,267,790	11,384	10,597,605	689	15,381
7	10,262	118,496,874	11,547	6,229,084	400	15,573
8	10,302	119,163,770	11,567	666,896	40	16,672
9	10,406	121,383,522	11,665	2,219,752	104	21,344
10	10,591	125,718,961	11,870	4,335,439	185	23,435
11	10,601	125,999,005	11,886	280,044	10	28,004
12	11,342	151,603,401	13,367	25,604,396	741	34,554
13	11,374	153,373,420	13,485	1,770,019	32	55,313
14	11,401	155,090,241	13,603	1,716,821	27	63,586
15	11,441	157,826,469	13,795	2,736,228	40	68,406
16	13,224	310,652,025	23,492	152,825,556	1,783	85,713
17	13,297	317,098,629	23,847	6,446,604	73	88,310
18	13,303	317,744,064	23,885	645,435	6	107,573
19	13,315	319,320,474	23,982	1,576,410	12	131,368
Note: Costs are October 2009 Price Levels						

Table 2-22. Best Buy Plan Descriptions

Best Buy	Description
1	No action.
2	Central Wetlands: Cypress measures CC1-CC6 and Violet, Louisiana Freshwater Diversion South Lake Borgne: LM1-3 East Orleans Landbridge: EM1 and 2 MRGO: MRGO 1-7 Biloxi Marsh: BR1 Bayou Terre aux Boeufs: TM1-2, JS1 (later determined to be infeasible due to water depths)
3	BB2 plus TM7, TM8, HM1
4	BB3 plus EM3 and 4, ES1 and 2
5	BB4 plus CM1-5
6	BB5 plus BM1, BS1, BS2
7	BB6 plus LM4, ES3, LS1
8	BB7 plus MRGO1-2 (later included in all action plans)
9	BB8 plus EM5, EV1
10	BB9 plus BS3
11	BB10 plus MRGO3-4 (later included in all action plans)
12	BB11 plus additional shoreline protection in Biloxi Marsh
13	BB12 plus MRGO5 (later included in all action plans)
14	BB13 plus MRGO6-7 (later included in all action plans)
15	BB14 plus MRGO8 (later included in Plans C and D)
16	BB15 plus backfilling MRGO to marsh elevation from Bayou Bienvenue to Bayou La Loutre
17	BB16 plus additional shoreline protection in the Biloxi Marsh
18	BB17 plus additional ridge restoration

Table 2-22. Best Buy Plan Descriptions

Best Buy	Description
19	BB18 plus Florissant

2.7.3 Selection of the Final Array of Alternatives

In the cost effectiveness/incremental cost analysis described in the previous section, measures were combined into alternatives and evaluated based solely on costs and outputs. In order to select a final array of alternatives from the 19 Best Buy plans, the following additional considerations were synthesized into the decision making process:

- Environmental Planning Guiding Principles
- Significance of Outputs
- Risk and Uncertainty
- Four Planning Criteria (completeness, efficiency, effectiveness, acceptability,)

The following sections describe how these principles and criteria were used to select plans to carry forward into the final array of alternatives for further analysis.

Environmental Planning Guiding Principles

All plans address the plan formulation guiding principles. The differences between the plans are a matter of scale. Consequently, the degree to which each plan follows the guiding principles is generally also a matter of scale.

Principle 1 - Relatively intact estuarine ecosystems are a key attribute in coastal Louisiana, and alternatives should seek to enhance the resilience and self-sustainability of the estuarine environments, including protection of existing high-quality estuaries.

Because all of the plans include the Violet, Louisiana Freshwater Diversion, all plans enhance the resilience and self-sustainability of the estuary. However, the plans vary in their ability to protect, maintain and restore the form of the ecosystem. Plans that do not provide extensive protection and restoration on the East Orleans Landbridge, Biloxi Marsh, and the MRGO/Lake Borgne Landbridge (Plans #2 to #5) may not contain all of the features needed to maintain and restore the form and function of the estuary, an institutionally significant resource recognized by the Estuary Protection Act. The need to protect existing high quality estuaries is better addressed by Plans #6 to #19, which include increasing scales of restoration and protection in these areas. Plans #16 to #19 include backfilling portions of the MRGO channel, and better address the need for an intact system and restoration to historic conditions.

Principle 2 - Restoration of key processes and dynamics are critical to the long-term health of the ecosystem.

The Violet, Louisiana Freshwater Diversion restores a key process of the estuary and is a component of every plan. However, the plans vary in the extent they restore biodiversity and promote accretion through sediment placement, vegetative planting, and shoreline protection.

Plans #2 to #11 provide incremental scales of marsh restoration and shoreline protection features that would promote accretion and restore biodiversity. Plans #12 to #15 do not increase marsh restoration, although additional shoreline protection features would help protect existing vegetation. Plans #16 to #19 incrementally increase the amount of marsh restored, with Plan #19 providing the greatest amount of restoration.

Principle 3 - Measures and alternatives must seek to maximize the combined benefits of diversions that seek to restore natural processes with mechanical marsh creation measures.

All plans seek to maximize the combined benefits of diversions. However, plans that include the most restoration features in the area benefitted by the diversion (Plans #7 to #19) better address the goal of combining the benefits of diversions with mechanical marsh creation measures. Plan #7 is the first plan to include all of the proposed marsh restoration features in the immediate influence area of the diversion (Central Wetlands, Golden Triangle, MRGO/Lake Borgne Landbridge, and areas adjacent to Lake Borgne and Mississippi Sound) with the exception of backfilling portions of the MRGO channel. Plans #16 to #19 would maximize the amount of marsh benefitted by the diversion by including these measures.

Principle 4 - Additional sources of sediments should be sought where feasible; recognizing that such measures should not contribute to ecosystem degradation in the source area.

All of the plans require significant amounts of sediments to restore and nourish sediment-deprived marsh. Alternative sediment sources were considered and are discussed in Section 2.5.3.2. The smaller plans better address this principle because the potential for environmental damage from obtaining and/or transporting borrow material is on a smaller scale than the larger plans. However, the potential adverse environmental impacts associated with obtaining and transporting borrow material must be considered in context with the long-term benefits associated with these actions.

Principle 5 - Measures should be combined synergistically to maximize possible cumulative benefits. Thus, the position of features within the landscape has a direct influence on the potential benefits derived.

Plans #2 to #5 work synergistically over the areas that they include, but do not include any features in the Biloxi Marsh. Therefore, they do not address restoration in a critical landscape feature necessary to maintain the form and function of the overall ecosystem. These plans do not capitalize on existing and planned foreshore protection measures. Plan #6 does not include measures ES3 and LM1, which are key pieces in a comprehensive shoreline protection plan for Lake Borgne. Plan #7 is a cohesive plan that reasonably maximizes cumulative benefits. Plans #8 to #19 continue to incrementally increase the potential for cumulative benefits; however, the incremental benefits associated with Plans #8 to #15 are minor. Plan #16, which is the first plan to include backfilling portions of the MRGO, maximizes the potential for synergistic benefits.

Principle 6 - Flexibility is required in project design and implementation to permit adaptive management as conditions change and more is learned.

All of the 19 Best Buy plans include plans for the Violet, Louisiana Freshwater Diversion, which offers the greatest opportunity for continued adaptive management.

Principle 7 - A concerted monitoring and adaptive management program should be a component of the restoration plan.

All of the plans would include a concerted monitoring and adaptive management plan.

Significance of Outputs

All of the action plans would protect and restore significant resources. The institutional significance of these resources is demonstrated by the Coastal Barrier Resources Act of 1982; Coastal Zone Management Act of 1972; Emergency Wetlands Resources Act of 1986; Estuary Protection Act of 1968; Fish and Wildlife Conservation Act of 1980; the Fish and Wildlife Coordination Act of 1958, as amended; Migratory Bird Conservation Act; Migratory Bird Treaty Act (MBTA); Endangered Species Act of 1973; Magnuson-Stevens Fishery Conservation and Management Act of 1976, as amended; Bald and Golden Eagle Protection Act of 1940; NEPA of 1969; the North American Wetlands Conservation Act; the Water Resources Development Acts of 1976, 1986, 1990, 1992, and 2007; Clean Water Act; EO 11990 Protection of Wetlands; and EO 13186 Migratory Bird Habitat Protection. The Obama administration‘s commitment to the restoration of the study area, as evidenced by the creation of the Louisiana-Mississippi Gulf Coast Ecosystem Restoration Working Group, and the area‘s designation as an ecosystem of national importance in *Clean Water: A Foundation of Healthy Communities and a Healthy Environment* further exemplifies the institutional significance of the ecosystem (EPA et al. 2011).

The resources of the area are also technically significant because of the uniqueness of the ecosystem, scarcity of the habitats that comprise the system, species richness and biodiversity produced by the system, and the area‘s importance to species of concern. Louisiana is losing land at an alarming rate between 20 and 50 square miles a year (USGS 1995, USGS 2011). Approximately 1,900 square miles of coastal habitat was lost between 1932 and 2010 (USGS 2011). The vegetative communities that would be restored by any of the action plans provide protection against substrate erosion and contribute food and structure for cover, nesting, and nursery habitat for wildlife and fish. Continued degradation and loss of existing areas, along with truncation of replenishing processes, will accelerate decline in the interdependent processes of plant production and vertical maintenance necessary for a stable ecosystem.

Coastal habitats are publicly significant because of the high priority that the public places on their aesthetic, ecological, recreational, and cultural value. The involvement of national, state, and local NGOs in restoration efforts demonstrates the public significance of these resources. The National Audubon Society, the Nature Conservancy, National Wildlife Federation and Ducks Unlimited are examples of national organizations actively involved in area restoration. Several regional and local NGOs are concerned with the restoration of the study area, including: the America's Wetland Foundation, Louisiana Environmental Action Network and Parishes Against Coastal Erosion. The MRGO Must Go Coalition was founded in 2006 ~~to~~ ensure that the wetlands affected by the MRGO are carefully restored in a timely manner” (MRGO Must Go 2011). The Coalition includes 17 local and national environmental, social justice, and community organizations including: American Rivers, Citizens Against the Widening of the Industrial Canal, Coalition to Restore Coastal Louisiana, Environmental Defense Fund, Global Green, Gulf Restoration Network, Holy Cross Neighborhood Association, Lake Pontchartrain Basin

Foundation, Levees.org, Louisiana Environmental Action Network, Louisiana Wildlife Federation, Lower Mississippi Riverkeeper, Lower Ninth Ward Center for Sustainable Engagement and Development, MQVN Community Development Corporation, National Audubon Society, National Wildlife Federation, and the Sierra Club - Delta Chapter.

The entire ecosystem has global, national, state, and local significance, and every part contributes to the unique services and functions of the whole. However, some components of the ecosystem have particular significance with respect to scarcity, biodiversity, connectivity, ecosystem structure, recreation, and culture that demonstrates their distinct technical, institutional and public significance. The Best Buy plans were evaluated for the extent to which they contributed to the restoration and conservation of these significant resources to determine which plans should be considered in further detail.

Table 2-23. Best Buy Plan Significance

Best Buy	Description	Contribution to Significant Resources
1	No action.	None
2	Central Wetlands: Cypress measures CC1-CC6 and Violet, Louisiana Freshwater Diversion South Lake Borgne: LM1-3 East Orleans Landbridge: EM1 and 2 MRGO: MRGO 1-7 Biloxi Marsh: BR1 Bayou Terre aux Boeufs: TM1-2,	Restoration of a key natural process by the Violet, Louisiana Freshwater Diversion. Restoration of scarce cypress swamp habitat. Some restoration in South Lake Borgne and MRGO, significant for ecosystem structure. Some restoration of the East Orleans Landbridge critical landscape feature. Restoration of rare coastal ridge habitat.
3	BB2 plus TM7, TM8, HM1	Additional restoration of brackish habitat adjacent to communities outside the HSDRRS.
4	BB3 plus EM3 and 4, ES1 and 2	Additional restoration on the East Orleans Landbridge critical landscape feature.
5	BB4 plus CM1-5	Restoration of scarce fresh marsh.
6	BB5 plus BM1, BS1, BS2	Biloxi Marsh critical landscape feature restoration. Restoration of globally imperiled oyster habitat.
7	BB6 plus LM4, ES3, LS1, MRGO8	Restoration of a publically significant urban area. ES3 and LS1 complete the protection of the Lake Borgne Shoreline. Additional protection of the East Orleans Landbridge critical landscape feature. Additional South Lake Borgne protection, which is significant to the maintenance of estuary structure.
9*	BB8 plus EM5, EV1	Additional marsh restoration in the East Orleans Landbridge critical landscape feature.
10	BB9 plus BS3	Additional protection of the Biloxi Marsh critical landscape feature.
12*	BB11 plus additional shoreline protection in Biloxi Marsh (014, 111, 98a, 107, 110, 017, 98b)	Additional protection of the Biloxi Marsh critical landscape feature.
16*	BB15 plus backfilling MRGO to marsh elevation from Bayou Bienvenue to Bayou La Loutre	Addition of a publicly significant feature addressing the direct impacts of the channel.

Table 2-23. Best Buy Plan Significance

Best Buy	Description	Contribution to Significant Resources
17	BB16 plus additional shoreline protection in the Biloxi Marsh (020, 042)	Additional protection of the Biloxi Marsh critical landscape feature.
18	BB17 plus additional ridge restoration (133b)	Additional restoration of rare coastal ridge habitat.
19	BB18 plus Florissant (191)	Additional brackish marsh restoration.
*BB 8, 11, 13, 14, and 15 added MRGO features that are part of the minimum planning increment.		

Risk and Uncertainty

In general, the larger the plan, the higher the uncertainty of producing expected outputs. Plans increase in size from Plan #1 (no action) to Plan #19 (largest plan). Conversely, the smaller the plan, the higher the residual risks in terms of ecosystem degradation and potential resulting storm surge increases in the future.

As described in Risk and Uncertainty Associated with Restoration Measure Types section, risk and uncertainty vary by measure type. Except for the No Action alternative, all Best Buy plans include a freshwater diversion, forested swamp restoration, and forested ridge restoration, so the risks and uncertainties associated with those features are the same for all plans. Risks and uncertainties associated with individual plans vary based on the amount and location of marsh restoration/nourishment and shoreline protection, which is discussed in the following section along with the application of the four planning criteria.

Rationale for Selection of the Final Array

In addition to the No Action Plan (Plan #1), three action plans (Plans #2, #7, and #10) were selected for the final array of alternatives.

Plan #2 was selected for further consideration for the following reasons:

- Plan #2 is the least costly Best Buy Plan.
- Plan #2 has the least amount of marsh restoration and nourishment and therefore has the least uncertainty associated with obtaining sufficient quantities of borrow material.
- Plan #2 contains the least amount of rock protection. Hard structures, such as rock protection, are less acceptable to some stakeholders than natural features. Shoreline protection measures are not self-sustaining and have risk of failure under the higher relative sea level rise scenarios.

Plan #2 does not achieve all of the goals of the study, but it includes some restoration measures for all of the targeted habitat types. Plan #2 would restore or protect 9,518 acres of fresh and intermediate marsh, 10,253 acres of brackish marsh, and 10,431 acres of cypress swamp. Plan #2 does not meet the target acre objectives for brackish marsh. Plan #2 has no features in the Biloxi Marsh and includes only one feature on the East Orleans Landbridge; therefore, Plan #2 does not fully address the objective to restore and protect critical landscape features and significant residual risks associated with not restoring critical landscape features.

Plan #7 was selected for further consideration for the following reasons:

- Plan #7 is the least costly Best Buy Plan that meets all of the objectives, including reasonably maximizing restoration and protection of the Biloxi Marsh and East Orleans Landbridge.
- Plan #7 is the least costly Best Buy plan to include Feature LS1, which is a key Lake Borgne restoration component. Feature LS1 would work synergistically with the Bayou Dupre and West of Shell Beach shoreline protection features currently under construction, and Feature LM2 to restore and protect the Proctor Point area.
- Plan #7 is a complete plan for the Lake Borgne ecosystem and the areas affected by the MRGO. For example, Plan #7 addresses the gaps left by existing and authorized restoration projects. Plan #7 includes the necessary shoreline protection and marsh restoration features to form a complete plan for the ecosystem.

Plan #10 was selected for further consideration for the following reasons:

- Plan #10 improves upon Plan #7 by further protecting critical landscape features, and better meets the storm surge objectives. It contains additional shoreline protection in the Biloxi Marsh and additional marsh restoration in the East Orleans Landbridge both of which are critical landscape features.
- Plan #10 is the least costly Best Buy plan to include a Submerged Aquatic Vegetation (SAV) project. SAV restoration measures are presented as pilot projects because of uncertainties surrounding the re-establishment of SAV beds.

The remainder of the Best Buy plans were not selected because they were either not significantly different from one of the selected plans or the benefits did not justify the significant additional costs. Plans #3 to #6 were not selected because all of the measures in Plans #3 to #6 are contained in #7, which was selected for the final array. Plans #3 to #5 do not contain features BM1, BS1, and BS2, and therefore do not meet the objective to restore and protect the Biloxi Marsh. The institutional, technical, and public significance of the Biloxi Marsh is demonstrated by the recognition that this landscape feature reduces risk associated with storm surge (USGS 1994, Burkett et al. 2002, USACE 2009, Walmsley et al. 2009, Howes et al. 2010, Shepard et al. 2011). The Biloxi Marsh was directly affected by the MRGO channel, and restoration in this area would contribute to the satisfaction of section a(3)B(i) of the study authority to ―restore areas affected by the navigation channel". Maintaining the Biloxi Marsh contributes to the structural integrity of the system by separating Lake Borgne from the higher salinity waters of Chandeleur Sound. If this barrier were removed, the resulting saltwater intrusion would destroy one of the most productive estuaries in the nation. Restoration in this area is consistent with LACPR and the 2007 State Master Plan, demonstrating the public significance of restoration in this area.

Feature BS1 is a critical component for the comprehensive protection of the Lake Borgne shoreline. This area has the highest erosion rates in Lake Borgne and is the only remaining piece of the southeast shore of Lake Borgne that is not protected by existing or planned projects. Feature BM1 would provide marsh nourishment along the Lake Borgne shoreline, contributing to the maintenance of the boundary between Lake Borgne and Chandeleur Sound. The only oyster reef restoration feature proposed as a plan component is BS2. Feature BS2 is an important component of the plan because it restores globally and nationally rare oyster habitat that were affected by the saltwater intrusion from the channel (Beck et al. 2011). The feature prevents erosion of Biloxi Marsh, contributing to the structural integrity of the system and multiple lines of defense through protection of a critical landscape feature. Additionally, the institutional, technical, and public significance of this feature is further demonstrated by the inclusion of an adjacent oyster restoration project in the Deepwater Horizon Oil Spill Draft Phase I Early Restoration Plan and Environmental Assessment (Deepwater Horizon Natural Resource Trustees 2012). Additionally, a considerable number of comments were received on the Draft MRGO Ecosystem Restoration Plan suggesting that the plan should contain more oyster reef restoration, demonstrating public significance. All of these features are consistent with the environmental planning guiding principles adopted for this study by maximizing benefits and sustainability through synergy with existing and planned adjacent projects. Because the protection of this critical landscape feature would require actions by others, these features contribute to the completeness of alternative plans.

Plan #6 includes restoration features in the Biloxi Marsh and more features that protect the East Orleans Landbridge; however, Plan #6 does not include LM4, ES3, and LS1. LM4 would provide restoration in the area forming the boundary between the portion of the MRGO/GIWW channel still authorized and the de-authorized portion of the channel. This feature would provide a buffer in front of the NASA Michoud Facility and its levees, as well as restoration adjacent to HSDRRS, contributing to multiple lines of defense. Ecologically, the marsh is located immediately across the GIWW from the hot-water canal a winter refuge for numerous estuarine fish species. Publicly, this marsh is significant as it provides a short-run recreational fishing spot for boat launches in Chalmette and New Orleans. The institutional significance of this feature is demonstrated by the commitment of President Obama‘s administration to the restoration of urban water resources (EPA et al. 2011). Restoration in this area is consistent with LCA, LACPR, and the 2007 State Master Plan, further demonstrating public significance of this restoration project.

ES3 and LS1 complete the protection of the Lake Borgne shoreline. Feature ES3 provides additional protection of the East Orleans Landbridge, which is institutionally, technically, and publically significant because this landscape feature reduces risk associated with storm surge (USGS 1994, Burkett et al. 2002, USACE 2009, Walmsley et al. 2009, Howes et al. 2010, Shepard et al. 2011). Feature LS1 provides protection for South Lake Borgne, which is significant to the maintenance of estuary structure by preventing the further confluence of the MRGO and Lake Borgne. The spatial integrity of the MRGO/Lake Borgne Landbridge was compromised by the construction of the channel, and restoration in this area would contribute to the satisfaction of section a(3)B(i) of the study authority to ―restore areas affected by the navigation channel". South Lake Borgne is considered a critical geomorphic feature to protect the form and function of the estuary, which is recognized as an institutionally significant resource by President Obama‘s administration (EPA et al. 2011).

Plans #8 and #9 were not selected because all of the measures contained in Plans #8 and #9 are also contained in Plan #10, which was selected for the final array. Plan #8 includes more shoreline protection features in the MRGO. Plan #9 includes the additional features in Plan #8 as well as additional features in the East Orleans Landbridge.

Plans #11 to #19 were not selected because although they would provide additional benefits, they are the most expensive plans providing diminishing returns at increasing financial risk and uncertainty. Plan #11 adds additional protection features along the MRGO/Lake Borgne Landbridge. The incremental cost difference between Plans #10 and #11 is relatively small. However the incremental cost per unit of output is relatively low.

Plan #12 includes the features in Plan #11 and increases the amount of shoreline protection and marsh restoration in the Biloxi Marsh at a relatively low incremental cost. However, it was determined that Plan #10 met the storm surge objective, and that Plan #12 would not be carried forward, although it may better meet this objective. Potential risks and uncertainties regarding extensive foreshore protection in the Biloxi Marsh were raised by some Federal partner agencies, and were an additional consideration in the decision to not carry this alternative forward.

The incremental costs associated with Plans #13 to #15 were not considered reasonable for the relatively minor amount of associated costs. Plans #16 to #19 provide a substantial increase in benefits (by filling in large portions of the MRGO channel), but the total estimated construction costs are considered too great for the associated ecosystem outputs.

The incremental costs associated with Plans #13 to #15 were not considered reasonable for the relatively minor amount of associated benefits. Plans #16 to #19 provide a substantial increase in benefits (by filling in large portions of the MRGO channel), but the total estimated construction costs are considered too great for the associated ecosystem outputs.

As illustrated in the IWR output graph, the final array selection is supported by the position of the plans on the efficient frontier. Best Buy 2 was selected because it was the least expensive action plan. The plans between Best Buy 2 and Best Buy 7 continue to increase benefits at relatively minor increases in incremental costs (illustrated by the gentle slope between the two points). Best Buy 7 appears on the efficient frontier at the point where the incremental cost of benefits becomes more significant (illustrated by the steep slope between the point for Best Buy 7 and the other plans).

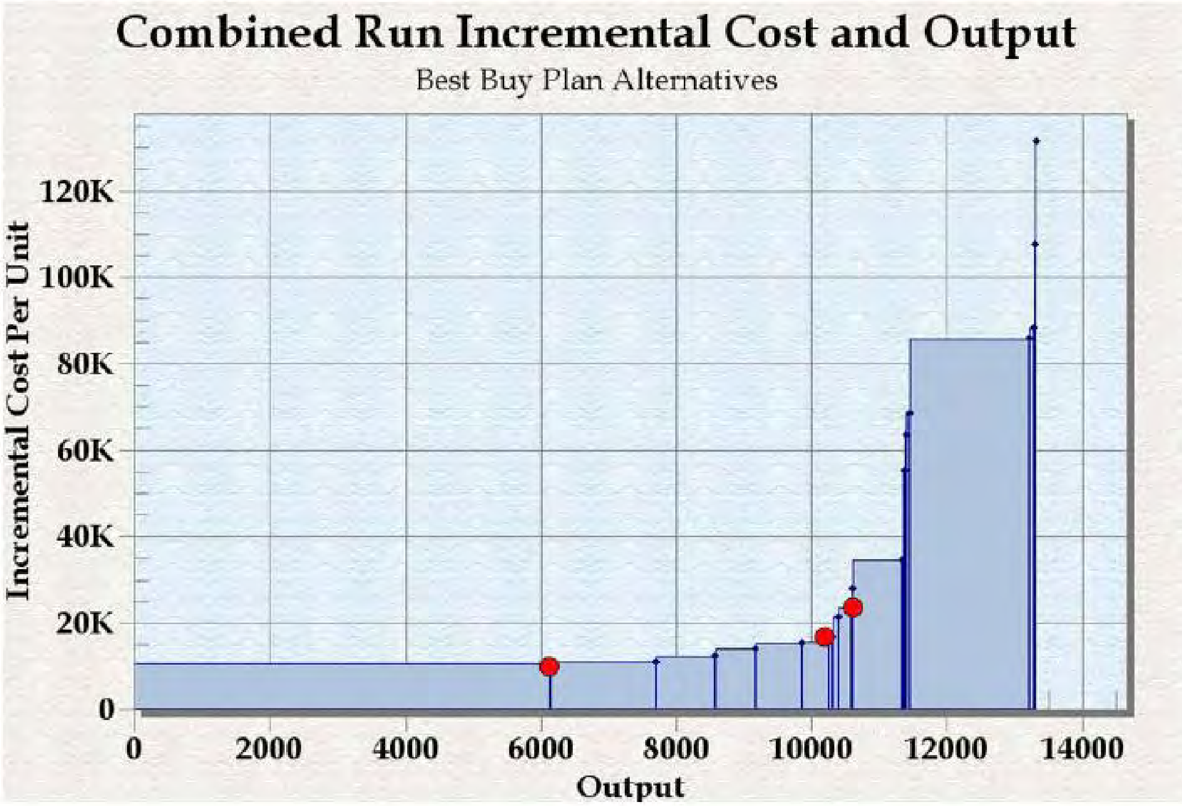


Figure 2-30. Incremental Costs and Outputs

Measures Not Included in the Final Array

The following measures were not included in the final array because they are the least cost effective and/or they have high risk and uncertainty:

- Marsh restoration and shoreline protection on the Breton Sound side of Biloxi marshes north of Morgan Harbor – These measures would be exposed to high wave action and would not perform well under higher levels of sea level rise.
- Backfilling in the MRGO channel - These plans have the highest uncertainty associated with obtaining sufficient quantities of borrow material.
- Large ridge restoration measure - Lack of technical knowledge is a risk associated with ridge restoration features. Very few coastal ridge restoration projects have been constructed, and there is limited data to contribute to the successful design and implementation of these features. The lack of knowledge could jeopardize project success, and the consequences of failure could result in a significant or total loss of benefits. By including the smaller ridge restoration measure in the final array, these risks are reduced without eliminating all of the benefits of this unique habitat type.
- Florissant marsh restoration – This measure is not cost effective and would contribute little to the overall plan.

Sensitivity Analyses

Sensitivity analyses were conducted to evaluate how the results would have been different if all of the Best Buys for each subarea were included in the Combined Run instead of a subset. Based on incremental cost vs. output, as well as the unique benefits of the the plans in the final array, the same plans would have been selected from among the more complete set of Best Buy Plans generated though the sensitivity analysis.

Additional sensitivity analyses were conducted to evaluate how the results would have been different if IWR-PLAN was ran by habitat type rather than by subarea. The results of this sensitivity analysis confirm the selection of the final array, even if the CE/ICA analysis had been conducted differently.

2.7.4 Final Array of Alternatives

Three action plans are included in the final array of alternatives. Best Buy plans #2, #7, and #10 (Plans B, C, and D, respectively) were chosen based on the analysis described in the previous section. WVAs were conducted for all of the plans in the final array considering the interaction between plan elements, the authorized Violet, Louisiana Freshwater Diversion, and projects in the FWOP.

These three plans provide a wide range of costs and outputs (see Table 2-24).

Table 2-24. Final Array of Alternatives

Plan	Estimated Construction Cost[1]	Measure AAHUs[2]	Plan AAHUs[3]	Acres Restored[4]
A	$0	0	0	0[5]
B	$1.7 B ($67 M annual)	6,008	13,608	30,250
C	$2.9 B ($124 M annual)	10,324	17,575[6]	58,861
D	$3.1 B ($130 M annual)	10,399	17,116	59,823

Notes:

1. Based on preliminary costs in October 2009 Price Levels. Does not include real estate, OMRR&R, or adaptive management costs.

2. The AAHUs presented in this column are the total AAHUs of all measures in the plan added together and does not consider interactions between restoration features, except for areas influenced by the freshwater diversion. 3. The AAHUs in this column are based on the Wetland Value Assessments (WVAs) for the entire plan, and does consider synergies. All benefits in this table consider the effects of the authorized Violet, Louisiana Freshwater Diversion.

4. The acres in this column are the total acres restored, nourished, and protected by the plan.

5. The table shows only the costs and benefits associated with this plan. Therefore, all values are zero for the no-action plan.

6. This number is reflective of the initial WVAs that were performed for the project in the plan formulation phase. WVAs were revised for the FIP based on a revised WVA methodology. In this final plan analysis, the Violet, Louisiana Freshwater Diversion was assumed operational in 2027. The total AAHUs for Plan C considering synergies is now 37,980 because the revised methodology considers the value of existing habitat , significantly increasing total benefits .

The historic rate of sea level rise was selected for primary display of ecological benefits in this table because this rate is supported by data.

No Action

The No-Action Alternative is required by the National Environmental Policy Act of 1969 and represents the future without project condition to which alternatives considered in detail are compared. The No-Action Alternative assumes there will be no ecosystem restoration measures constructed within the study area beyond existing and presently authorized projects.

The study area would continue to be subjected to natural and human land-loss factors such as tropical storms, subsidence, erosion, sea level rise, oil and gas exploration, and saltwater intrusion. Wetland loss would continue at the same or accelerated rates. Critical landscape features would continue to erode and degrade, potentially increasing storm surge damages. Large uncertainties surround land loss rates including climate change; sea level rise rates; subsidence rates; changes in frequency and intensity of tropical storm events; and/or changes in drought conditions. All of these factors could contribute to the acceleration of degradation. Continued wetland fragmentation and the eventual conversion to shallow open water habitat would have negative consequences on a variety of important resources.

Summary of Recreation Features

The Recreation Development Plan recommends recreational features for the MRGO Ecosystem Restoration project in concurrence with facilities that are approved in ER 1105-2-100 for ecosystem restoration projects. When implementation funds are appropriated, a non-Federal sponsor, yet to be identified, would participate in a cost-sharing agreement for construction of the recreation plan. Accordingly, the non-Federal share will be 50 percent of the recreation development costs. Non-Federal sponsors are responsible for 100 percent of lands, easements, rights-of-way, utility or public facility relocations, and dredged or excavated material disposal areas (LERRD), and operation, maintenance, repair, rehabilitation, and replacement (OMRR&R). The value of LERRD is credited to the 50 percent share. For a more detailed discussion of the recreation features, drawings, and benefit-cost ratios presented below, see Appendix W.

The recommended recreational features are ancillary to the ecosystem restoration project, work harmoniously with the measures of the restoration project and are proposed on fee title lands for cost-sharing. Recreation features recommended were first identified through USACE meetings with community groups and non-governmental organizations (NGOs). Additionally, this report refers to the Louisiana Department of Culture, Recreation and Tourism‘s Statewide Outdoor Recreation Plan (SCORP), which presents findings from focus group meetings regarding locally preferred outdoor recreation activities. A third source, University of Wisconsin (UW), prepared a recreation needs report for St. Bernard and part of Orleans Parishes. All three of these resources are used in identifying the recommended recreation features, including development of the benefits of each recreation development. Both sites offer American Disability Act (ADA) accessible features, including parking, bathrooms, access to boardwalks, ramps, and picnic shelters.

Lower Ninth Ward Bienvenue Triangle Recreation Feature

Existing Condition – The site of the proposed recreation feature is located in Orleans Parish‘s Bienvenue Triangle. Located at the terminus of Caffin Avenue, the site currently offers a viewing platform overlooking the marsh. The platform is used by the neighborhood, tourists and schools both recreationally and as an educational tool. Martin Luther King Elementary School located on Caffin Avenue and North Claiborne Avenue currently uses the platform for teaching about environmental principles, processes and general education concerning marshland, habitat, and wildlife.

Proposed Improvement – The entrance of the proposed recreation development would offer interpretive signage detailing the history of the Bienvenue Triangle, its various functions to the community, the wetlands‘ restoration mission, the project development process, educational programming, and sustainable design elements. Opportunities for increasing the recreational and environmental education experience include development of a nature boardwalk through the marsh with interpretive signs describing viewsheds, plants, processes, and wildlife within the area. The features would be constructed before wetland restoration begins to afford viewing opportunities of the restoration process. Also, the local sponsor could develop wetland research pilot sites that schools could use to develop test sites of certain types of marsh grasses and other research projects. Information from a UW report revealed the need at this site for children‘s programs; such as some discussion about plants and animals living in the bayou and wetland preservation efforts. Signage explaining the proposed project would educate children about wetland restoration and ways to counter man-made and natural environmental degradation. A multi-use, nature boardwalk would provide access to the restored wetland while a bird watching boardwalk would provide access for viewing wildlife in a very secluded structure. An enlarged land-based viewing platform and shelter/classroom in the swamp would also provide space for larger groups visiting the site.

Constraints to development include the Alabama Great Southern Railroad and local sponsor real estate acquisition. Discussion regarding crossing the railroad must be finalized. Currently, the railroad is crossed to gain access to the existing platform. An at-grade, ADA compliant crossing is proposed, such as is available at other crossings to recreational features in the city of New Orleans. Finally, the local sponsor must obtain real estate fee title for recreation development lands. The land between Florida Avenue and the railroad track is owned by the Sewerage and Water Board (City of New Orleans), the railroad is owned by Alabama Great Southern Railroad (aka Southern Norfolk), the levee is owned by the New Orleans Levee Board, and the swamp by less than five owners.

The recommended design selection is based upon maximizing net benefits. Two designs, Option A and B, are based upon input from community groups in the Lower 9th ward. Both Option A and B are evaluated in terms of benefits and costs and the resulting ratio is the basis for selection. Option A maximizes net benefits, has a BCR, 1.05, and is recommended for implementation. It consists of a 100 lf (linear feet) of platform, 995 lf of boardwalk into the swamp, 4 picnic shelters, interpretive signage, bathrooms, parking, solar lighting and vegetative plantings.

Figure 2-31. Lower Ninth Ward Bienvenue Triangle Recreation Feature

Shell Beach Recreation Feature

Currently, the shoreline of Shell Beach, located in St. Bernard Parish at the end of Yscloskey Road where it meets the MRGO, is often used by fisherman. Fishermen are confronted with a rocky, jagged shoreline and snakes in the area. The shoreline is used extensively on the weekends by many in the area. Additionally, a memorial is located at this location which lists the names of those who lost their lives as a result of Hurricane Katrina. The recreational plan will attempt to incorporate the memorial in a way that is both respectful and functional.

Opportunities for recreational development feature include a boardwalk into the MRGO for fishing and wildlife viewing and to gain access to other spots along the shore including picnic tables and shelters. Two designs, Option A and B, are based upon input from the Coastal Zone Administration of St. Bernard Parish. Both Option A and B are evaluated in terms of benefits and costs. Shell Beach Option B maximizes net benefits, has a BCR of 1.80 and is recommended as part of the plan.

The recommended plan for Shell Beach consists of a 343 lf of boardwalk into the MRGO, 805 lf of shoreline boardwalk to 5 picnic shelters (2 handicap accessible), interpretive signage, bathrooms, parking, solar lighting and vegetative plantings. Option B is the recommended plan for Shell Beach.

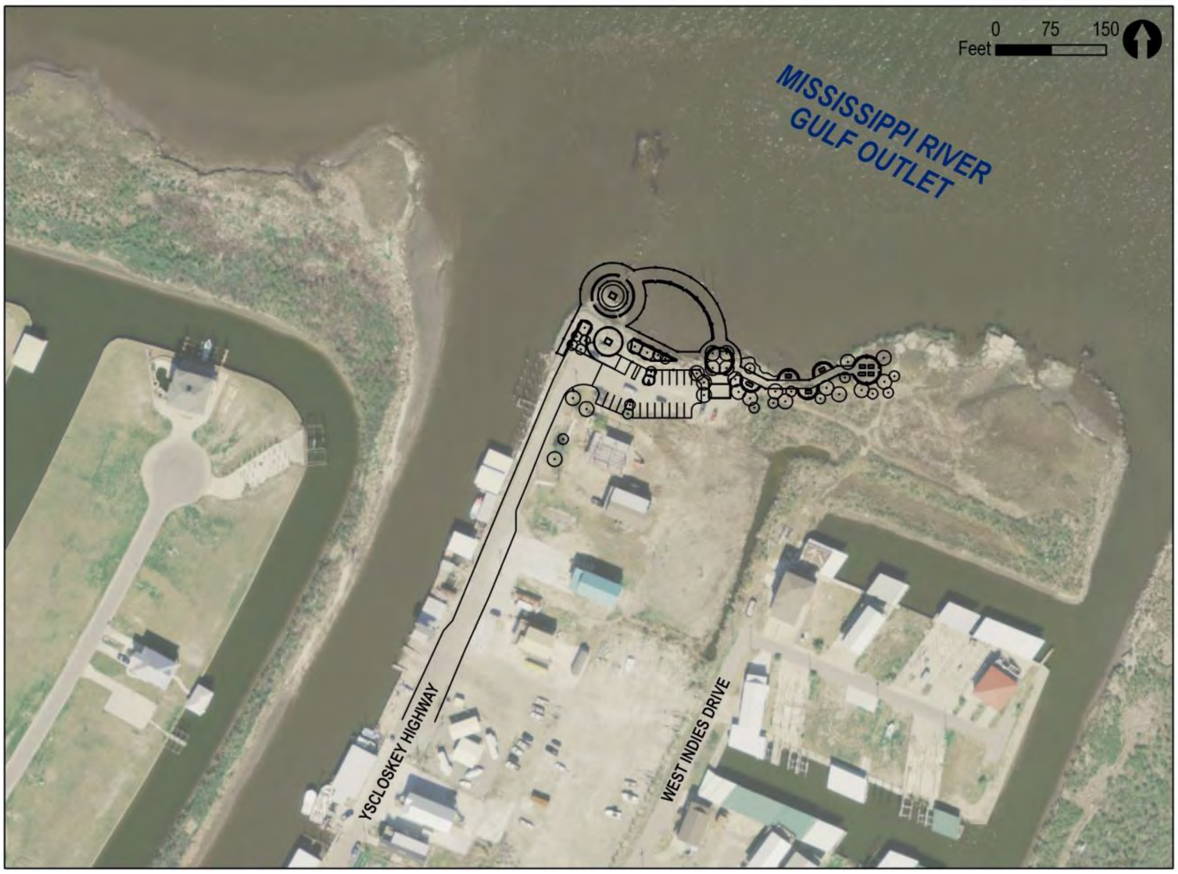


Figure 2-32. Shell Beach Recreation Feature

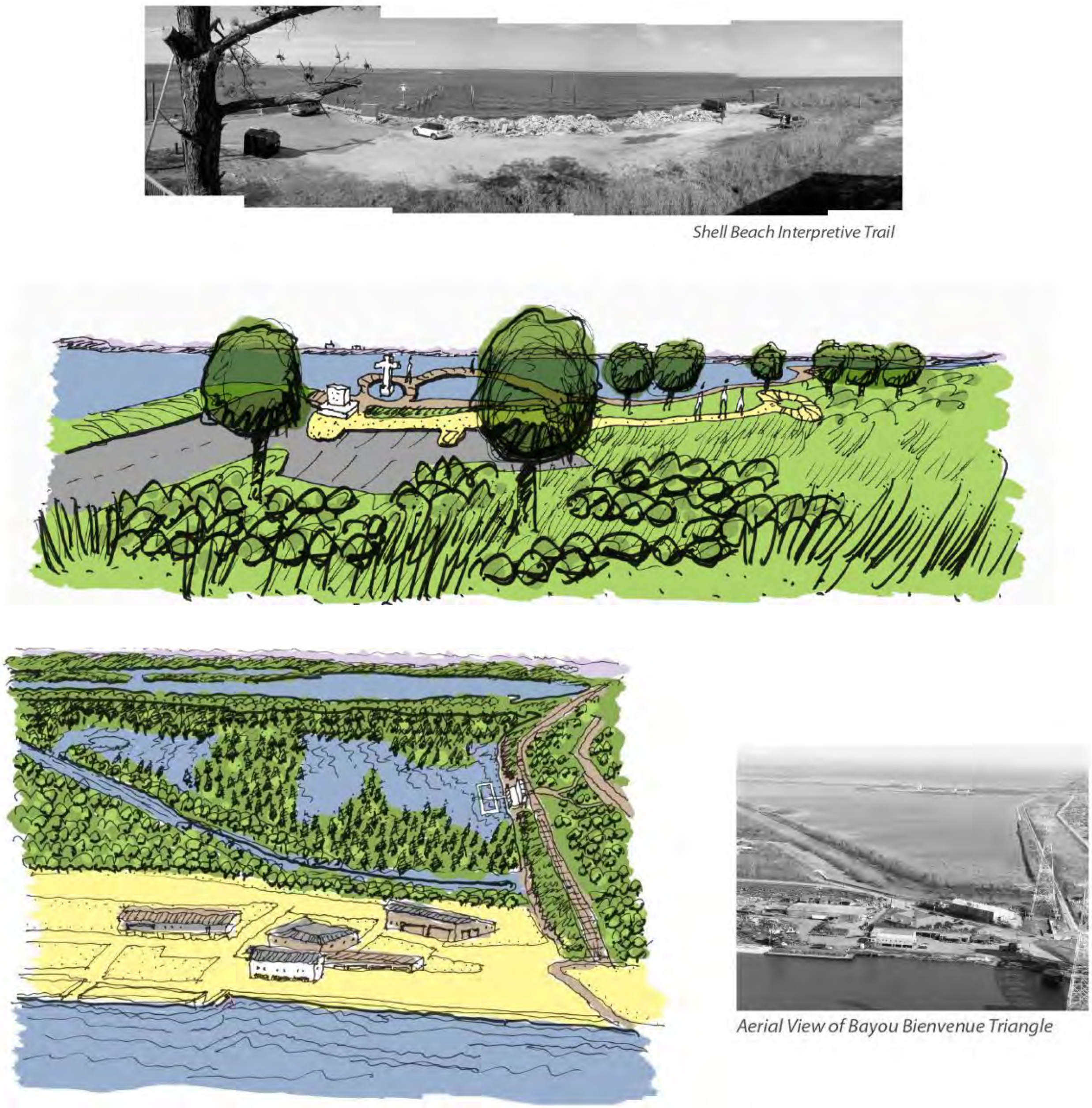


Figure 2-33. Recreation Features Overview

Summary of Features Included in the Final Array

The following table provides a brief description of each feature and indicates which plans in the final array include these features.

Table 2-25 Restoration Features Included in the Final Array

Area	Measure	Description	Plan B	Plan C	Plan D
Biloxi Marsh	BM1	8,000 acres of marsh nourishment along the south shore of Lake Borgne. 11 million cubic yards of material would be obtained from South Lake Borgne Borrow Cycle 6.		Y	Y
	BS1	Approximately 50,637 linear feet (9.5 miles) of shoreline protection along the southeast shore of Lake Borgne. This feature begins at the northern terminus of the Biloxi Marsh Shoreline Protection Project (PO-72) south of Point aux Marchettes and extends north to Malheureax Point.		Y	Y
	BS2	Approximately 30,750 linear feet (5.8 miles) of artificial oyster reef development on the Chandeleur Sound side of the Biloxi Marsh between Eloi Point and the mouth of Bayou La Loutre.		Y	Y
	BS3	67,623 linear feet (12.8 miles) of shoreline protection extending from the south shore of Treasure Bay, around Point Paulina and Point Lydia to the north side of the mouth of Bayou La Loutre.			Y
	BR1	Approximately 54.1 acres of ridge restoration on the south bank of Bayou La Loutre. 400,000 cubic yards of silty sand material to be obtained from the Mississippi River between river miles 83R and 85R.	Y	Y	Y
MRGO	MRGO1	3,850 feet (0.75 miles) of new foreshore protection between MRGO miles 56.6 and 57.4. This stone protection feature is embedded within the limits of MRGO7.	Y	Y	Y
	MRGO2	Repair and maintenance of approximately 21,630 linear feet (4.1 miles) of foreshore protection between Mile 44.5 and 40 of the MRGO.	Y	Y	Y
	MRGO3	Repair and maintenance of existing approximately 26,650 linear feet (5 miles) of foreshore protection between approximately Mile 56 to 51 of the MRGO.	Y	Y	Y
	MRGO4	Repair and maintenance of approximately 11,770 linear feet (2.2 miles) of existing retention dike MRGO Miles 36.6 to 37.1 and MRGO Miles 33.9 to 32.9.	Y	Y	Y
	MRGO5	202 acres of marsh would be restored behind 13,685 linear feet of vinyl sheet pile wall to establish the shoreline. 3 million cubic yards of material would be obtained from South Lake Borgne Borrow Cycle 4.	Y	Y	Y
	MRGO6	8,132 linear feet (1.5 miles) of new, non-continuous foreshore protection between MRGO miles 36.0 and 34.4, immediately east of the existing stone closure of the MRGO. MRGO6 ties into an existing foreshore dike immediately downstream.	Y	Y	Y
	MRGO7	110 acres of marsh restoration adjacent to approximately 9,170 linear feet of bankline reclamation, consisting of 9,700 linear feet of vinyl sheet pile wall. 1.65 million cubic yards of material would be obtained from North Lake Borgne borrow cycle 5.	Y	Y	Y

MRGO	MRGO8	236 acres of marsh restoration adjacent to approximately 17,785 linear feet of bank reclamation constructed using vinyl sheet pile wall. 3.5 million cubic yards of material would be obtained from South Lake Borgne Cycle 4.. Approximately 14,225 linear feet (2.6 miles) of new foreshore protection would also be included between approximate channel miles 51.0 and 48.3.		Y	Y
	SHELL BEACH	Recreation Feature - 343 lf of boardwalk into the MRGO, 805 lf of shoreline boardwalk to 5 picnic shelters (two handicap accessible), interpretive signage, bathrooms, parking, solar lighting and vegetative plantings.	Y	Y	Y
Central Wetlands	CC1	1,020 acres of cypress swamp restoration and 935 acres of cypress swamp nourishment in the area north of the existing Violet Canal along the Forty Arpent levee. 6 million cubic yards of borrow material to be obtained from North Lake Borgne Borrow Cycle 9.	Y	Y	Y
	CC2	250 acres of cypress swamp restoration and 250 acres of swamp nourishment to the northeast of CC1. 1.7 million cubic yards of borrow material to be obtained from North Lake Borgne Borrow Cycle 9.	Y	Y	Y
	CC3	370 acres of cypress swamp restoration and 790 acres of swamp nourishment along the Forty Arpent Levee south of Paris Road. Approximately 3.7 million cubic yards of material to be obtained from North Lake Borgne Borrow Cycle 9.	Y	Y	Y
	CC4-A	400 acres of cypress restoration in the Bienvenue Triangle. Approximately 2.6 million cubic yards of silty sand material to be obtained from the Mississippi River between river miles 84.45R and 83R.	Y	Y	Y
Central Wetlands	CC4-B	1,065 acres of cypress swamp restoration in the open water areas adjacent to the Forty Arpent Levee north of Paris Road. 7.8 million cubic yards of borrow material to be obtained from North Lake Borgne Borrow Cycle 9.	Y	Y	Y
	CC5	1,120 acres of swamp restoration and 1,550 acres of swamp nourishment south of the Violet Canal along the Forty Arpent Levee and the Chalmette Loop Levee. 7.8 million cubic yards of borrow material to be obtained from North Lake Borgne Borrow Cycle 10.	Y	Y	Y
	CC6	2,568 acres of swamp nourishment in the southwest corner of the Central Wetlands. 5.2 million cubic yards of borrow material would be obtained from North Lake Borgne Borrow Cycle 10.	Y	Y	Y
	CM1	1,240 acres of marsh nourishment south of Paris Road between cypress restoration feature CC3 and the Chalmette Loop Levee. Approximately 1.5 million cubic yards of material would be obtained from GIWW/MRGO Reach 1 starting at mile 66, as well as the turning basin at mile 65.5 and the Michoud Canal project that ties into MRGO/GIWW at mile 60.		Y	Y
	CM2	795 acres of marsh restoration and 190 acres of marsh nourishment north of Paris Road. Approximately 4.72 million cubic yards of material would be obtained from North Lake Borgne Borrow Cycle 2.		Y	Y
	CM3	300 acres of marsh restoration and 215 acres of marsh nourishment in the area north of Bayou Dupre and south of MRGO.		Y	Y

		1.6 million cubic yards of borrow material would be obtained from North Lake Borgne Borrow Cycle 7.			
	CM4	97.5 acres of marsh restoration and 128.5 acres of marsh nourishment south of Bayou Dupre. 600,000 cubic yards of dredged material would be obtained from North Lake Borgne Borrow Cycle 7.		Y	Y
	CM5	245 acres of marsh restoration and 70 acres of marsh nourishment in the area north of Bayou Bienvenue and Paris Road. 1million cubic yards of material would be obtained from GIWW/MRGO Reach 1 starting at mile 66, as well as the turning basin at mile 65.5 and the Michoud Canal project that ties into MRGO/GIWW at mile 60.		Y	Y
	BAYOU REC	Recreation Feature 100 linear feet of platform, 995 linear feet of boardwalk into the swamp, 4 picnic shelters, interpretive signage, bathrooms, parking, solar lighting and vegetative plantings in the Bienvenue Triangle.	Y	Y	Y
East Orleans	EM1	1,175 acres of marsh restoration and nourishment of 2,830 acres of surrounding marsh in the area bounded by the Lake Pontchartrain shoreline, Chef Menteur Pass, and the levee. Approximately 8.1 million cubic yards of material would be obtained from North Lake Borgne Borrow Cycle 5.	Y	Y	Y
	EM2	1,095 acres of marsh nourishment on Hog Island, located between the west and east mouth of the West Pearl River. Approximately 1.3 million cubic yards of dredged material would be obtained from Northeast Lake Borgne Borrow Cycle 8.	Y	Y	Y
	EM3	861 acres of marsh restoration and 180 acres of adjacent marsh nourishment bounded by Highway 433, Little Lagoon, Salt Bayou and Highway 90. 4.1 million cubic yards of dredged material would be obtained from Northeast Lake Borgne Borrow Cycle 8.		Y	Y
	EM4	2,625 acres of marsh restoration and 1,455 acres of adjacent marsh nourishment in the area bounded by Salt Bayou to the north, the West Pearl River to the east, the Rigolets to the south and Highway 80 to the north. 9.2 million cubic yards of material would be obtained from North east Lake Borgne Borrow Cycle 8.		Y	Y
	EM5	704 acres of brackish marsh restoration in the area on the south side of the Rigolets from Sawmill Pass to Counterfeit Pass. 2.6 million cubic yards of dredged material would be obtained from Lake Borgne Borrow Area 8.			Y
	ES1	20,530 linear feet (3.8 miles) of shoreline protection from the south shore of Lake Pontchartrain to the terminus of the existing Bayou Chevee shoreline protection feature.		Y	Y
	ES2	30,750 (5.8 miles) linear feet of shoreline protection in Lake Pontchartrain between Chef Menteur Pass and The Rigolets.		Y	Y
	ES3	69,900 linear feet (13.2 miles) of foreshore protection along Lake Borgne between Alligator Point and The Rigolets.		Y	Y
	EV1	Three Submerged Aquatic Vegetation (SAV) protection structures 5,000 linear feet in length, consisting of five 750 feet low level rock weirs spaced 100 feet apart. This feature is located along the south shore of Lake Pontchartrain from near the former mouth of Turtle Bayou to the railroad bridge.			Y

South Lake Borgne	LS1	45,000 linear feet (8.5 miles) of shoreline protection beginning at the terminus of the Bayou Dupre supplemental shoreline project, extending around Proctor Point to the West of Shell Beach supplemental funding shoreline protection.	Y	Y	Y
	LM1	3,253 acres of marsh restoration from open water and nourishment of 1,064 adjacent acres in the Golden Triangle, south of the IHNC Surge Barrier. Approximately 14.3 million cubic yards of borrow to be obtained from North Lake Borgne Borrow Cycle 1.	Y	Y	Y
	LM2	225 acres of marsh restoration and 2,628 acres of marsh nourishment in the area between Proctor Point and the MRGO. Approximately 4.45 million cubic yards of borrow material to be obtained from North Lake Borgne Borrow Cycle 1.	Y	Y	Y
	LM3	911 acres of marsh creation and 950 acres of marsh nourishment in South Lake Borgne north of Lena Lagoon in the area bounded by the lake, Bayou St. Malo, MRGO, and Doulets Canal. Approximately 6.4 million cubic yards of borrow to be obtained from South Lake Borgne Borrow Cycle 6.		Y	Y
	LM4	225.5 acres of marsh restoration and nourishment of 54.8 adjacent acres of marsh in the portion of the Golden Triangle bordered by the GIWW, the IHNC Surge Barrier, and the MRGO. Approximately 1.16 million cubic yards of borrow material would be obtained from North Lake Borgne Borrow Cycle 1.		Y	Y
Terre aux Boeufs	TM1	798 acres of marsh restoration and 223 acres of marsh nourishment, requiring approximately 3.8 million cubic yards of material to be obtained from South Lake Borgne Borrow Cycle 4.	Y	Y	Y
	TM2	770 acres of marsh restoration and 2,734 acres of marsh nourishment in the vicinity of Lake Ameda. Approximately 8.8 million cubic yards of borrow material would be obtained from South Lake Borgne Borrow Cycle 4.	Y	Y	Y
	TM7	2,255 acres of brackish marsh restoration and up to 3,338 acres of adjacent marsh nourishment on the east side of Bayou Terre aux Boeufs. 11.5 million cubic yards of material would be obtained from Lake Lery if available, but it is currently assumed that material will be obtained from Lake Borgne Borrow Area 2.		Y	Y
	TM8	1,511 acres of marsh restoration on the east side of Bayou Terre aux Boeufs in the vicinity of Delacroix. 9.7 million cubic yards of material will be obtained from South Lake Borgne Borrow Cycle 8.		Y	Y
Hopedale	HM1	757 acres of marsh restoration and the nourishment of 973 acres of adjacent marsh, located in the Hopedale area bordered by MRGO to the northeast. 4.5 million cubic yards of dredged material would be obtained from South Lake Borgne Borrow Cycle 4.		Y	Y

2.8 EVALUATION OF ALTERNATIVE PLANS

The evaluation of effects, or comparison of the with-project and without-project conditions for each alternative, is a requirement of NEPA and ER-1105-2-100. The evaluation was conducted by assessing or measuring the differences between each with- and without-project condition and by appraising those differences. Evaluation consists of four general tasks described below:

- Forecast the most likely with-project condition expected under each alternative plan,
- Compare each with-project condition to the without-project condition and document the differences between the two,
- Characterize the beneficial and adverse effects by magnitude, location, timing and duration, and
- Identify the plans that will be further considered in the planning process, based on a comparison of the adverse and beneficial effects and the evaluation criteria.

Plans were evaluated based on the following criteria: all relevant resources, outputs and plan effects; contributions to the Federal objective (NER), the study goals and objectives, compliance with environmental protection requirements, the Planning Guidance Notebook‘s four evaluation criteria (completeness, effectiveness, efficiency and acceptability) and other criteria deemed significant by participating stakeholders.

Ecosystem restoration alternatives must be evaluated based on CE/ICA and significance of ecosystem outputs. Display of the environmental quality account is required for this study using a minimum of two categories of effects: costs and ecosystem restoration outputs.

2.8.1 Risks and Uncertainties

Risk is the product of the likelihood of failure and its consequences. Uncertainty describes any situation lacking absolute surety. There are significant risks and uncertainties associated with all ecosystem restoration plans. The adaptive management plan will address specific risks and uncertainties associated with the implementation of the selected plan, and potential changes to the plan to respond to and minimize the potential effects of these unknown variables that could affect plan performance and/or costs. The following section describes major sources of risk and uncertainty and how they could impact each plan in the final array.

Tropical Storms

Tropical storm events can directly and indirectly contribute to coastal land loss through erosion from increased wave energies, removal and/or scouring of vegetation from storm surge, and saltwater intrusion into estuaries and interior wetlands. Wetland loss and degradation of large areas can occur in a short period of time from storms. All of the plans in the final array (and the associated costs and benefits) are at some risk from storm damage. The extent of potential damage is dependent upon several unknown variables, including: the track and intensity of the storm, the development stage of the project, changes in future conditions in the study area, and variability of project performance from forecast conditions due to other factors.

Sediment-rich areas impacted by storms are able to re-vegetate naturally if they are not disturbed by additional storms (Barras 2009). Therefore, the proposed placement of dredged material could promote the natural recovery of areas affected by storms. The nutrients and suspended solids associated with freshwater diversions would also assist in minimizing the adverse effects of storms to restored marsh.

Brackish and saline marsh communities appear to be more resilient to shearing than fresh and intermediate communities (Barras 2009). The majority of fresh and intermediate marsh areas proposed for restoration in the FIP are located in the Central Wetlands, where storm damage risk is reduced by the Chalmette Loop Levee. Intermediate marsh restoration proposed along the Lake Borgne/MRGO Landbridge would remain susceptible to storm surge and shearing. However, these areas would be more resilient than the existing marsh due to the anticipated benefits of proposed shoreline protection, dredged material placement, vegetative planting, and nourishment from the proposed freshwater diversion. Although these areas could be significantly damaged by a storm event, the proposed action would decrease the extent of damage and increase the likelihood that these areas could recover naturally compared to existing and future without project conditions.

The brackish features in the Terre aux Boeufs and Hopedale areas are located in interior areas that are less susceptible to scouring and removal of vegetation than areas directly adjacent to large open water areas. The anticipated benefits of restoration in these areas could be significantly reduced by a storm, particularly if marsh vegetation was not well established. Some of the sediment placed in these areas could be lost in a storm event. However, because there is a buffer between these features and large open water areas, it is less likely that the benefits of restoration features in this area would be lost entirely.

Depending on the track and intensity of the storm, the proposed ridge feature at Bayou La Loutre could reduce potential storm damage to adjacent areas, including features LM3 and BM1. The ridge feature would be more resilient when fully vegetated than during construction. However, if the ridge feature was damaged during construction, it is likely that sediment would be dispersed throughout the adjacent marsh areas, benefitting those areas while reducing or eliminating the benefit to the proposed ridge.

The predicted benefits of Features EM1, EM2, EM3, and EM4 are at risk of scouring and shearing from storms. Depending on the track and intensity of a storm, the benefits in these areas could be significantly reduced. However, without restoration, the destruction of these areas could increase storm damage risk in the study area.

The benefits of shoreline protection features could be reduced by a storm through the displacement of rocks and damage to the structures. Repair of storm damage to these features would increase the anticipated costs to maintain the anticipated erosion reduction benefits, reducing the cost-effectiveness of these features.

Increased Sea Level Rise

Increased sea level rise could convert emergent wetlands to shallow open water, and shallow open water to deeper water habitat, reducing or eliminating the effectiveness of restoration plans. Proposed restoration features adjacent to open water are more susceptible to the effects of increased sea level rise than more interior areas. Risks associated with increased sea level rise are discussed separately in the following section.

Climate Change

Extreme changes in climate could result in conditions that cannot support the types of habitat restored, reducing the effectiveness of the restoration plan. Extreme climate change could essentially eliminate the benefits of vegetative plantings, if the change resulted in fatality. The adaptive management plan includes provisions for monitoring climate change and triggers for adjusting plan implementation to these potential changes.

Errors in Analysis

Future conditions are inherently uncertain. The forecast of future conditions is limited by existing science and technology. Future conditions described in this study are based on an analysis of historic trends and the best available information. Some variation between forecast conditions and reality is certain. Restoration features were developed in a risk-aware framework to minimize the degree to which these variations would affect planning decisions. However, errors in analysis or discrepancies between forecast and actual conditions could affect the effectiveness of plans.

All of the models used in this study are abstract mathematical representations of reality. Models simulate complex systems by simplifying real processes into expressions of their most basic variables. These tools assist with finding optimal solutions to problems, testing hypothetical situations, and forecasting future conditions based on observed data. No model can account for all relevant variables in a system. The interpretation of model outputs must consider the limitations, strengths, weaknesses and assumptions inherent in model inputs and framework. Inaccurate assumptions or input errors could change benefits predicted by models used in this study. The potential for significant changes due to errors has been reduced through technical review, sensitivity analyses, and quality assurance procedures. However, there is inherent risk in reducing complex natural systems into the results of mathematic expressions driven by the simplified interaction of key variables.

Salinity

Salinity is a specific source of potential analytical variability because salinity in the study area is changing. For instance, salinity in the MRGO in the vicinity of the Central Wetlands was reduced to approximately 4 to 7ppt following the closure of the MRGO. Coastwide Reference Monitoring Stations indicate that Central Wetlands salinity is lower than 4ppt and is continuing to decline. Contributing factors include the closure of MRGO, the closure of Bayou Dupre during the construction of the Chalmette Loop Levee, the construction of the IHNC Surge Barrier, and the concurrent operation of the existing Violet Siphon. If salinity is different from predicted conditions, it may not be possible to support the habitat type planned for that area.

Implementation

The timing and availability of financial resources for implementation is a major uncertainty that must be considered. If the plan is not implemented in the near future, the problems in the study area will continue to degrade conditions. The impact of the uncertainties associated with the future condition of the study area could increase restoration costs, decrease restoration benefits, or both. The uncertainties associated with implementation are increased because a non-Federal sponsor has not been identified.

All plans in the final array of alternatives require phased implementation, which can reduce risk. With phased implementation, costs are expended periodically, rather than all at once, which reduces risk to the monetary investment. Phased implementation also provides the opportunity to adjust project design and develop lessons learned from projects built in the initial phase.

The relative risk of each plan is based on the differences in consequences. Because it has the lowest benefits and costs, Plan A involves no action, and therefore the risk to the ecosystem is greatest under this scenario. The risk associated with Plan B is less than Plan A, because some key restoration features, would be implemented. Plan B reduces the risk to some critical landscape features, but does not provide as much restoration and protection as Plan C. The risk to ecosystem form and function is less with Plan C than Plans A and B, because it includes more actions to protect and restore key geographic components of the ecosystem. Plan D provides the most restoration features of all of the plans evaluated in the final array, and further decreases the risk to ecosystem form and function. Table 2-26 evaluates the susceptibility of plan features to risks.

Table 2-26. Relative Sustainability of Features

Measure	Relative Susceptibility to Risk					
	Tropical Storms	**Climate Change**	**Increased RSLR**	**Analytical Variability**	**Implementation**	**Overall Risk**
EM2	High	Moderate	High	Moderate	Moderate	Moderate-High
EM3	Moderate	Moderate	High	Moderate	Moderate	Moderate
EM4	Moderate	Moderate	High	Moderate	Moderate	Moderate
EM1	Moderate	Moderate	High	Moderate	Moderate	Moderate
EM5	High	Moderate	High	Moderate	Moderate	Moderate-High
ES1	High	Low	High	Low	Low	Moderate
ES2	High	Low	High	Low	Low	Moderate
ES3	High	Low	High	Low	Low	Moderate
EV1	High	Low	High	Low	Low	Moderate
MRGO1	High	Low	High	Low	Low	Moderate
MRGO2	High	Low	High	Low	Low	Moderate
MRGO3	High	Low	High	Low	Low	Moderate
MRGO4	High	Low	High	Low	Low	Moderate
MRGO5	High	Moderate	High	Moderate	Moderate	Moderate-High
MRGO6	High	Low	High	Low	Low	Moderate
MRGO7	High	Moderate	High	Moderate	Moderate	Moderate-High
MRGO8	High	Moderate	High	Moderate	Moderate	Moderate-High
LM1	High	Moderate	High	Moderate	Moderate	Moderate-High

Table 2-26. Relative Sustainability of Features

Measure	Relative Susceptibility to Risk					
	Tropical Storms	**Climate Change**	**Increased RSLR**	**Analytical Variability**	**Implementation**	**Overall Risk**
LM2	High	Moderate	High	Moderate	High	Moderate-High
LM3	High	Moderate	High	Moderate	Moderate	Moderate-High
LM4	Low	Moderate	High	Moderate	Low	Moderate
LS1	High	Low	High	Low	Low	Moderate
CC1 –CC6	Low	Moderate	Moderate	Moderate	Moderate	Moderate
CM1-CM5	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate
TM1	High	Moderate	High	Moderate	Moderate	Moderate-High
TM2	High	Moderate	High	Moderate	Moderate	Moderate-High
TM7	High	Moderate	High	Moderate	Moderate	Moderate-High
TM8	High	Moderate	High	Moderate	Moderate	Moderate-High
HM1	High	Moderate	High	Moderate	Moderate	Moderate-High
BR1	High	High	Low	High	Moderate	High
BS1	High	Low	High	Low	Low	Moderate
BS2	High	Moderate	High	Moderate	Low	Moderate-High
BS3	High	Low	High	Low	Low	Moderate
BM1	High	Moderate	High	Moderate	Moderate	Moderate-High

2.8.2 Assessment of Sustainability for Relative Sea Level Rise Scenarios

Features contained within the final array of alternatives were assessed on a Yes/No scale for each of the following four sustainability factors:

1. Elevation – Features at higher elevations are more sustainable under relative sea level rise, e.g. ridges, than features at marsh elevation. (Y = features that are higher than marsh elevation; N = features that are at marsh elevation)
2. Freshwater influence – Features that are influenced by rivers or river diversions have a sustainable source of freshwater and sediment to nourish them and aid in accretion. (Y = features nourished by freshwater; N = features not nourished by fresh water)
3. Wave energy – Features that are protected from wave energy (e.g. interior marsh) are more sustainable than features subjected to high wave energy. (Y = features protected from high wave energy; N = features not protected from high wave energy)
4. Natural features – Features that are natural, living features of the ecosystem such as marsh are more sustainable than hard structures such as rock that subside more quickly and cannot sustain themselves and therefore require more O&M. (Y = natural features; N = hard features)

After each feature or groups of features was assessed for each sustainability factor, the feature was assigned numerical and qualitative scores as follows:

- Sustainability factors were convert to points: Yes (Y) = 1 point. No (N) = 0 points. If a feature included more than one component and received a Yes score for one component and a No score for the other component, it received a half point.
- Points were then totaled and converted into a qualitative score as follows: 0 = Poor; 1 = Fair; 2 = Good; 3 = Very Good; 4 = Excellent.

Table 2-27. Sustainability under Relative Sea Level Rise by Feature.

Area	ID	Plans	Sustainability Factors				Score	
			Elev.	FW Influ.	Wave Energy	Natural feature		
East Orleans Landbridge	EM2	B, C (FIP), D	N	Y	N	Y	2	Good
	EM3	C (FIP), D	N	Y	Y	Y	3	Very Good
	EM4	C (FIP), D	N	Y	N	Y	2	Good
	EM1	B, C (FIP), D	N	N	N	Y	1	Fair
	EM5	D	N	N	N	Y	1	Fair
	ES1	C (FIP), D	N	N	N	N	0	Poor
	ES2	C (FIP), D	N	N	N	N	0	Poor
	ES3	C (FIP), D	N	N	N	N	0	Poor
	EV1	D	N	N	N	N	0	Poor
MRGO	MRGO1	B, C (FIP), D	N	N	N	N	0	Poor
	MRGO2	B, C (FIP), D	N	N	N	N	0	Poor
	MRGO3	B, C (FIP), D	N	N	N	N	0	Poor
	MRGO4	B, C (FIP), D	N	N	N	N	0	Poor
	MRGO5	B, C (FIP), D	N	Y	N	Y/N	1.5	Fair/Good
	MRGO6	B, C (FIP), D	N	N	N	N	0	Poor
	MRGO7	B, C (FIP), D	N	Y	N	Y/N	1.5	Fair/Good
	MRGO8	C (FIP), D	N	Y	N	Y/N	1.5	Fair/Good
South Lake Borgne	LM1	B, C (FIP), D	N	Y	N	Y	2	Good
	LM2	B, C (FIP), D	N	Y	N	Y	2	Good
	LM3	B, C (FIP), D	N	Y	N	Y	2	Good
	LM4	C (FIP), D	N	Y	Y	Y	3	Very Good
	LS1	C (FIP), D	N	N	N	N	0	Poor
Central Wetlands	CC1 – CC6	B, C (FIP), D	Y	Y	Y	Y	4	Excellent
	CM1-CM5	C (FIP), D	N	Y	Y	Y	3	Very Good
Terre aux Boeufs	TM1	B, C (FIP), D	N	N	Y	Y	2	Good
	TM2	B, C (FIP), D	N	N	Y	Y	2	Good
	TM7	C (FIP), D	N	N	Y	Y	2	Good
	TM8	C (FIP), D	N	N	Y	Y	2	Good
	HM1	C (FIP), D	N	N	Y	Y	2	Good
Biloxi Marsh	BR1	B, C (FIP), D	Y	Y	Y	Y	4	Excellent
	BS1	C (FIP), D	N	N	N	N	0	Poor
	BS2	C (FIP), D	N	N	N	N	0	Poor
	BS3	D	N	N	N	N	0	Poor
	BM1	C (FIP), D	N	Y	N	Y	2	Good

If the sustainability scores are averaged, Plans B, C, and D are all in the range of Fair to Good sustainability (1-2). All plans include the most sustainable types of features, i.e. the cypress swamp and ridge habitat. The smallest plan, Plan B is marginally more sustainable simply because it includes the least number of features. For Plans C and D, sustainability decreases marginally as less sustainable features, such as shoreline protection, are added.

Relative Sea Level Rise Scenario Analysis Conclusions

Under the medium scenario, the cost-effectiveness of all of the action plans would decrease. To achieve the level of benefits projected for the historic rate under the medium scenario, additional lifts and maintenance of restoration features beyond predicted OMRR&R actions may be required. The alternative to increased maintenance would be significantly reduced benefits.

Under the low and medium sea level rise scenarios, it does not appear that land/water ratios would be altered to the extent that habitat-switching would occur in the restored areas. Adaptive management actions could mitigate potential switching under these sea level rise scenarios.

The diminished output of the alternative plans under the high sea-level rise scenario requires serious consideration. The recommendations for this study include an assessment of sea level rise rates and appropriate responses.

2.8.3 Comparison of Impacts to Significant Resources

Table 2-28 provides a comparative summary evaluation of the potential adverse and beneficial impacts to significant resources for the pans included in the final array of alternatives.

Table 2-28. Evaluation of Potential Impacts to Significant Resources by Alternative over the Period of Analysis

Significant Resources	Plan A No Action	Plan B	Plan C	Plan D
HYDROLOGY AND HYDRAULICS	No direct impacts. Indirect and cumulative impacts include: altered flow patterns, paths of tidal propagation, and loss of tidal connection. Some reduction in salinity is anticipated due to other authorized freshwater diversion projects.	Wave modeling conducted for this study indicates that impacts from dredging Lake Borgne would be negligible.	Impacts would be similar to Plan B.	Impacts would be similar to Plan B.
WATER QUALITY	Current water quality conditions would persist; low DO levels and bacterial pollution would persist; continues loss wetlands reduce ability to filter and absorb pollutants.	The protection, restoration and nourishment of 30,020 acres of marsh and swamp would benefit water quality in terms of increased DO, reduced turbidity, and filtration and trapping of pollutants once construction completed.	The protection, restoration and nourishment of 57,452 acres of marsh and swamp would benefit water quality as described for Plan B. The area potentially benefitted by Plan C is greater than Plan B.	The protection, restoration and nourishment of 58,409 acres of marsh and swamp would benefit water quality as described for Plan B. The area potentially benefitted by Plan D is slightly greater than Plan C.
NAVIGABLE WATERWAYS	Current conditions would persist. Other projects such as other fresh water diversions; MRGO closure; sector gates on the Gulf Intracoastal Waterway and Bayou Bienvenue; and construction of the storm surge barrier may affect current navigable waterways.	Mississippi River navigation would not be impacted. Navigation in the GIWW minimally impacted by the diversion flow current.	Impacts would be similar to Alternative B.	Impacts would be similar to Alternative B.
SOILS	Continued loss of sediments due to shoreline erosion and wetland loss.	No prime farmland soils would be adversely impacted.	Impacts would be similar to Alternative B.	Impacts would be similar to Alternative B.

Table 2-28. Evaluation of Potential Impacts to Significant Resources by Alternative over the Period of Analysis

Significant Resources	Plan A No Action	Plan B	Plan C	Plan D
AIR QUALITY	St. Bernard, St Tammany, Orleans, and Plaquemines Parish are in attainment for all pollutants. Air quality trends would have no direct beneficial or adverse impacts.	Emissions increases from construction are not expected to cause or contribute to a violation of Federal or state ambient air quality standards.	Impacts would be similar to Plan B.	Impacts would be similar to Plan B.
NOISE	No impacts anticipated from FWOP condition	No significant impacts anticipated; potential temporary and local impacts to communities near the diversion site during construction. Some temporary disturbance to wildlife during construction of other features.	Impacts would be similar to Plan B.	Impacts would be similar to Plan B.
HTRW	No potential impacts because there are no associated construction activities.	An HTRW Phase I in the study area was performed on the study area, and identified a low probability of encountering contaminants of concern.	Potential impacts would be similar to Plan B.	Potential impacts would be similar to Plan B.
COASTAL VEGETATIVE RESOURCES	Loss of 131,091 acres by 2065.	The protection, restoration and nourishment of 30,020 acres of marsh and swamp would benefit coastal vegetation resources. Losses would be significantly less in areas benefitted by the plan; however, in areas outside of project areas land loss are likely to continue at current or increased rates.	Beneficial impacts would be greater than Plan B, due to 27,452 acres of additional restoration.	Beneficial impacts would be greater than Plan C, due to 937 acres of additional restoration.

Table 2-28. Evaluation of Potential Impacts to Significant Resources by Alternative over the Period of Analysis

Significant Resources	Plan A No Action	Plan B	Plan C	Plan D
WILDLIFE RESOURCES	Continued decline in quality of wildlife habitat adversely impacts wetland dependent wildlife populations.	Significantly beneficial impacts vital to neotropical migratory birds; colonial nesting birds, waterfowl and mammals.	Beneficial impacts would be similar to Plan B; although the scope of benefits is greater due to 27,452 acres of additional restoration.	Plan D would benefit 937 more acres of potential wildlife habitat than Plan C.
AQUATIC AND FISHERY RESOURCES	Wetland fragmentation, emergent wetland loss, shoreline and bank line erosion would result in loss of critical EFH, reducing the area's ability to adequately support federally managed species.	Preliminary analyses indicate no significant adverse impacts to fishery species. Wetlands restoration and protection would benefit fisheries.	Potential impacts similar to Plan B. Potential benefits are greater than Plan B due to additional 27,452 acres of restoration.	Potential impacts similar to Plan B. Potential benefits are slightly greater than Plan C, due to an additional 937 acres of restoration.
COMMERCIAL FISHERIES	Declined expected as habitat loss and degradation from erosion due to salinity changes leads to overfishing of the resource.	Restoreed marsh is anticipated to increase productivity.	Similar to Plan B, although greater beneficial impacts due to 27,452 acres of additional wetland habitat restoration. Additional beneficial impacts to oyster fisheries anticipated with the inclusion of an artificial oyster reef in the Biloxi Marsh.	Similar to Plan C; slightly greater potential impacts due to 937 acres of additional restoration.
PLANKTON RESOURCES	No Action would have an additive impact due to increasing salinity and a transition to more marine-dominated community.	No substantial affect on plankton abundance or distribution.	Similar to Plan B.	Similar to Plan B.
WATER BOTTOMS AND BENTHIC RESOURCES	Persistence of existing conditions, including existing emergent wetlands converted to water bottoms no longer available for use by benthic species assemblages typically using this habitat.	Excavation of 87 million cubic yards of material, from a total of 9,036 acres of water bottom.	Excavation of 152 million cubic yards of material from a total of 15,724 acres of water bottom.	Impacts would be similar to Plan C, although borrow material would increase by 2.3 million cubic yards.

Table 2-28. Evaluation of Potential Impacts to Significant Resources by Alternative over the Period of Analysis

Significant Resources	Plan A No Action	Plan B	Plan C	Plan D
ESSENTIAL FISH HABITAT	Wetland fragmentation and emergent wetland loss contributing to the continued degradation of EFH for species utilizing this habitat such as; larvae and juvenile brown shrimp, juvenile white shrimp, all life stages of red drum, and juvenile dog snapper.	30,020 acres of marsh and swamp restoration would create a more continuous emergent transitional wetland and would benefit EFH.	57,452 acres of marsh and swamp restoration would create a more continuous emergent transitional wetland would benefit EFH. Preliminary analyses same as Plan B.	59,409 acres of marsh and swamp restoration would create a more continuous emergent transitional wetland would benefit EFH. Preliminary analyses same as Plan B.
THREATENED AND ENDANGERED SPECIES	Loss of coastal wetland habitat resulting from the continued transition of wetland habitats and barrier island habitats to shallow open water habitats.	Approximately 87 million cubic yards of material to be borrowed from Gulf sturgeon critical habitat. Preferred habitat was excluded from potential borrow sites to minimize potential adverse impacts.	Potential impacts are greater than Plan B due to approximately 65 million cubic yards of additional borrow material to be obtained from Gulf sturgeon critical habitat. Approximately 44 miles of foreshore protection in critical habitat.	Potential impacts are greater than Plan C approximately 2.3 million cubic yards of additional borrow material and 3 miles of SAV protection in Gulf sturgeon critical habitat.
SOCIO-ECONOMIC RESOURCES - Population	The No Action Alternative would have no direct, indirect, or cumulative impacts on human populations.	The plan is not anticipated to have any direct, indirect, or cumulative effects on nearby populations.	Impacts would be similar to Plan B.	Impacts would be similar to Plan B.
SOCIO-ECONOMIC RESOURCES – Community Cohesion	The No Action Alternative would have no impact on community cohesion	The construction of the diversion would create a new canal in an agricultural field between two communities potentially impacting community cohesion.	Impacts similar to Plan B.	Impacts similar to Plan B.

Table 2-28. Evaluation of Potential Impacts to Significant Resources by Alternative over the Period of Analysis

Significant Resources	Plan A No Action	Plan B	Plan C	Plan D
SOCIO-ECONOMIC RESOURCES – Employment and Income	The No Action Alternative would result in continued wetland loss and localized impacts on employment and income.	Plan B would work synergistically with other projects to help support coast wide wetland-dependent employment.	Plan C have greater beneficial synergistic effects than Plan B due to the 27,452 acres of additional wetland habitat restoration.	Impacts would be similar to Plan C.
SOCIO-ECONOMIC RESOURCES - Infrastructure	The decline wetlands would contribute to the deterioration of substrate upon which infrastructure features are constructed.	Plan B would restore or protect 30,020 acres in the study area, which would assist with protection of existing infrastructure.	Plan C would provide greater beneficial impacts through the restoration of 27,452 acres more than Plan B.	Impacts would be slightly greater than Plan C, because 937 additional acres would be restored.
SOCIO-ECONOMIC RESOURCES – Oil, Gas and Utilities Pipelines	The No Action Alternative could expose buried pipelines thereby increasing the risk of failure or damage due to lack of structural stability, anchor dragging, and boat collisions.	The restoration proposed for Plan B would prevent the increase in maintenance and relocation costs for pipelines in and around the project areas.	Plan C would provide more complete protection for oil and gas infrastructure than Plan B, and would produce more beneficial impacts through the restoration of 27,452 additional acres.	Impacts would be slightly greater than Plan C, because 937 additional acres would be restored.
SOCIO-ECONOMIC RESOURCES – Commercial Fisheries	Continued conversion of existing wetlands to open water habitats, continued bankline erosion and sloughing of the shoreline. Sharp declines are predicted in fisheries productivity under the No-Action Alternative.	Plan B would increase important fisheries habitat. Overall, the industry would be more stable in the study area due to a long-term increase in the quality of fisheries habitat.	Plan C would provide greater beneficial impacts to fisheries habitat than plan B, by providing an additional 28,452 acres of marsh benefits.	Impacts would be similar to Plan C.
SOCIO-ECONOMIC RESOURCES – Recreation	There are no recreational benefits of Plan A,	The net value of incidental recreational benefits associated with Plan B is estimated to be increase by $1,751,000 or $78,374 of annualized benefits compared to Plan A.	The net value of incidental recreational benefits associated with Plan C is estimated to be increase by $3,956,000 or $177,070 of annualized benefits compared to Plan A.	The net value of incidental recreational benefits associated with Plan D is estimated to be increase by $3,956,000 or $177,070 of annualized benefits compared to Plan A.

Table 2-28. Evaluation of Potential Impacts to Significant Resources by Alternative over the Period of Analysis

Significant Resources	Plan A No Action	Plan B	Plan C	Plan D
SOCIO-ECONOMIC RESOURCES – Oyster Leases	The loss of wetlands in the project area would likely alter the detritus-based food web of the oyster thereby reducing the localized carrying capacity for oyster leases in the area.	Increases to productivity are anticipated in the Biloxi Marsh.	Impacts would be similar to Plan B.	Impacts would be similar to Plan B.
SOCIO-ECONOMIC RESOURCES – Flood Control and Hurricane Protection Levees	The No Action Alternative would have no direct impacts on flood control or hurricane protection levees. Indirect impacts would result in the continued degradation of the landbridge separating Lake Borgne from the MRGO channel, the conversion of existing wetlands to open water habitats, and the continued bankline erosion and sloughing of the shoreline.	Plan B would protect and restore marsh outside of the levees, which would help protect the levees, allowing current level of risk reduction in the project areas to be maintained.	Benefits would be greater than Plan B, by providing an additional 28,452 acres of marsh benefits	Impacts slightly greater than Plan C, by providing additional marsh benefits.
SOCIO-ECONOMIC RESOURCES – Navigation	As Louisiana's coastal wetlands continue to fragment and convert to open water, the protection wetlands provide to inland waterways from wind-driven waves would be reduced.	Plan B would work with other projects to protect adjacent waterways, such as the GIWW, from waves propagated through the lake, thus providing a safer route for inland water-borne traffic.	Impacts would be similar to Plan B.	Impacts would be similar to Plan B.
ENVIRONMENTAL JUSTICE	With continued wetland loss, loss of valuable property increased flooding risk of homes and businesses, impacts would affect all population groups.	Communities are located on either side of the agricultural field where the proposed diversion would be located.	Potential impacts would be the same as Plan B.	Potential impacts would be the same as Plan B.

Table 2-28. Evaluation of Potential Impacts to Significant Resources by Alternative over the Period of Analysis

Significant Resources	Plan A No Action	Plan B	Plan C	Plan D
HISTORIC AND CULTURAL RESOURCES	Continued erosion of cultural sites is expected.	Deposition of dredged material could increase the rate of subsidence and the disappearance of important sites from the archaeological record. National Register eligible sites would be avoided or adverse effects will have to be mitigated. A programmatic agreement with the SHPO and ACHP is being pursued for this study.	Plan C includes 27,452 acres of restoration activities more than Plan B, and therefore greater potential impacts.	Plan D includes 937 acres of restoration activities more than Plan C, and therefore greater potential impacts.
RECREATION RESOURCES	Continued wetland loss and conversion of existing wetlands to open water habitats resulting in decreased structural complexity and habitat diversity of recreational fish caught and game species hunted.	Restoration would likely improve recreational fishing and wildlife hunting opportunities.	For wetland measures, beneficial impacts are to a greater extent due to additional 27,452 acres of restoration.	Impacts are similar to Plan C, with slightly greater beneficial impacts due to an additional 937 acres of restoration.
AESTHETICS (Scenic Rivers)	Continued habitat deterioration, land loss, and conversion to open water reducing scenic qualities of area.	The plan would benefit marsh and swamp in the vicinity of the scenic streams restoring their viewscape to its original habitat types.	Impacts similar to Plan B.	Impacts similar to Plan B.

2.9 COMPARISON OF ALTERNATIVE PLANS

Alternative plans were compared against each other, with emphasis on benefits and impacts, with respect to study goals and objectives and NER objectives. Table 2-29 provides a summary of how each alternative plan meets the study objectives.

Table 2-29. Comparison of the Alternative Plans and Plan Objectives

Objective	Plan A	Plan B	Plan C	Plan D
1. Salinity Target	No	Yes	Yes	Yes
2. Cypress (Minimum 9,500 acres)	No	Yes	Yes	Yes
3. Fresh/Intermediate (Minimum 6,800 acres)	No	Yes	Yes	Yes
4. Brackish (Minimum 18,100 acres)	No	No	Yes	Yes
5. Additional marsh types lost through erosion (Minimum 3,900 acres)	No	No	Yes	Yes
7. Ridge Habitat	No	Yes	Yes	Yes
8. Landscape Features for Surge Reduction[a]	No	Yes	Yes	Yes

[a] Landscape features for surge reduction include acres restored, nourished or protected on the East Orleans Landbridge and the Biloxi Marsh.

2.9.1 Completeness, Effectiveness, Efficiency and Acceptability

Acceptability is the extent to which the alternative plans are acceptable in terms of applicable law, regulations and public policies. “An ecosystem restoration plan should be acceptable to state and Federal resource agencies, and local government. There should be evidence of broad based public consensus and support for the plan.” (ER 1105-02-100).

Completeness is the extent to which an alternative plan provides and accounts for all necessary investments or other actions to ensure the realization of the planning objectives. It is an indication of the degree that the outputs of the plan are dependent upon the actions of others. Plans that require substantial activity by others in order to achieve their objectives are not likely to be complete. “The plan must provide and account for all necessary investments or other actions needed to ensure the realization of the planned restoration outputs…Real estate, O&M, monitoring, and sponsorship factors must be considered.” (ER 1105-02-100).

Effectiveness is the extent to which an alternative plan contributes to achieving the planning objectives. “An ecosystem restoration plan must make a significant contribution to addressing the specified restoration problems or opportunities (i.e., restore important ecosystem structure or function to some meaningful degree.” (ER 1105-02-100).

Efficiency is the extent to which an alternative plan is the most cost effective means of achieving the objectives. "An ecosystem restoration plan must represent a cost-effective means of addressing the restoration problem or opportunity. It must be determined that the plan's restoration outputs cannot be produced more cost-effectively by another agency or institution." (ER 1105-02-100).

Table 2-30 compares the final array in terms of completeness, effectiveness, efficiency and acceptability.

Table 2-30. Comparison of Completeness, Effectiveness, Efficiency, and Acceptability

	Completeness	Effectiveness	Efficiency	Acceptability
Plan A	No	No	No	No
Plan B	No	No	No	No
Plan C	Yes	Yes	Yes	Yes
Plan D	Yes	Yes	Yes	Yes

Plan A (No-Action Alternative)
Plan A is the least acceptable plan in terms of public law and regulation, in that it violates the mandate of the Congress in WRDA 2007, Section 7013. It does not meet the acceptability criterion because it is not consistent with public policy, as evidenced by CWPPRA, LCA, LACPR, the 2007 State Master Plan, the Louisiana-Mississippi Gulf Coast Ecosystem Restoration Working Group's Roadmap for Restoring Ecosystem Resiliency and Sustainability, and other restoration initiatives.

The no-action alternative does not meet the completeness criterion because it does not provide any means to realize the planning objectives of this feasibility study.

Plan A does not meet the effectiveness criterion because it does not achieve any of the planning objectives.

Plan A is the least efficient alternative because it is estimated to result in a net economic loss to the nation. Plan A would not produce any benefits but would result in increased costs to protect infrastructure in the study area.

Plan B
Plan B is more acceptable than Plan A, but it does not fully address this criterion. Plan B does not meet the acceptability criterion because it does not include elements that would protect and restore the Biloxi Marsh, a critical landscape feature for storm surge risk reduction. Restoration in this area has been identified as important in previous restoration studies.

Plan B does not meet the completeness criterion because it would require actions by others to realize the planning objectives; i.e. restoration of brackish habitat and the Biloxi Marsh.

The effectiveness criterion is not fully addressed by Plan B because it does not achieve the brackish marsh objective. The restoration features included in Plan B would contribute to restoring ecosystem structure and function.

Plan B is an efficient plan. However, it does not achieve all of the planning objectives, and therefore is not the most efficient means of achieving the objectives.

Plan C
Plan C is acceptable in terms of public law and regulation, in that it provides a plan for ecosystem restoration in areas affected by the navigation channel, consistent with WRDA 2007, Section 7013. Plan C also addresses previously documented public policy as evidenced by CWPPRA, LCA, LACPR, the 2007 State Master Plan, the Louisiana-Mississippi Gulf Coast Ecosystem Restoration Working Group's Roadmap for Restoring Ecosystem Resiliency and Sustainability, and other restoration initiatives.

All actions required to achieve the planning objectives are accounted for in Plan C, and it is not significantly dependent on the actions of others. Plan C is a complete plan that would enhance the overall goals of coastal restoration by complementing other restoration efforts.

Plan C meets the effectiveness criterion because it achieves all of the planning objectives and would significantly contribute to restoring ecosystem structure and function. Plan C is a complete plan for the Lake Borgne ecosystem and the areas affected by the MRGO. The restoration features included in Plan C work with existing and authorized projects to restore and protect the Lake Borgne ecosystem.

Plan C is the most efficient means of achieving the objectives because it is the least-cost Best Buy plan that meets all of the study objectives.

Plan D
Plan D is slightly more acceptable than Plan C, because it includes more restoration features desired by the public. Plan D does not violate public laws and regulations.

Plan D is a complete plan that is not significantly dependent on the actions of others, and would enhance the overall goals of ecosystem restoration.

Plan D is slightly more effective than Plan C because it includes more features that would contribute to restoring ecosystem structure and function.

Plan D is a cost effective means of achieving the objectives of the study, but due to increased incremental costs compared to Plan C, it is not the most efficient.

2.9.2 Comparison to Recommendations in LCA, LACPR, and the 2007 State Master Plan

WRDA 2007 Section 7013(B)(iv) states that the MRGO Ecosystem Restoration Plan recommendations should include efforts to integrate with LCA and the analysis and design in LACPR. The authorization for LACPR was directed to be consistent with the 2007 Louisiana State Master Plan. The final array of alternatives was compared to these plans to determine consistency with other restoration efforts. Consistency with these plans also contributes to the completeness and acceptability of the plan. Additionally, the public significance of the resources protected and restored by the plan is demonstrated by consistency with other plans.

Introduction of Sediment into the Central Wetlands (LCA, LACPR and 2007 State Master Plan): Plan B includes 10,431 acres of swamp restoration in the Central Wetlands. Plans C and D also include 3,281 acres of marsh restoration in the Central Wetlands. The placement of dredged material is one component of the restoration strategy for the area.

Introduction of Sediment into the Golden Triangle (LCA, LACPR, and 2007 State Master Plan): Plan B includes 4,017 acres of restoration in the Golden Triangle. Plans C and D include the restoration of over 4,469 acres of marsh in the Golden Triangle.

Opportunistic use of Bonnet Carré Spillway (LCA and LACPR): The State of Louisiana is historically opposed to large freshwater diversions at this location. A small diversion at Bonnet Carré would not meet the salinity objective for this study. Any size diversion at this location would be less effective than closer locations to sustain salinity conditions and restoration in the project area. Cypress and fresh marsh restoration in the Central Wetlands would not receive direct inputs from Bonnet Carré, and could not be as effectively adaptively managed. Therefore, this location was removed from further study under this effort. A freshwater diversion at Bonnet Carré is still authorized and may be re-assessed in future studies.

Marsh Restoration on East Orleans Landbridge (LCA and LACPR): Plan B includes 5,100 acres of restoration and protection in the East Orleans Landbridge and the Pearl River areas. Plan C includes over 11,222 acres of marsh restoration and shoreline protection in this area. Plan D includes 11,926 acres of restoration and protection in the vicinity.

Mississippi River Gulf Outlet (MRGO) Environmental Restoration Features (LCA and LACPR): Shoreline protection features in the MRGO were originally not included in Plan B and C. The incremental cost of these features exceeded the ecological benefits. All shoreline protection features on the south shore of the channel were removed from further consideration, as these features did not provide any ecological benefits because they are located on the levee side of the MRGO. Additionally, maintenance of shoreline protection features adjacent to levees would be conducted as needed as part of levee maintenance. Several options for shoreline protection on the north shore were evaluated and included in the minimum planning increment.

Breton Sound Marsh Restoration (LACPR and 2007 State Master Plan): Plan B includes 5,153 acres of restoration in the marsh adjacent to Breton Sound. Plans C and D include 12,252 acres of restoration in the marsh adjacent to Breton Sound.

Biloxi Marsh Restoration and Protection (LACPR and 2007 State Master Plan): Plan B does not include any restoration features in the Biloxi Marsh. Plan C includes 8,000 acres of marsh restoration and approximately 24 miles of shoreline protection in the Biloxi Marsh. Plan C includes approximately 7 more miles of shoreline protection in the Biloxi Marsh than Plan C. The areas targeted for restoration in Plans C and D differ from those proposed in LACPR.

Bayou La Loutre Ridge Restoration (LACPR and 2007 State Master Plan): 54 acres of ridge restoration along Bayou La Loutre are included in all of the action plans. However, ridge restoration to the extent proposed in LACPR and 2007 State Master Plan was not cost-effective.

Maintain MRGO – Lake Borgne Landbridge (2007 State Master Plan): Plan B includes 2,945 acres of marsh restoration on Proctor Point and 2,816 acres or marsh restoration on the Lake Borgne / MRGO Landbridge. Plans C and D also include these features and approximately 9 miles of shoreline protection along Proctor Point.

Mississippi River Diversion at Violet (2007 State Master Plan): All of the action alternatives are consistent with this recommendation.

Bayou Bienvenue Diversion (LACPR): This diversion was developed to target land-building in the marshes on the East Orleans Landbridge in LACPR. Flows examined in LACPR ranged from an average flow of 5,000 cfs in a low flow year to 175,000 cfs pulse in a high flow year. Planning for the Violet, Louisiana Freshwater Diversion for this study is consistent with this feature.

Lake Borgne and East Orleans Landbridge Shoreline Protection (LACPR): Plan B does not include any shoreline protection features in Lake Borgne or the East Orleans Landbridge. Plans C and D include approximately 33 miles of Lake Borgne shoreline protection and approximately 10 miles of Lake Pontchartrain shoreline protection along the East Orleans Landbridge.

Rehabilitate Violet Siphon and Post-Authorization Change for the IHNC to divert Freshwater into the Central Wetlands (LCA): Preliminary analyses indicate a rehabilitation of the Violet Siphon and/or diversion from the IHNC would not meet the salinity objectives in the Biloxi Marsh and Western Mississippi Sound established for the study. The Violet, Louisiana Freshwater Diversion as authorized in WRDA 2007 Section 3083 is anticipated to restore cypress in the Central Wetlands as well as establish an optimal salinity regime.

Plans C and D are consistent with the recommendations made in the LCA and LACPR Reports. Plan D is the most consistent because it includes restores more acres than Plans B and C. Plan B is the least consistent, as it does not include features in the Biloxi Marsh or shoreline protection features in Lake Borgne and the East Orleans Landbridge.

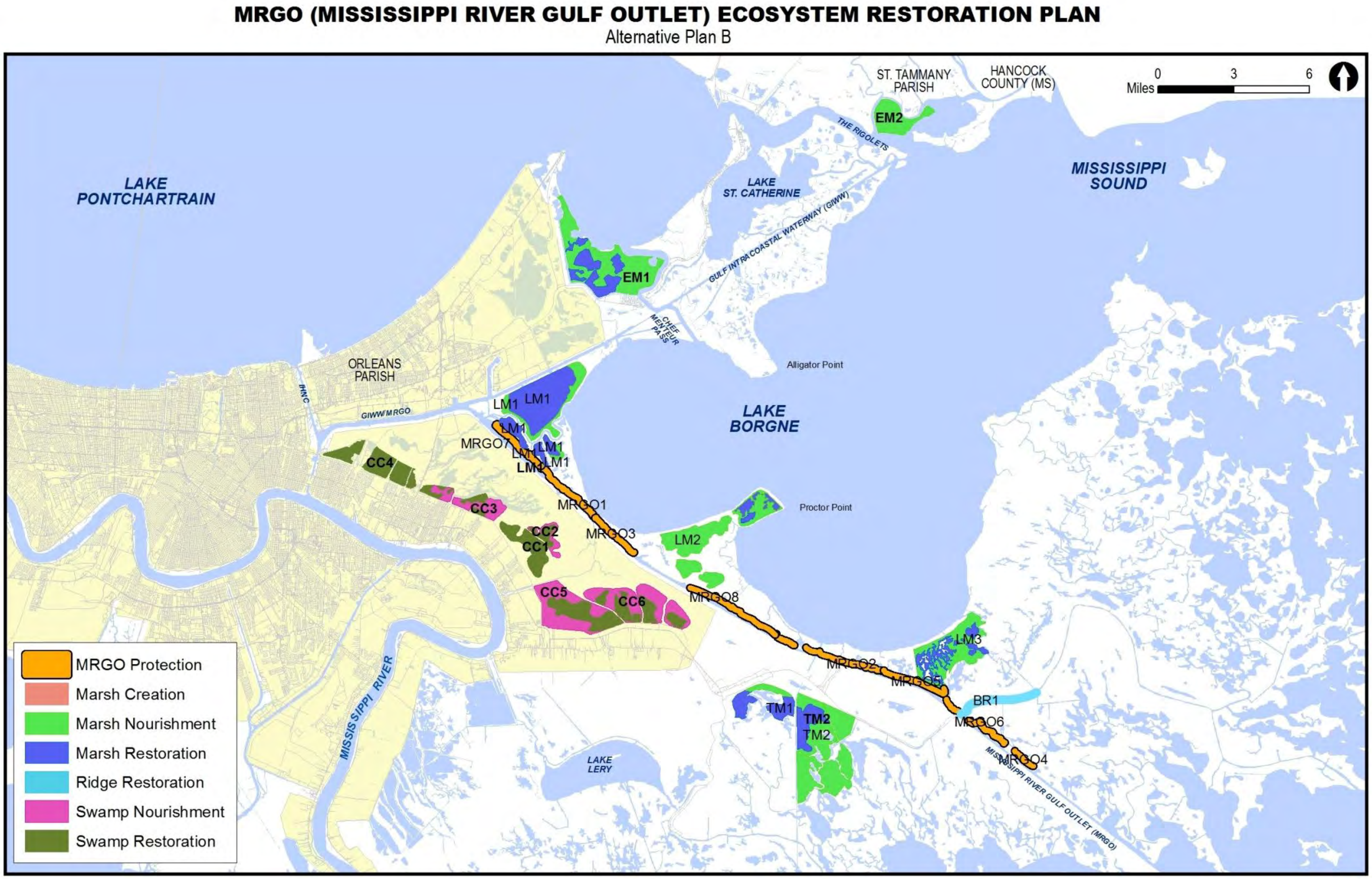


Figure 2-34. Alternative B

MRGO (MISSISSIPPI RIVER GULF OUTLET) ECOSYSTEM RESTORATION PLAN
Alternative Plan C

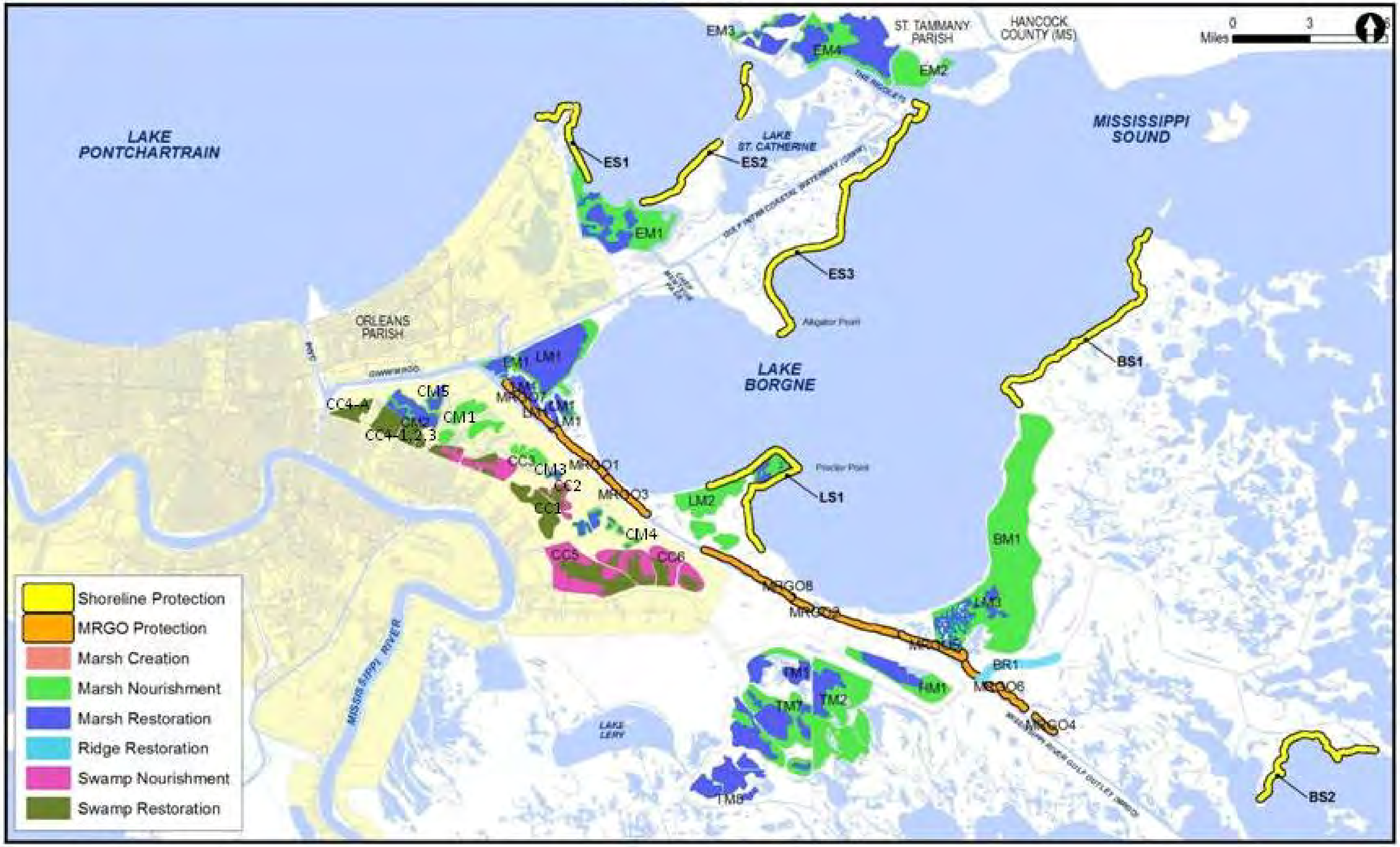


Figure 2-35. Alternative C

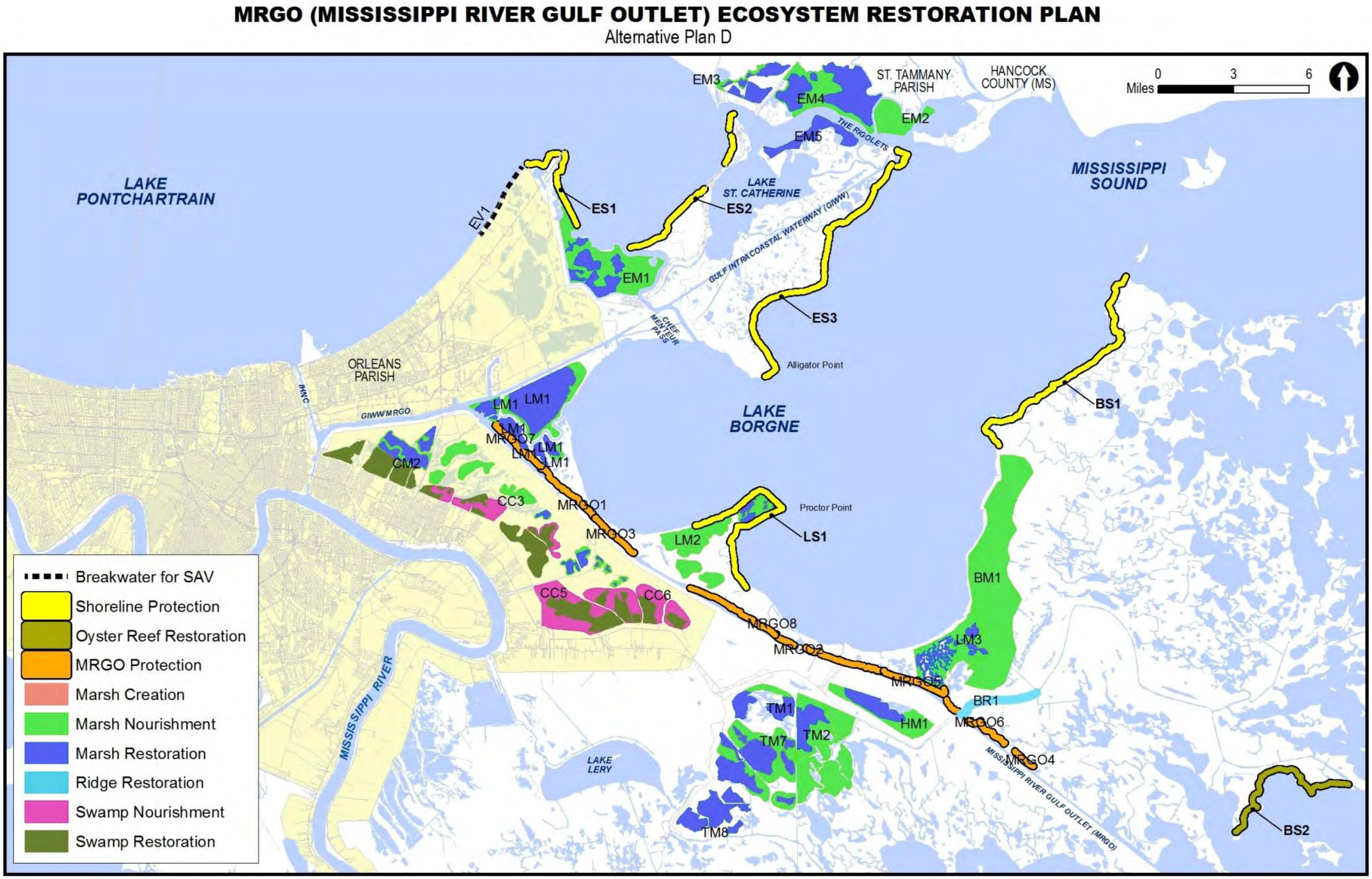


Figure 2-36. Alternative D

2.10 IDENTIFICATION OF THE FEDERALLY IDENTIFIED PLAN

Plan C is the Federally Identified Plan (FIP) and NER plan as determined by all of the evaluation criteria discussed in Section 2.8. Selecting the NER plan requires careful consideration of planning goals, objectives, and constraints. The NER plan reasonably maximizes environmental benefits considering cost effectiveness and incremental cost analyses, significance of outputs, completeness, efficiency, effectiveness and acceptability. Section 7013 of WRDA 2007 requires the MRGO Ecosystem Restoration features of the plan to be cost effective, environmentally acceptable, and technically feasible determined by the Secretary of the Army for Civil Works.

Plan C is the FIP and NER plan for this study because it is the lowest cost alternative that meets all of the study objectives and provides a complete plan to restore the structure and function of the Lake Borgne ecosystem. Other plans were evaluated that provide additional benefits, but the increases in costs were not considered reasonable given the relative outputs. Plan C is cost-effective, and maximizes the opportunities to achieve the objectives of the study for the least cost. The incremental costs associated with Plan C are considered reasonable for the significance of the outputs achieved.

Plan C protects and restores the portions of the Lake Borgne ecosystem that are not addressed by existing and authorized restoration projects. Existing and authorized shoreline protection projects along the shores of Lake Borgne do not comprehensively address erosion in the lake. Plan C would provide protection in the areas between existing and authorized projects to stabilize the entire shore of Lake Borgne. Marsh restoration features included in Plan C would work synergistically with existing and authorized projects to restore the structure of the Lake Borgne ecosystem.

Although it is not feasible to restore the area to a historic condition, the FIP would restore and significantly improve the areas affected by the navigation channel. Plan C would restore and protect approximately 57,472 acres of habitat in the study area, including 14,123 acres of fresh and intermediate marsh; 32,511 acres of brackish marsh; 10,430 acres of cypress swamp; 466 acres of saline marsh; and 54 acres of ridge habitat. Plan C provides 71 miles of shoreline protection in Lake Borgne, along the MRGO, and in the Biloxi Marsh, including 5.8 miles of oyster reef restoration in the Biloxi Marsh.

Implementing the FIP is anticipated to restore significant ecosystem function, structure, and processes through a comprehensive systems-based approach. The FIP would restore unique habitat in a nationally significant watershed. The FIP has significant costs, and would represent a continuing national commitment to the restoration of one of the Nation‘s most productive estuaries. There is no construction cost associated with the No Action Alternative; however, the loss of unique habitat and natural resources that would result from this alternative would represent unacceptable costs to the Nation.

The FIP would restore rare and unique habitat, including coastal ridge, cypress swamp, and fresh marsh. These habitat types are institutionally and technically significant due to relative scarcity and importance. Wetlands of national interest, including those found in the Bayou

Sauvage National Wildlife Refuge and the Pearl River and Biloxi Wildlife Management Areas, would be restored by the FIP.

Current and past Administrations have repeatedly demonstrated a commitment to Louisiana coastal restoration. President Barack Obama made the following statement during his 2009 visit to the Gulf Coast:

> *"We've already seen 220 miles worth of levees and flood walls repaired, and we are working to strengthen the wetlands and barrier islands that are the first line of defense for the Gulf Coast. This isn't just critical to this region's physical protection, it's critical to our environment, it's critical to our economy."*
> - President Barack Obama, October 15, 2009

The nation derives significant benefits from the coastal Louisiana ecosystem: protection for the production and transport infrastructure for about 30 percent of the nation's oil and gas supply; the Nation's second largest commercial fishery; and navigation and port facilities which together support America's number one port complex by tonnage.

2.11 DESCRIPTION OF THE FEDERALLY IDENTIFIED PLAN

Plan C would restore and protect 57,472 acres of habitat, including 10,318 acres of cypress swamp, 14,123 acres of fresh and intermediate marsh, 32,511 acres of brackish marsh, 466 acres of saline marsh, and 54 acres of ridge habitat. Plan C includes 71 miles of shoreline protection (including 5.8 miles of artificial oyster reef).

Approximately 11,222 acres of the restoration and protection features would be located in the East Orleans Landbridge/Pearl River area and approximately 9,012 acres of restoration features would be located in the Biloxi Marsh area, which have been determined to be critical landscape features with respect to storm surge. Additionally, the cypress swamp and ridge restoration feature would include forested habitat, which has been demonstrated as having some storm surge damage risk reduction benefits.

Salinity is a key ecosystem driver. Additional study of the Violet, Louisiana Freshwater Diversion, as authorized for design and construction in WRDA 2007 Section 3083, is recommended. This project may be a means of restoring river flooding processes that would enhance system sustainability through freshwater, nutrients and sediment inputs.

2.12 BORROW SITES

The implementation of the FIP would require a significant amount of sediment. Figure 2-37 illustrates the proposed borrow site for each feature included in the FIP.

Borrow sites would be located a minimum of 3,000 feet from the Lake Borgne shoreline to minimize potential impacts to hydraulic conditions (e.g., wave climate), and to avoid existing oyster leases to the extent practicable. Borrow material would be excavated with a hydraulic dredge and transported via pipeline to wetland creation and nourishment sites. Designated borrow areas are estimated larger than needed for each feature to ensure that adequate material is available in the event that environmental or cultural resources are discovered during PED that require avoidance. Borrow areas would be designed to minimize hypoxic (lack of dissolved oxygen) formation.

A phased implementation plan is proposed to remove borrow material from Lake Borgne. Borrow would be removed from the lake gradually over 10 implementation cycles that would allow no more than 2.5 percent of the lake bottom to be impacted during any given implementation cycle. The borrow plan limits dredging to one lobe of Lake Borgne per implementation cycle, therefore isolating increased turbidity to one lobe of the lake. As a new implementation cycle is being initiated, the borrow areas disturbed in the previous cycle for that lobe would have recovered sufficiently to support foraging and to allow benthic species to recover between implementation cycles.

In consultation with NMFS, two years of water quality monitoring are included in the plan. Three test borrow pits would be constructed in implementation cycle 1. Pit 1 would be constructed to 15 feet deep below the water surface, Pit 2 would be constructed to the proposed depth of 20 feet deep below the water surface, and Pit 3 would be constructed to approximately 25 feet deep below the water surface. After the borrow pits are constructed, monthly water quality monitoring would be used to determine if hypoxia formation was occurring within the borrow pits. When monitoring is complete, the remaining borrow pits would be adjusted to ensure that hypoxia formation would not result within the remaining borrow pits. The design of the borrow pits and water quality monitoring is proposed to ensure that impacts to the water quality of Lake Borgne would be temporary and localized. In addition, USACE will collect data describing Gulf sturgeon movements within the Lower Pontchartrain Sub-basin and recovery rates of Gulf sturgeon prey species in response to re-colonization of muddy-sand substrate that would assist in future assessments of impacts to Gulf sturgeon prey items.

2.13 IMPLEMENTATION APPROACH

Three areas of uncertainty were identified as most likely to affect ecological success and sustainability: salinity, implementation, and increased RSLR. Based on these factors, features were divided into tiers.

- Tier 1 includes features that have been developed to a feasibility level of detail and are not dependent on a freshwater diversion. Tier 1 features are recommended for construction through the WRDA 2007 Section 7013 authority upon the identification of a non-Federal sponsor.
- Tier 2 includes features with feasibility level detail that are dependent upon salinity conditions but may be sustainable without the implementation of a freshwater diversion. If future conditions and further analysis indicate that favorable conditions for ecological success and long term sustainability exist (as defined in the adaptive management plan[2]), then these projects may be constructed. Tier 2 features would be constructed through the WRDA 2007 Section 7013 authority upon the identification of a non-Federal sponsor.
- Tier 3A includes further study of the Violet, Louisiana Freshwater Diversion under the WRDA 2007 Section 3083 authority. The non-Federal cost-share responsibilities for the Violet, Louisiana Freshwater Diversion would be consistent with the 75 percent/25

[2] Average annual salinity: fresh marsh: <1.1 parts per thousand (ppt); intermediate marsh: <4.1 ppt; brackish marsh: <8.3 ppt, and swamp <4.0.

percent Federal/non-Federal cost share identified in Section 3083 of WRDA 2007, together with such other items of cost-share responsibilities as may be identified in the Feasibility Report for the project, as approved by the decision of the Chief of Engineers. Presently, as identified in the 1984 Chief's Report for *Mississippi and Louisiana Estuarine Areas Freshwater Diversion to Lake Pontchartrain and Mississippi Sound Feasibility Study*, the 25 percent non-Federal share of the cost of the design and implementation of the Violet, Louisiana Freshwater Diversion project is allocated 80 percent to the State of Louisiana and 20 percent to the State of Mississippi. It is not anticipated that this allocation will change as a result of completing the feasibility study for the project; however, if it does, the change in allocation will be addressed in the study, as approved by the decision of the Chief of Engineers.

- Tier 3B includes any features that are dependent on freshwater diversion, and features in Tier 2 that future conditions and further analyses indicate are not sustainable. Subsequent to the completion of Tier 3A, Tier 3B features would be constructed through the Section 7013 authority upon the identification of a non-Federal sponsor.

Salinity

Salinity is a specific source of potential analytical variability because salinity in the study area is changing. For instance, salinity in the MRGO in the vicinity of the Central Wetlands was reduced to approximately 4 to 7ppt following the closure of the MRGO. Coastwide Reference Monitoring Stations indicate that Central Wetlands salinity is lower than 4ppt and is continuing to decline. Contributing factors include the closure of MRGO, the closure of Bayou Dupre during the construction of the Chalmette Loop Levee, the construction of the IHNC Surge Barrier, and the concurrent operation of the existing Violet Siphon. FWOP scenarios include the baseline conditions at Violet Siphon, Caernarvon, and Bonnet Carré Spillway leakage and openings. Planned diversions at Maurepas Swamp (Convent/Blind River, Hope Canal/Maurepas Swamp River Reintroduction), Caernarvon operation modifications, and the Central Wetlands Wastewater Treatment Program are also included in the FWOP conditions.

Salinity is changing in the study area. Current conditions in the Central Wetlands are optimum for intermediate marsh species and the FWOP scenario predicts that conditions will be favorable for fresh marsh species and cypress swamp in the future. However, because conditions are variable and assumptions may not be accurate, all features that are dependent upon salinity conditions or freshwater diversions to be sustainable are not included in Tier 1.

Implementation

Following the identification of the FIP, a construction sequence was developed. Assumptions factoring into the construction sequence include production rates for building rock projects, dredge equipment availability, land loss rates, and the limitation of alternating dredging cycles in the lobes of Lake Borgne.

The timing and availability of financial resources for implementation is a major uncertainty that must be considered given current Federal budgetary constraints. If the plan is not implemented in the near future, conditions will continue to degrade. The impact of the uncertainties associated with the future condition of the study area could increase restoration costs, decrease restoration benefits, or both. The uncertainties associated with implementation are increased because a non-Federal sponsor has not been identified.

Funding assumptions, as detailed in the Engineering Appendix, were required for planning purposes and to develop costs and benefits for the plan. Construction sequencing assumed optimal funding appropriations and an aggressive schedule to complete implementation as soon as realistically possible. Given the considerable need for the plan, Federal interest, significance of resources, and the conditional authorization for implementation, an aggressive implementation sequence was considered appropriate. The implementation of the HSDDRS demonstrates National interest in study area resources and the magnitude of what can be achieved when stakeholders are united in purpose. However, current budgetary conditions and the lack of a non-Federal sponsor make it very likely that reality will differ from these optimal assumptions. Risk and uncertainties related to implementation have been assessed in the Cost Risk Analysis, as detailed in the Engineering Appendix. However, due to uncertainties associated with the timing and availability of funding for the plan, only features that are sustainable without the implementation of any other feature are recommended for construction at this time.

Increased Relative Sea Level Rise

A detailed WVA analysis of the three relative sea level rise scenarios was performed for the FIP. Table 2-31 below shows the net acres projected under each of the three relative sea level rise scenarios based on feature locations.

Table 2-31. Robustness of Features in FIP under All Relative Sea Level Rise Scenarios*

	LOW RSLR		MEDIUM RSLR		HIGH RSLR	
Features	**AAHU**	**Net Acres**	**AAHU**	**Net Acres**	**AAHU**	**Net Acres**
Biloxi Marsh (BM1, BS1-2)	1,685	1,819	1,948	602	401	0
Bayou La Loutre Ridge (BR1)	33	19	34	55	49	55
Central Wetlands Marsh (CM1-5)	5,275	2,593	9,289	5,668	8,934	0
Central Wetlands Swamp (CC1-6)	4,600	6,387	4,843	9,577	5,584	11,332
East Orleans Landbridge (EM1, ES 1-3)	2,110	1,568	1,612	581	718	0
Lower Pearl River (EM2-4)	419	3,379	505	1,303	121	0
Lake Borgne (LM1-4, LS1)	18,112	7,965	18,034	11,940	10,021	0
Hopedale (HM1)	176	736	192	286	70	0
Terre Aux Bouefs (TM1-2, 7-8)	1,595	5,123	1,678	2,008	519	0
TOTAL	**33,839**	**29,353**	**37,980**	**31,930**	**26,322**	**11,387**
* All benefits in this table include the influence of the authorized Violet, Louisiana Freshwater Diversion.						

Although it may seem counterintuitive that some AHHUs and net acres for some features increase as relative sea level rise increases, the reason is that the WVA calculation subtracts existing and future without project marsh acres from project footprints. As relative sea level rise increases, future marsh acres decrease. For example, the ridge produces 55 net acres. Under the historic (low) rate of sea level rise, the ridge would replace 36 acres of marsh that is anticipated to continue to exist in the future; therefore the net acres are 19. In the medium and high sea level rise scenarios, no marsh acres are anticipated to exist in the FWOP condition, therefore, 55 net acres are produced.

Under the medium scenario, the cost-effectiveness of all of the action plans would decrease. The medium scenario requires more OMRR&R actions than the historic rate of sea level rise. The alternative to increased maintenance would be significantly reduced benefits. The plan includes OMRR&R and adaptive management measures that are anticipated to maintain predicted benefits under the low and medium sea level rise scenarios.

The diminished output of the FIP under the high RSLR scenario necessitates a systematic approach to assess and respond to the high level of sea level rise scenario. Sea level rise rates will be monitored in the pre-construction, construction, and post construction phases. Data will be evaluated at key decision points. An assessment of relative sea level rise trends would be made prior to partnership agreements, PED, construction award and any cost shared Adaptive Management actions. If at any time data indicate that the high level of RSLR is occurring , additional Federal investments in the plan would be re-assessed.

Priority of Features for Tier 1

The first features proposed for implementation in Tier 1 are LS1, MRGO1, and MRGO6 because these areas are critical for ecosystem structure (maintaining the MRGO landbridge), subject to high rates of erosion, in close proximity to the MRGO, and are currently unprotected. The next features proposed for construction are located in areas that have been identified as critical landscape features, including BS1, BS2, ES1, ES2, ES3, BR1, EM2, EM3, and EM4. These geographic areas are significant structural elements to maintain ecosystem function and reduce storm surge damage risk. The shoreline protection features fill in gaps between existing and planned projects to provide a complete plan to address erosion along Lake Borgne and the East Orleans Landbridge. Most of the features in the second priority phase are in areas of relatively low land loss rates, and are therefore more sustainable. Feature BR1 is considered one of the most sustainable features under the high RSLR scenario because of its elevation. Features HM1, TM1, TM2, TM7, and TM8 are the next features proposed for implementation because they are located in interior areas that are less susceptible to sea level rise. In the last phase of Tier 1, the one-time repair of existing shoreline protection projects MRGO2, MRGO3, MRGO4, and the Shell Beach recreation feature associated with MRGO2 are proposed for implementation. These features are the lowest priority within Tier 1 because they currently have some protection.

Priority of Features for Tier 2

In Tier 2, features inside the HSDRRS are prioritized for construction. These features are considered to be more likely to exhibit favorable conditions for ecological success and sustainability because of their location behind existing infrastructure that provides protection from storms and saltwater intrusion. These features include CC4-A, CC4 (Sites 2, 3, 4), CM2, CM5 , LM4 and the Bienvenue Triangle recreation feature associated with CC4-A. The features in the Central Wetlands included in Tier 2 are located north of Paris Road and therefore have more barriers to saltwater intrusion than features south of Paris Road. Feature CC4-A is considered the highest priority in this tier because of high public interest, proximity to the City of New Orleans, and its educational value.

Priority of Features for Tier 3

Further study of the Violet, Louisiana Freshwater Diversion as authorized by WRDA 2007 Section 3083 is designated as Tier 3A because it is the highest priority for Tier 3, as all of the features in Tier 3B are dependent upon the implementation of a freshwater diversion for salinity or to ensure long-term sustainability. Implementation priority of these features would be determined following additional analysis.

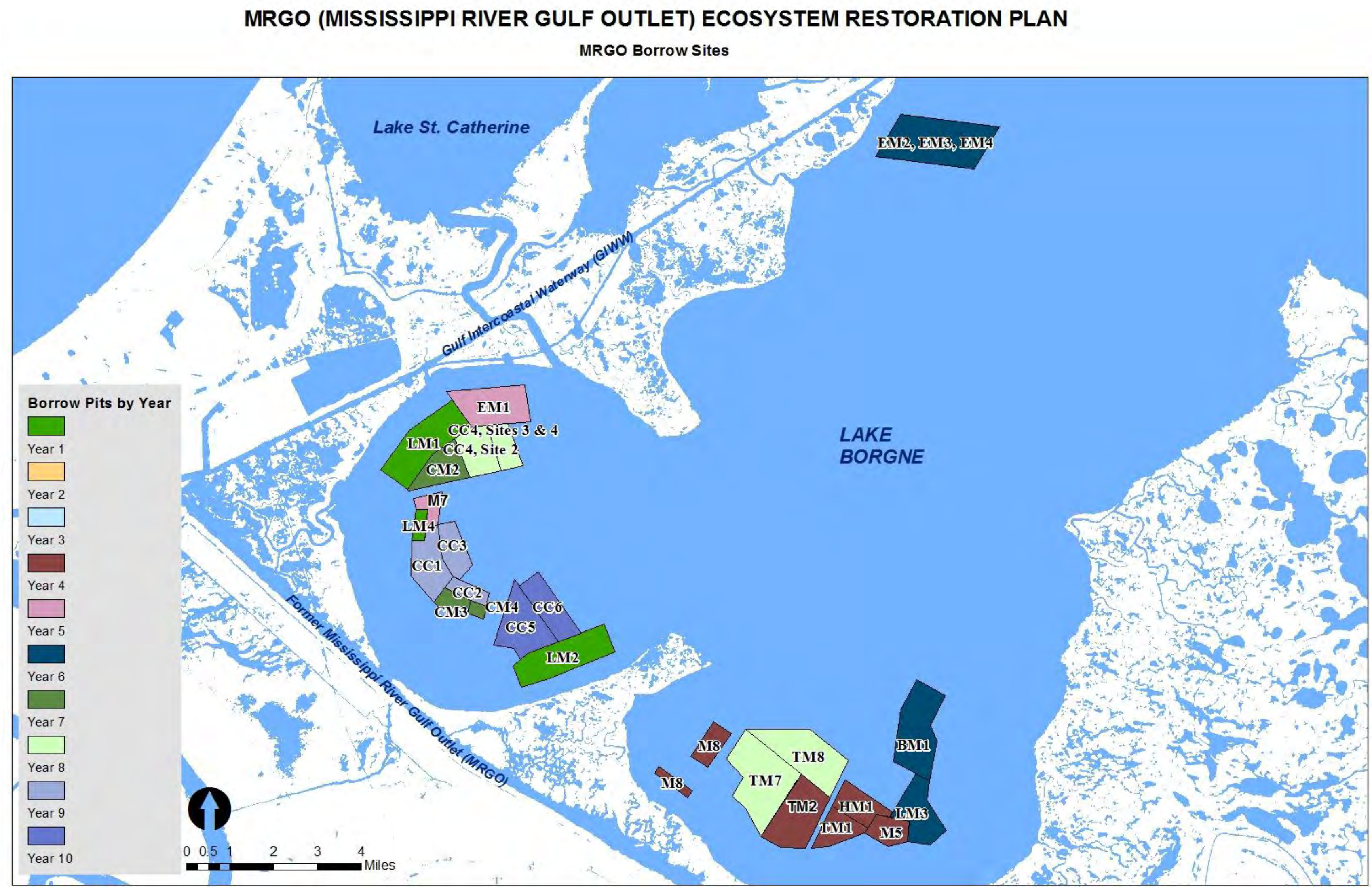


Figure 2-37 Borrow Sites for Federally Identified Plan

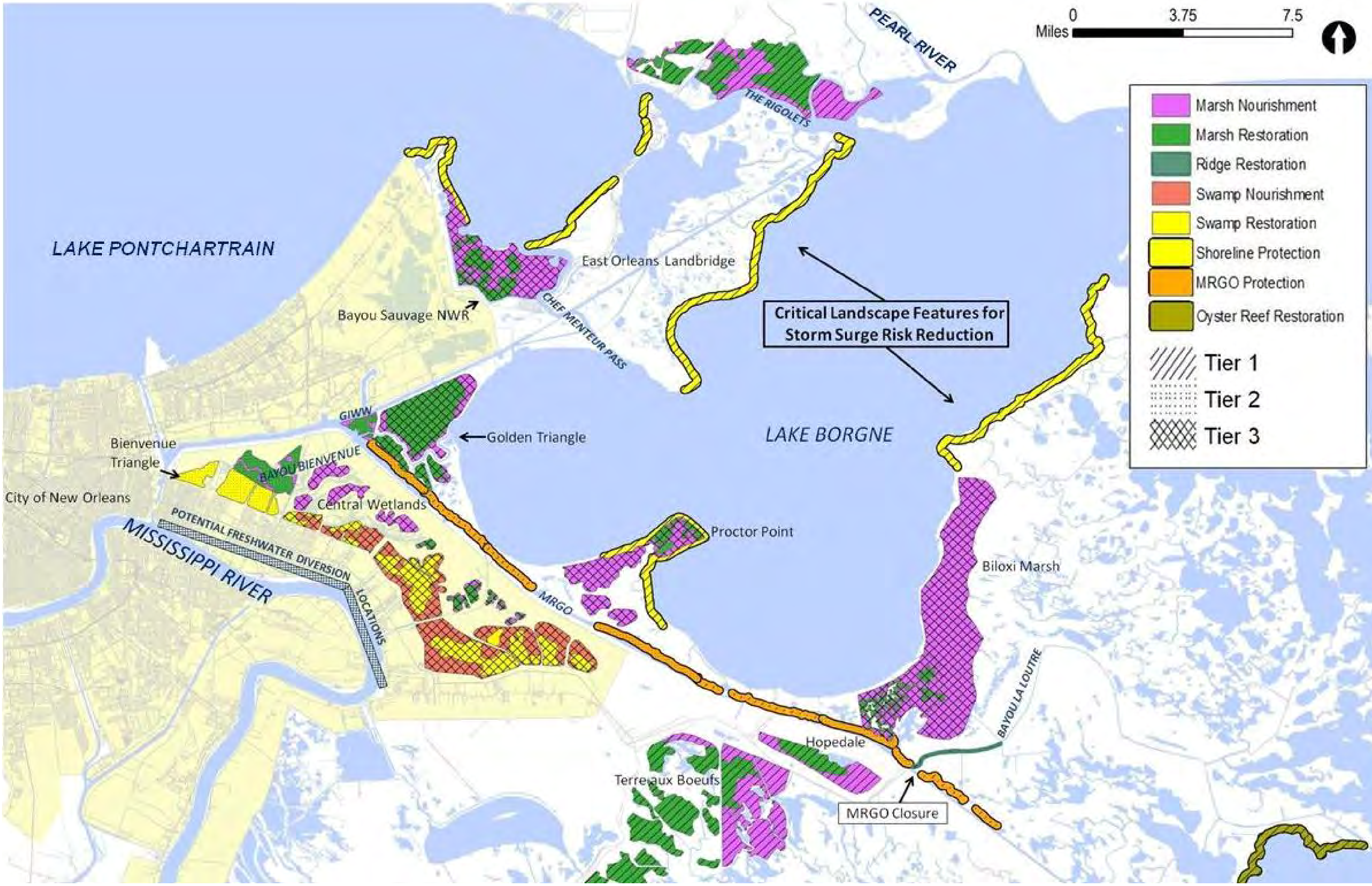


Figure 2-38 Implementation Sequence for Federally Identified Plan

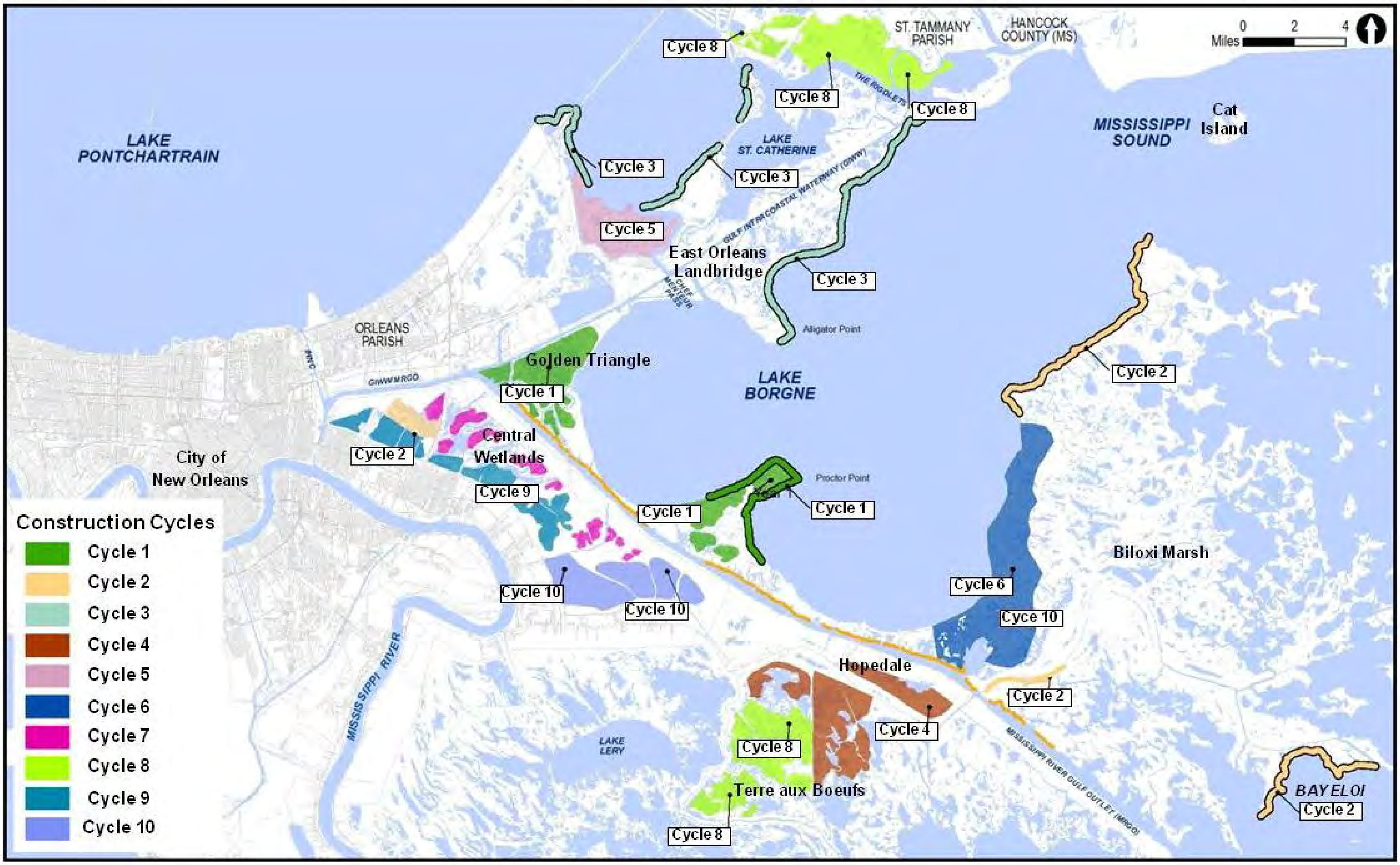


Figure 2-39 Construction Sequence for Federally Identified Plan

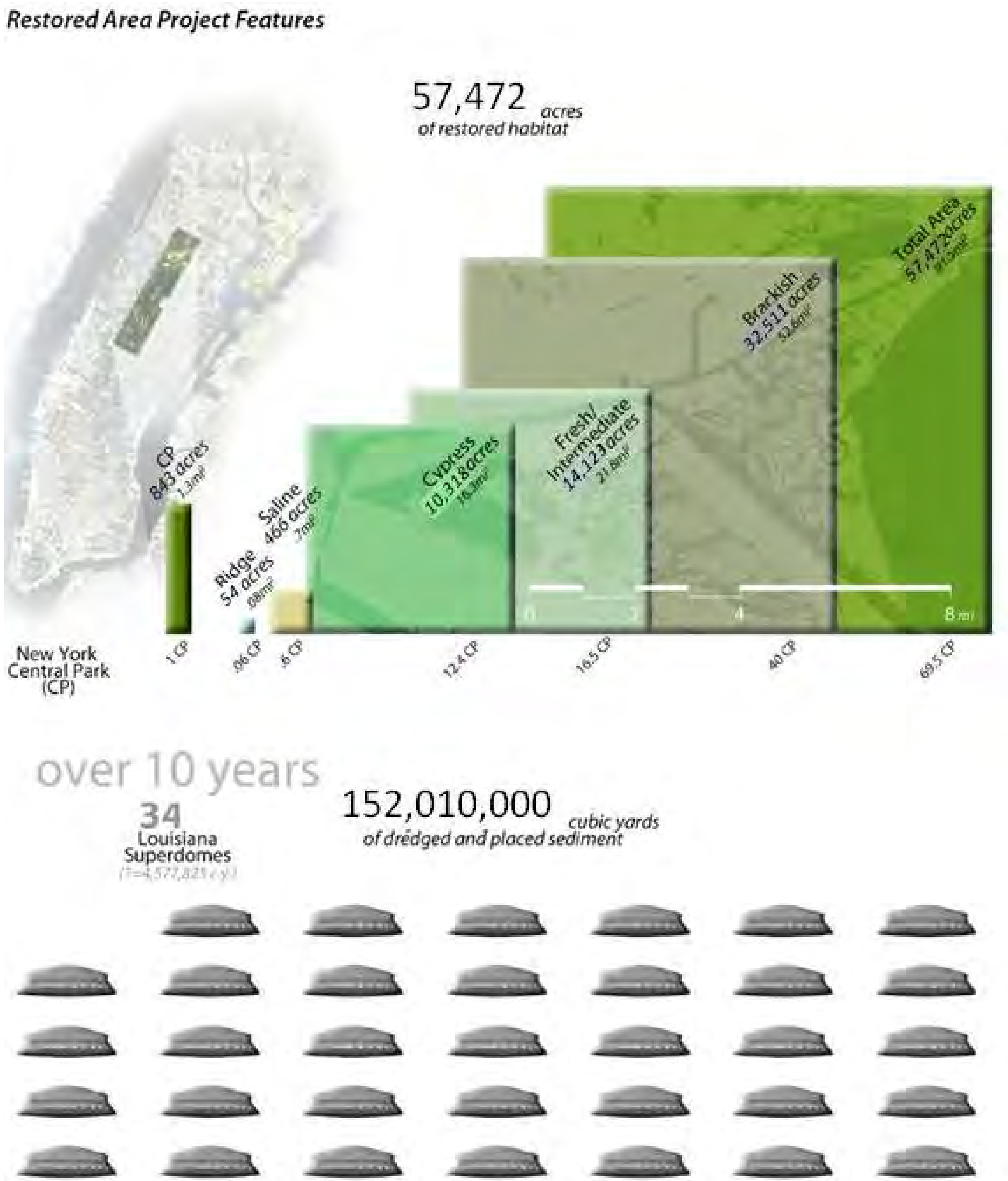


Figure 2-40. Restoration and Dredged Material Quantities

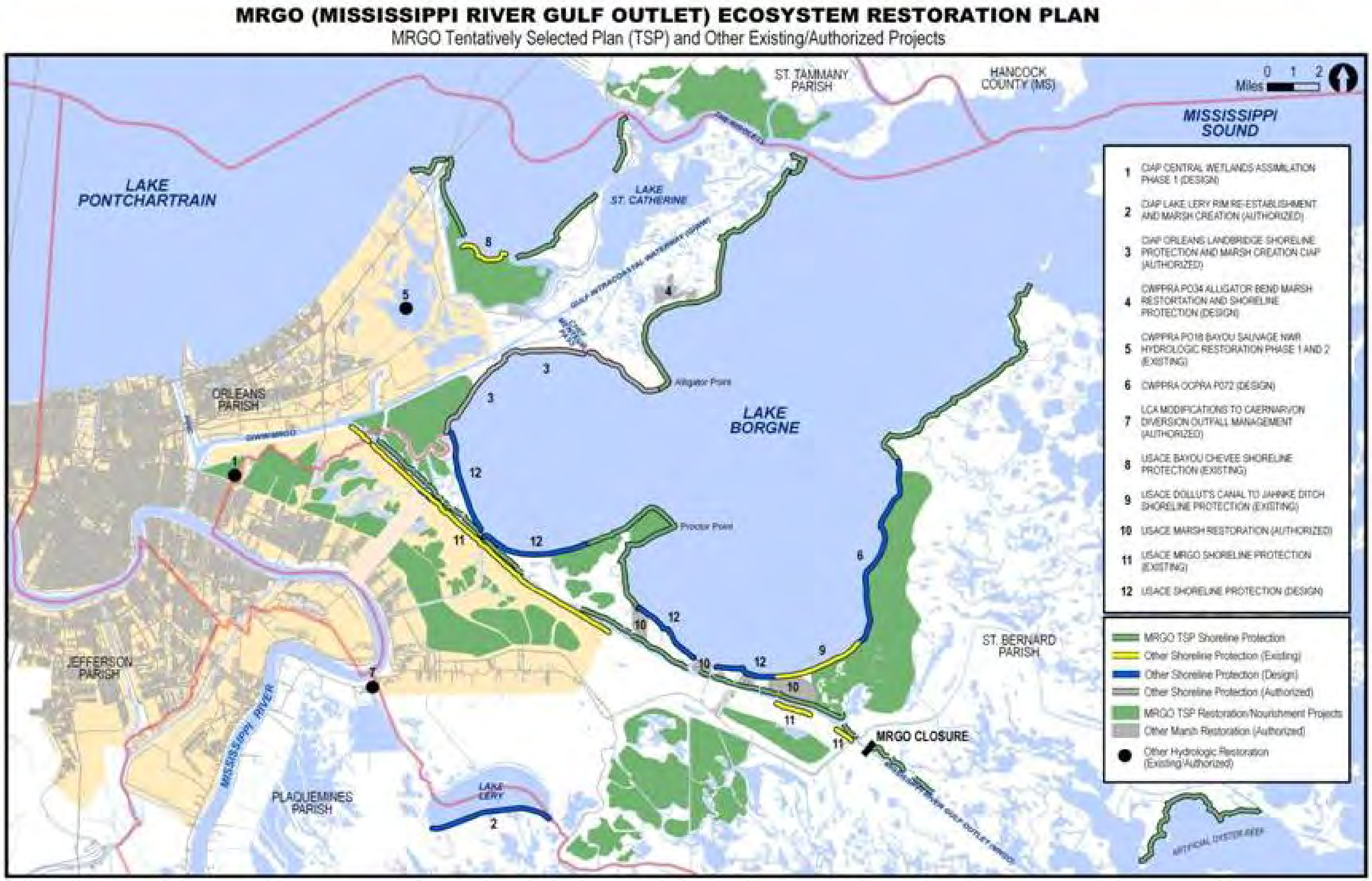


Figure 2-41. Federally Identified Plan and Actions by Others

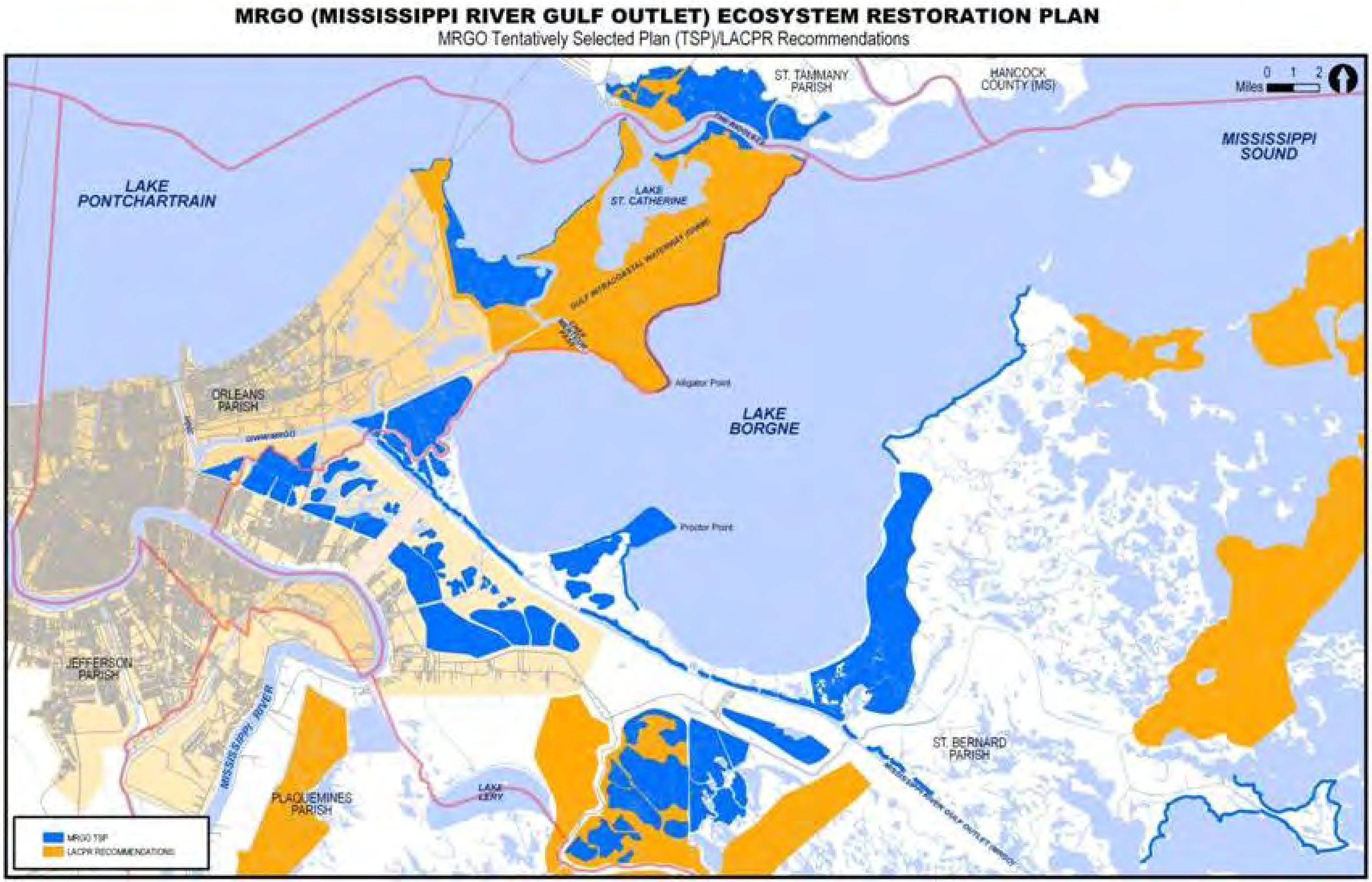


Figure 2-42. Federally Identified Plan and LACPR Recommendations

3 SUMMARY OF COORDINATION, PUBLIC VIEWS AND COMMENTS

3.1 COLLABORATIVE PLANNING

In accordance with EC 1105-2-409 (Planning in a Collaborative Environment) representatives of Federal and State agencies have been invited to be members of the Project Delivery Team (PDT) and the Interagency Team. Federal and State agencies are also involved through the NEPA process, with some agencies serving as official cooperating agencies and other agencies with official coordination and consultation roles.

3.2 PROJECT DELIVERY TEAM (PDT)

The PDT is a multi-disciplinary, multi-agency team responsible for the successful development and execution of all aspects of the study. The PDT is led by the USACE (New Orleans District) Senior Planner. USACE team members include Functional Team Leads (New Orleans and Mobile Districts) and USACE District Support Teams and Regional Integration Teams in Vicksburg, Atlanta, and Washington, D.C. The PDT also includes the Interagency Team, internal and external review teams, and Federal and State agency representatives. The PDT facilitates the interagency collaboration and coordination necessary for study execution. NEPA coordination with Federal and State agencies will occur through the PDT. Agency team members will provide guidance and recommendations throughout the planning process to assure the successful delivery of a quality product. The PDT will expand as necessary to include all necessary expertise for study execution. Some agency PDT members may also serve on the Interagency Team or as NEPA cooperating agencies.

3.3 INTERAGENCY TEAM PARTICIPATION

The Interagency Team is part of the PDT and is composed of resource agency representatives. The Interagency Team performs planning and technical assessments consistent with their agency responsibilities and expertise. The USACE (New Orleans District) Environmental Manager leads the Interagency Team. The Interagency Team is involved at all stages of the planning process, and will assist with the development, evaluation, and analysis of project alternatives. The Interagency Team will participate in the public information/involvement program, exchange study information, provide recommendations, and assist in the resolution of any interagency issues that may surface in the study process. Membership on the Interagency Team includes participants from both Louisiana and Mississippi State and Federal agencies as well as USACE members from New Orleans District, Mobile District and ERDC. The State of Mississippi‘s participation has been limited to the Violet, Louisiana Freshwater Diversion.

3.3.1.1 Interagency Team Tasks

The Interagency Team was assigned several responsibilities including the formulation of coastal restoration measures and alternatives; identification of screening criteria for evaluating the restoration plan; and quantification of the environmental impacts and benefits of those plans.

3.4 NEPA COOPERATING AGENCIES

Cooperating Agencies (as defined under 40 CFR 1501.6) include: USFWS, NMFS, NRCS, EPA, and BOE (formerly MMS). Other participating agencies include LDEQ, LDWF, LDEQ, and MDMR.

3.5 AGENCY COORDINATION

Preparation of this restoration plan and environmental impact statement is coordinated with appropriate Congressional, Federal, state and local interests as well as environmental groups and other interested parties.

A project kick-off meeting was held on October 8, 2008, to present the study authority, purpose, goals and objectives. Federal, state and local agencies from Mississippi as well as Louisiana participated in the discussions.

Agencies were invited by email on August 27, 2008, and letter dated October 23, 2008, to participate in the study as cooperating agencies and provide a team member for the PDT as well as the Interagency Team. Informal agency coordination meetings will be held throughout the study to discuss issues and clarify information.

3.6 PUBLIC INVOLVEMENT ACTIVITIES TO DATE

3.7 STUDY WEBSITE

The MRGO website, http://mrgo.gov, is dedicated to the many aspects of the MRGO, including the Ecosystem Restoration Feasibility Study. In addition to general information about the MRGO, it includes an interactive map, fact sheets, presentations, past documents, posters from public meetings, handouts from public meetings, as well as a calendar of events.

This site was used to announce the NEPA scoping meetings as well as a record of the materials used and distributed at the meetings. In addition, the public was also able to use a comment button on the left navigation pane to submit comment relevant to scoping.

The site is updated as new products and reports are released.

3.8 STAKEHOLDER VISITS

The success of USACE planning efforts depends, to a great extent, on establishing partnerships with stakeholders. Introducing the study is the first step in establishing partnerships and this effort is a key component.

Members of the PDT made appointments with key stakeholders, which included public officials, members of non-governmental organizations, Federal partners, and landowners, to introduce the study through a series of short office visits conducted in advance of the launch of full-scale planning efforts.

3.9 NATIONAL ENVIRONMENTAL POLICY ACT SCOPING

Scoping is a critical component of the overall public involvement program to solicit input from affected Federal, state, and local agencies, Indian Tribes, and interested stakeholders. The NEPA scoping process is designed to provide an early and open means of determining the scope of issues (problems, needs, and opportunities) to be identified and addressed in the Draft Environmental Impact Statement (DEIS). Scoping is the process used to: a) identify the affected public and agency concerns; b) facilitate an efficient DEIS preparation process; c) define the issues and alternatives that will be examined in detail in the DEIS; and d) save time in the overall process by helping to ensure that relevant issues are adequately addressed. Scoping is a process, not an event or a meeting; it continues throughout the EIS (draft and final) process and may involve meetings, telephone conversations, and/or written comments.

A Notice of Intent to prepare a DEIS for the Mississippi River – Gulf Outlet (MRGO) Ecosystem Restoration Plan Study, Louisiana, was published on October 2, 2008, in the *Federal Register* (Vol. 73, No. 192).

A project kick-off meeting was held on October 8, 2008, and public scoping meetings were held on November 3 and 6, 2008.

The scoping comment period began with the filing of the Notice of Intent and continues through release of the DEIS for public comment. Higher participation was received in Chalmette, LA with approximately 79 stakeholders attending. A total of 322 comments were received during the comment period; 257 comments were expressed at the scoping meetings and 65 written (letter, fax and email) and verbal comments were received during the comment period.

The scoping comments were documented in a Scoping Report that describes the public‘s concerns about the restoration effort and strategies for restoration efforts. The Scoping Report is posted on the study website. All restoration strategies suggested during the scoping process were included in the initial array of alternatives. The Scoping Report is available under separate cover and is incorporated by reference in the associated EIS for this study.

There were several reoccurring themes in the NEPA scoping comments. Five themes accounted for 52 percent of the comments received:

- Use sediment diversions and placement for wetland restoration.
- Restore the ecosystem to pre-disturbance/historical condition. 50 percent of these comments specifically mention cypress trees or forests.
- Restoring the first line of hurricane defense for public safety is a priority.
- Restore hydrology.
- Implement/incorporate existing plans.

3.10 STAKEHOLDER FORUMS

USACE Central Wetlands Forum

Over fifty participants attended an open public forum on Central Wetlands restoration projects and concepts at the New Orleans District Assembly Room on April 2, 2009. Attendees included non-governmental organizations, community members, local elected officials, academics, state and Federal agency representatives and USACE representatives. The purpose of the forum was to share information and identify data gaps, discuss the physical requirements for restoration; develop common restoration goals; discuss implementation alternatives; and determine what restoration measures should be evaluated as part of the MRGO Ecosystem Restoration Plan. Presentations were made by the MRGO Ecosystem Restoration Plan PDT, the New Orleans Sewerage and Waterboard, LSU School of Landscape Architecture, and the Environmental Defense Fund.

USACE Recreation Forum

A recreation forum was held at the USACE New Orleans District on September 28, 2009, to gather information in order to estimate the impact of the various restoration measures on the recreational activities of the study area, including fishing, boating, hunting, park or refuge access and usage, area-wide recreational access and usage. Invitations were sent to NGOs, various public agencies and private citizens involved in recreation (charterboat operators, hunting and fishing clubs, boat ramp operators, marinas, etc).

USACE/Lake Pontchartrain Basin Foundation Ridge Restoration Workshop

In partnership with the Lake Pontchartrain Basin Foundation, the USACE co-sponsored a coastal ridge restoration workshop on October 26, 2009. The purpose of the interdisciplinary workshop was to advance the understanding of these coastal restoration features. Issues addressed included: identifying measurable benefits of these features; practical development of design goals; construction techniques; ridge vegetation; and the high probability of cultural resource issues. Ridge restoration opportunities for the MRGO Ecosystem Restoration Plan were discussed at this workshop. Participants included members of the academic community, non-governmental organizations, engineers, planners, landscape architects, and other stakeholders.

St. Bernard Parish Central Wetlands Workshop

The St. Bernard Parish Government hosted a Central Wetlands Workshop on January 6, 2010. Members of the MRGO Ecosystem Restoration PDT participated in the workshop, as well as the District Commander, HPO Commander, and Deputy District Engineer for Project Management. Restoration priorities were identified and alternative implementation strategies were discussed at this workshop.

3.11 NEW ORLEANS DISTRICT QUARTERLY NGO MEETINGS

Quarterly meetings are held at the New Orleans District to update NGOs on the status of various projects in the area. Representatives of the team attend these meetings to answer questions regarding the study.

3.12 SMALL GROUP MEETINGS

The team regularly meets with several government and NGOs to provide study updates. The team also attends regular meetings of groups such as the St. Bernard Parish Coastal Zone

Advisory Committee to discuss the study. Additionally, the team attends other meetings in the study area to be available to discuss the study. To date, the team has participated in the following meetings:

Table 3-1. Small Group Meetings

Date	Organization	Topic
11-Feb-09	Lake Pontchartrain Basin Foundation Board	MRGO Closure Construction and MRGO Ecosystem Restoration Feasibility Study
11-Mar-09	USACE	IER 8-10 public meeting
18-Mar-09	State of Louisiana	Violet, Louisiana Freshwater Diversion
23-Mar-09	Lake Pontchartrain Basin Foundation	MRGO Ecosystem Restoration Feasibility Study Public Involvement
25-Mar-09	St. Bernard Parish Coastal Zone Advisory Committee	Monthly Meeting
20-May-09	Various NGOs	Update on MRGO Ecosystem Restoration Study
21-May-09	Southeast Louisiana Flood Protection Authority - East	Update on MRGO Channel Closure and Ecosystem Restoration Study
10-Jun-09	National Wildlife Federation	Great Waters Summit Field Trip to Lower 9th Ward and Bayou Bienvenue
2-Jul-09	Environmental Defense Fund	Central Wetlands Restoration Planning
6-Jul-09	State of Louisiana	Violet, Louisiana Freshwater Diversion
8-Jul-09	New Orleans Sewer and Water Board	Central Wetlands Wastewater Assimilation CIAP Project and Central Wetlands Restoration Planning
16-Jul-09	LCA Science Board	MRGO Ecosystem Restoration Study
23-Jul-09	State of Louisiana	Lake Borgne Shoreline Protection Project Pre-Application Meeting with MVN Regulatory Office
24-Jul-09	University of New Orleans	MRGO Barrier Islands Meeting
29-Jul-09	St. Bernard Parish Coastal Zone Advisory Committee	
6-Aug-09	Southeast Louisiana Flood Protection Authority - East	Use of I-10 Twin Span bridge rubble for shoreline protection on the East Orleans Landbridge
7-Aug-09	Lake Pontchartrain Basin Foundation	Update on MRGO Ecosystem Restoration Study
11-Aug-09	MRGO Must GO Coalition	St. Bernard Community Forum on MRGO Ecosystem Restoration
15-Aug-09	Environmental Defense Fund	Rebuilding the Bayou: Visions of Restoration in the Central Wetlands
27-Aug-09	Delacroix Area Landowners	Study alternatives and Right of Entry
4-Sep-09	US Fish and Wildlife Service	Ecosystem modeling
8-Sep-09	Biloxi Marsh Lands Corporation	Study alternatives and Right of Entry
15-Sep-09	National Wildlife Federation	Sea Level Rise Considerations
28-Sep-09	Federal Resource Agencies	Ecosystem modeling
30-Sep-09	St. Bernard Parish Coastal Zone Advisory Committee	Monthly Meeting
15-Oct-09	Council on Environmental Quality	Wetlands event at Central Wetlands associated with President Obama's visit
27-Oct-09	St. Bernard Parish Government and Environmental Defense Fund	Central Wetlands Restoration Plans
28-Oct-09	St. Bernard Parish Coastal Zone Advisory Committee	Monthly Meeting
28-Oct-09	USACE	IER 11 - Pontchartrain Seabrook Gate public meeting
29-Oct-09	USACE	Industrial Canal Corridor public meeting
30-Oct-09	St. Bernard Parish Coastal Zone Advisory Committee	CWPPRA Project Development and MRGO Study Coordination
13-Nov-09	St. Bernard Parish Coastal Zone Advisory Committee	CWPPRA Project Development and MRGO Study Coordination
23-Nov-09	US Fish and Wildlife Service	MRGO - Bayou Sauvage land access meeting
1-Dec-09	Governor's Advisory Commission on Coastal Activities Meeting	Commission meeting on coastal protection and restoration including brief on MRGO Ecosystem Restoration

Table 3-1. Small Group Meetings

Date	Organization	Topic
2-Dec-09	The Nature Conservancy	Tour of Central Wetlands
3-Dec-09	The Nature Conservancy	Partnering meeting; covered oyster reef restoration in MRGO study area
4-Dec-09	Mister Go Must Go Coalition	MRGO Ecosystem Restoration Study information exchange meeting
21-Dec-09	Mississippi Department of Marine Resources	MRGO Study Update and Violet, Louisiana Freshwater Diversion Evaluation Status
21-Dec-09	City of New Orleans - Mayor's Office of Environmental Affairs	Coastal Planning Meeting
6-Jan-10	St. Bernard Parish Government	Central Wetlands Workshop
14-Jan-10	LCA Science Board	Science Board Meeting
21-Jan-10	Southeast Louisiana Flood Protection Authority - East	Board meeting - presentation on coastal restoration studies including MRGO Ecosystem Plan
1-Feb-10	St. Bernard Parish Coastal Zone Advisory Committee	Special Meeting on Request to Open Bypass Channel Around the MRGO Closure Structure
8-Feb-10	State of Louisiana	State restoration plan public meeting
10-Feb-10	Mississippi Department of Marine Resources	Violet, Louisiana Freshwater Diversion and MRGO Restoration Plan
11-Feb-10	St. Bernard Parish Government	Coordination with Parish Leaders on Violet, Louisiana Freshwater Diversion Neighborhood Focus Meeting
12-Feb-10	National Wildlife Federation	IHNC surge barrier and MRGO wetlands site visit
22-Feb-10	US Fish and Wildlife Service	USFWS - MRGO - Bayou Sauvage NWR Access Permit
22-Feb-10	USACE	MRGO - Violet, Louisiana Freshwater Diversion neighborhood focus meeting
24-Feb-10	St. Bernard Parish Coastal Zone Advisory Committee	Monthly meeting
23-Feb-10	USACE	Coastal Restoration Town Hall Meeting
24-Feb-10	USACE	Coastal Restoration Town Hall Meeting
25-Feb-10	USACE	Coastal Restoration Town Hall Meeting
12-Mar-10	Tulane University and Lake Borgne Levee District	IHNC Surge Barrier and MRGO Wetlands Tour
22-Feb-10	Lake Catherine Civic Association	East Orleans Landbridge Features of MRGO Ecosystem Restoration Plan
29-Mar-10	City of New Orleans - Mayor's Office of Environmental Affairs	Orleans Parish Coastal Advisory Group

3.13 DRAFT REPORT

The Draft Feasibility Report and EIS were released to the public following a Notice of Availability (NOA) that was published in the Federal Register on December 17, 2010. This notice provided a description of the proposed action including the project features, a point of contact to obtain more information regarding the DEIS, and a means of commenting on the DEIS and MRGO Ecosystem Restoration Plan Feasibility Report.

Following the NOA, the USACE held three Public Meetings as an opportunity for the public, resources agencies, and elected officials to participate in the NEPA planning process, to provide input regarding the proposed restoration features, and to provide comments on the DEIS. Public hearings were held on January 20, 2011 in Chalmette, LA, on January 25, 2011 in Waveland, MS, and on February 8, 2011 in New Orleans, LA.

The formal comment period began with the filing of the NOA on December 17, 2010 and was extended by the USACE twice due to special requests to provide additional time to comment, coupled with an overwhelming response. The final date for the acceptance of comments was established as March 5, 2011, resulting in an overall 78-day comment period.

Verbal comments received at each of the Public Hearings were made part of the Public Hearing transcript and were included within the comment database. During the comment period, over 31,400 individual commenters provided written comments (via email, letter, and fax) and/or verbal comments on one recurring subject matter alone – Support of Plan Elements. The large comment response was primarily attributed to approximately 31,270 individual commenters associated with 4 non-government organizations that submitted multiple form letters, with each set being identical in content. These form letters represented 99.5 percent of the comments received on the most common recurring comment theme. Individuals associated with one organization alone submitted 10,325 identical representing 33 percent of the total comments received on this specific subject matter.

As comments were received, each was read and entered into a database. Names, organizations, addresses, and emails were all entered. Comments were initially identified under ―major topics" and then by ―recurring themes" to gain an understanding of key issues. Major topics included the diversion; sediment; additional plan features; and funding; just to name a few. Since each commenter generally commented on more than one issue, the comments were categorized among the 64 recurring themes or similar issues. All comments were reviewed to determine significance of each comment regardless of the recurrence of the comment.

Appendix Y of the FEIS presents summarizes the comments received during the comment period and the responses to comments for recurring comment themes.

3.14 US FISH AND WILDLIFE SERVICE RECOMMENDATIONS

The TSP will benefit the fish and wildlife resources of the MRGO Ecosystem Restoration area by providing freshwater, nutrients, and sediments, and restoring ridge, swamp and marsh habitats in the study area thus facilitating increasing organic production, increasing biological productivity, increasing habitat diversity, and reducing wetland loss. Approximately 37,980 Average Annual Habitat Units (AAHUs) and 31,930 net acres of fresh/intermediate, brackish, and saline marsh, swamp and ridge habitats would benefit by the proposed project at the end of the project life given an intermediate sea level rise scenario. The Service supports implementation of the TSP and respectfully request the following fish and wildlife recommendations be implemented concurrently with project construction:

1. Regarding the barrier island component of the MRGO Ecosystem Restoration; the Service recommends, with support from NMFS and LDWF, the selection of a barrier island component be a part of the TSP. The Service feels the design and evaluation of the barrier island alternatives was sufficient to warrant selection, though further engineering would be required prior to construction. Breton Island is a National Wildlife Refuge, managed by the Service and is of National importance. Recent scientific investigations (Lavoie, D, ed., 2009; Thomson et al., 2009) demonstrate the long-term impacts to this important refuge as a result of the MRGO channel. Therefore, the Service recommends amelioration of the areal loss of Breton Island due to the construction and maintenance of the MRGO channel should be appropriately addressed in the TSP. The Corps should contact the Service regarding a compatibility determination, Wilderness Act provisions and special use permits that may be necessary to conduct activities on Breton NWR. The Corps is encouraged to establish and continue coordination with the Service until construction of any project feature is complete

and prior to any subsequent maintenance. Points of contacts for the Service are: Kenneth Litzenberger, Project Leader for the Service's Southeast National Wildlife Refuges and Neil Lalonde (985) 882-2000, Refuge Manager for the Breton Island NWR.

USACE Response. The USACE recognizes the importance of the barrier island chain and the need for restoration; however, we believe that additional study is warranted before a sustainable restoration plan can be recommended for construction. Given the uncertainties of conditions at this time due to the oil spill and recovery efforts, USACE would seek additional authority for further study before recommending a viable restoration plan. The Corps will continue to coordinate with the Service throughout the study process.

2. The Corps should contact the Service regarding a compatibility determination, and special use permits that may be necessary to conduct activities on Bayou Sauvage NWR. The Corps should establish and continue coordination with the Service until construction of any project feature is complete and prior to any subsequent maintenance. Points of contacts for the Service are: Kenneth Litzenberger, Project Leader for the Service's Southeast National Wildlife Refuges and Neil Lalonde (985) 882-2000, Refuge Manager for the Breton Island NWR.

USACE Response. The Corps will continue to coordinate with the Service throughout the study process.

3. The final recommendations for the MRGO Ecosystem Restoration Plan include additional analysis, design and implementation of the Violet Freshwater Diversion as authorized by WRDA 2007 Section 3083. This means the Violet Diversion will be funded and constructed under a different authorization than the authorization for the MRGO Ecosystem Restoration Plan. The Service recommends any additional study, design, and implementation include the Service and other resource agency involvement. In addition if the diversion location or other aspects of the diversion change significantly from what was analyzed in the MRGO Ecosystem Restoration Plan, the Service recommends the Sediment and Nutrient Diversion model (SAND2) and Wetland Value Assessment benefits analysis be revised to reflect the changes.

USACE Response. Concur. The Service and other resource agencies would be included in any additional study, design and implementation of the Violet, Louisiana Freshwater Diversion.

4. The Service recommends the operational plans for the Violet Diversion be evaluated to include more flexibility of flow (flows between 1000cfs and 7000cfs) to achieve optimal habitat conditions favorable to nearby intermediate marsh and to bald cypress germination, growth, and reproduction by controlling depth and duration of inundation and salinity levels. As the operational plan for the Violet Diversion is further developed, future hydrological and fisheries (i.e., CASM) modeling, and updated habitat assessments (i.e., Wetland Value Assessments) should be conducted.

USACE Response. The USACE plans to adaptively manage the freshwater flows from the diversion to promote a sustainable swamp habitat and fresh/intermediate marsh in the Central Wetlands. Additional hydrologic modeling and aquatic modeling would be conducted during additional studies of the diversion. The diversion would be operated in coordination with other diversions planned in the watershed to achieve the goals and objectives of the study.

5. The Service recommends, with support from NMFS and LDWF, the diversion operational plan be developed in a way to avoid or minimize adverse impacts to marine fisheries and Essential Fish Habitat (EFH) while maximizing freshwater and nutrient input to the extent practicable to meet habitat objectives.

USACE Response. Concur.

6. The Service and LDWF recommend salinity meters be placed in appropriate locations to assist in determining when target salinities are met.

USACE Response. Seven hourly recorders will be deployed to measure salinity, temperature, water level and turbidity at three sites located along the MRGO / Lake Borgne Landbridge, three sites in the Biloxi Marsh, and one site located in the western Mississippi Sound.

7. The Service recommends the diversion be adaptively managed to enhance surrounding wetlands, that habitat switching (as a result of re-introduced river water) is allowed to occur in a manner that is not detrimental or destructive to the ecological processes, and that the diversion allows for draw down periods sufficient for cypress regeneration and cypress growth.

USACE Response. The diversion would be adaptively managed to achieve the study goals and objectives and minimize adverse effects to the extent practicable.

8. The Service recommends, with support from LDWF, a comprehensive examination of the river and all existing and proposed diversions to coordinate their operation and ensure that their operation will maximize their restoration capabilities. The ongoing Mississippi River Hydrodynamic and Delta Management Study could be utilized to address this issue.

USACE Response. USACE supports the need for a comprehensive plan to coordinate the water needs of the basin. The Mississippi River Hydrodynamic and Delta Management Study is anticipated to address those needs with full participation by natural resource agencies.

9. The Service recommends, with support from NMFS and LDWF, establishment of a committee similar to review the operation and monitoring and adaptive management results of the Violet, Louisiana Freshwater Diversion and when necessary, provide recommendations regarding any future operational and maintenance changes. The Service and other natural resource agencies are amenable to participate on this committee.

USACE Response. Concur. An adaptive management planning team, including members from other natural resource agencies would be established for recommending project and program adaptive management actions.

10. The large quantity of borrow material proposed to be taken from Lake Borgne, which is designated Gulf sturgeon critical habitat, for the TSP may have an adverse effect to fisheries, EFH, and the threatened Gulf sturgeon by: 1) alteration in water bottom substrate habitat: 2) direct removal of benthos from a large area which may (at least temporarily) reduce food availability for fishery organisms; 3) other sessile resources, such as oysters could be affected; and 4) by continually moving the dredge, the resuspended sediments will take

longer to settle and could prolong the periods of high turbidity associated with dredging operations. The Service recommends, with support from NMFS and LDWF, careful consideration be given to the affects of taking all borrow, including monitoring for benthos and water quality, from Lake Borgne and consideration should be give to obtaining borrow from other ―outside" sources, such as the Mississippi River, and adjacent bays, and offshore areas. Over the project life, search for borrow from outside sources should continue as alternative sources may become economically feasible or as new advances in technology become available.

USACE Response. Concur. Additional analyses on borrow areas has been conducted and the borrow plan modified, in coordination with NMFS, to minimize adverse impacts to fisheries, EFH, and the threatened Gulf sturgeon including additional borrow sources. The corps will continue to consider sources outside of Lake Borgne throughout the study process.

11. The NMFS is responsible for consultations regarding impacts to the Gulf sturgeon and its critical habitat for the MRGO Ecosystem Restoration project. Therefore, please contact Dr. Stephania Bolden (727/824-5312) in St. Petersburg, Florida, for information concerning that species and its critical habitat. Should the proposed project directly or indirectly affect the Gulf sturgeon or its critical habitat in Louisiana, further consultation with that office will be necessary.

USACE Response. the NMFS has been a member of the habitat evaluation team throughout the planning process. The Corps will continue to coordinate with both NMFS offices.

12. The Service, with support from NMFS and LDWF, recommends the Lake Borgne borrow plan should initially specify monitoring three different depths of borrow sites for a minimum of two-years post dredging and prior to continued excavation. The Service recommends monitoring of water quality parameters are included in the MAMP in order to assess if anoxic or hypoxic conditions occur. If anoxia is a problem at 10 feet below the existing sediment surface with a +/- 5 foot tolerance, then the borrow sites will have to be dug shallower and other borrow source options explored to minimize impacts to estuarine water bottoms and EFH. The Service, NMFS, and LDWF recommend a summary of the Monitoring and Adaptive Management Plan for borrow be included in the Feasibility Study or Environmental Impact Statement. The Service, NMFS, and LDWF also recommend that all borrow sites be at least 1,000 feet from the shoreline to help avoid increasing shoreline erosion via increased wave height.

USACE Response. All borrow sites would be excavated at a minimum of 3,000 feet from the Lake Borgne shoreline. Three test sites would be dredged and monitored to determine the maximum depth of future borrow pits. If anoxia is a problem at 15 feet below water surface, then the borrow sites would be dug shallower and other borrow source options would be explored. This is part of the adaptive management plan. A brief summary of this test pit monitoring plan is included in the borrow section of the EIS.

13. The proposed borrow areas in Lake Borgne do include private leases as well as public oyster seed grounds. LDWF manages the public seed grounds and should be consulted before final borrow locations are determined.

USACE Response. Concur. Borrow sites would be excavated at a minimum of 3,000 feet from the Lake Borgne shoreline. LDWF is an active member of the habitat evaluation team.

14. The Service recommends that all shoreline protection features include one fish dip every 1,000 feet (ft) constructed to a 25 ft bottom width to the pre-project elevation. On a case by case basis the 1,000 ft distance can be adjusted, in consultation with NMFS, to incorporate existing water exchange points.

USACE Response. Concur. During the detail design phase for each feature, USACE would closely coordinate with USFWS and NMFS before implementation of these measures.

15. The Service and NMFS recommends the retention dikes constructed for swamp and marsh creation and nourishment areas be gapped and degraded within three years of use if they have not naturally degraded on their own. Please coordinate gapping and degrading efforts with the Service and NMFS.

USACE Response. Concur. The dike features would be mechanically breached or degraded within three years of construction, if natural degradation has not sufficiently removed the earthen material.

16. The Service and LDWF recommend a buffer of at least 500 feet be placed around existing hard bottom and oyster leases to minimize impacts to those resources.

USACE Response. Non-concur. Designated borrow areas are estimated larger than needed for each feature to ensure that adequate material is available in the event that environmental or cultural resources are discovered during construction that require avoidance. Hard bottom areas would be avoided because they are considered preferred habitat for the Gulf sturgeon. Borrow sites would be located a minimum of 3,000 feet from the Lake Borgne shoreline to avoid existing oyster leases to the maximum extent practicable. However, in the southern lobe proposed borrow sites do overlap existing oyster leases and these oyster leases would be impacted by dredging acitivity.

17. The Monitoring and Adaptive Management Plan, as it is further developed, should be provided to the Service, NMFS, and LDWF for continued review, comment, and input.

USACE Response. Concur.

18. If a proposed project feature is changed significantly or is not implemented within one year of the Endangered Species Act consultation letter, we recommend that the Corps reinitiate coordination with the Service and NMFS to ensure that the proposed project would not adversely affect any Federally listed threatened or endangered species or their critical habitat.

USACE Response. Concur.

19. The proposed Violet Freshwater Diversion structure off the Mississippi River has the potential to entrain pallid sturgeon, that effect should be addressed in the diversions future planning studies. Should the proposed project directly or indirectly affect the pallid sturgeon or its habitat, further consultation with this office will be necessary.

USACE Response. Concur. The Corps would coordinate with the Service during the future planning studies of the diversion.

20. Avoid adverse impacts to nesting bald eagles, gulls, terns, and/or black skimmers, wading birds, and brown pelicans through the careful design of project features and timing of construction. A qualified biologist should inspect the proposed work area for the presence of undocumented nesting colonies and bald eagles during the nesting season (i.e., September 15 through March 31 for brown pelican, September 1 through February 15 for wading bird nesting colonies, September 16 through April 1 for colonies containing nesting gulls, terns, and/or black skimmers, and October through mid-May for bald eagles).
    - To minimize disturbance to colonies containing nesting wading birds (i.e., herons, egrets, night-herons, ibis, and roseate spoonbills), anhingas, and/or cormorants, all activity occurring within 1,000 feet of a rookery should be restricted to the non-nesting period (i.e., September 1 through February 15, exact dates may vary within this window depending on species present).
    - For colonies containing nesting brown pelicans, all activity occurring within 2,000 feet of a rookery should be restricted to the non-nesting period (i.e., September 15 through March 31). Nesting periods vary considerably among Louisiana's brown pelican colonies so it is possible that this activity window could be altered based upon the dynamics of the individual colony.
    - For colonies containing nesting gulls, terns, and/or black skimmers, all activity occurring within 650 feet of a rookery should be restricted to the non-nesting period (i.e., September 16 through April 1, exact dates may vary within this window depending on species present).
    - If a bald eagle nest is discovered within or adjacent to the proposed project area, then an evaluation must be performed to determine whether the project is likely to disturb nesting bald eagles. That evaluation may be conducted on-line at: http://www.fws.gov/southeast/es/baldeagle. Following completion of the evaluation, that website will provide a determination of whether additional consultation is necessary and those results should be forwarded to this office.

USACE Response. Concur.

21. Land clearing associated with project features should be conducted during the fall or winter to minimize impacts to nesting migratory birds, when practicable.

USACE Response. The USACE will to the extent practicable implement land clearing activities during the fall and winter. When this is not feasible, the USACE would coordinate with the USFWS and conducted surveys for nesting colonies and bald eagles prior to initiating work activities.

22. Further detailed planning of project features (e.g., Design Documentation Report, Engineering Documentation Report, Plans and Specifications, or other similar documents) should be coordinated with the Service and other State and Federal natural resource agencies, and shall be provided an opportunity to review and submit recommendations on all work addressed in those reports.

USACE Response. Concur

23. A report documenting the status of implementation, maintenance, and adaptive management measures should be prepared every three years by the managing agency and provided to the Corps, the Service, NMFS, U.S. Environmental Protection Agency (EPA), Louisiana Department of Natural Resources (LDNR), Office of Coastal Protection and Restoration

(OCPR), and LDWF. That report should also describe future management activities, and identify any proposed changes to the existing management plan.

USACE Response. Concur. The adaptive management team would be the responsible party for preparation of this report.

24. The Service recommends minimizing impacts to marsh from marsh buggy activities. Options to achieve that minimization include limiting the repetitive use of a route or to build temporary boardwalks over marsh where feasible and then backfilling the boardwalk area if needed. In areas with large marsh creation features that have minimal access routes, such as the inner Terre Aux Bouef marsh features, the Service recommends that work begin at the farthest location and proceed to the outer edges of the site to minimize the amount of damage.

USACE Response. Concur. USACE plans to utilize boardwalks over existing marsh to reduce marsh impacts and backfill impacted marsh when the boardwalks are removed. USACE would restore the farthest location of Bayou Terre aux Boeufs and work to the outer edges to minimize adverse impacts to existing and newly restored marsh. Marsh buggies would be required to avoid repetitive use of the same tracts to reduce marsh impacts. Any impacts to existing marsh would be backfilled to the extent practicable.

25. The Service recommends the CASM model should be updated to incorporate conditions from the oil spill in the adaptive management plan. This model should also use the corrected assumptions.

USACE Response. Funding and time constraints limit the ability to re-run any models at this stage. An update of the CASM model could potentially take place during PED phase.

26. Due to the significant acreage of marsh that will be accessed for swamp and marsh creation/nourishment, the Service request the Corps quantify the estimated acreage of flotation and construction access canal impacts to shallow open water habitat.

USACE Response. Concur. Additional analyses on flotation access and construction access will be conducted during the detailed planning, engineering and design phase following approval of the recommended plan.

4 FEDERALLY IDENTIFIED PLAN

4.1 FEDERALLY IDENTIFIED PLAN (FIP)

As the District Engineer, I have considered the environmental, social, and economic effects, the engineering feasibility, and the comments received from other resource agencies and the public during the MRGO Ecosystem Restoration Study effort and plan formulation. Based upon the sum of this information, I am recommending for implementation the MRGO Ecosystem Restoration Plan that includes the highest priority actions from among those considered during plan formulation. I am convinced that the MRGO Ecosystem Restoration Plan would restore areas affected by the MRGO, begin to reverse the current trend of degradation of Louisiana‘s coastal ecosystem, support Nationally significant resources, provide a sustainable and diverse array of fish and wildlife habit, provide infrastructure protection, and make progress towards a more sustainable ecosystem.

The plan I am recommending includes features recommended for construction (contingent upon the identification of a non-Federal sponsor), features that may be constructed if conditions for ecological success and long term sustainability exist, features recommended for additional study, and a Monitoring and Adaptive Management Plan (MAMP). These recommendations are subject to modifications at the discretion of the Commander, HQUSACE.

Plan C is the FIP and NER plan for this study because it is the lowest cost alternative that meets all of the study objectives and provides a complete plan to restore the structure and function of the Lake Borgne ecosystem as described in sections 2.8 and 2.9. Other plans were evaluated that provide additional benefits, but the increases in costs were not considered reasonable given the relative outputs. Plan C is cost-effective, and maximizes the opportunities to achieve the objectives of the study for the least cost. The incremental costs associated with Plan C are considered reasonable for the significance of the outputs achieved.

The components of the FIP would produce 37,980 Annual Average Habitat Units (AAHUs) and restore and protect approximately 57,472 acres of habitat. The plan includes the following:

- A freshwater diversion at or near Violet, Louisiana;
- 14,123 acres of fresh and intermediate marsh;
- 32,511 acres of brackish marsh;
- 10,318 acres of cypress swamp;
- 466 acres of saline marsh;
- 54 acres of Bayou La Loutre ridge habitat;
- 71 miles of shoreline protection in Lake Borgne, along the MRGO, and in the Biloxi Marsh, including 5.8 miles of oyster reef restoration in the Biloxi Marsh;
- 2 recreation features.

Based on October 2011 Price Levels, the Project First Cost of the FIP is estimated at $2.9 billion. The total cost of the Monitoring and Adaptive Management Plan is $190 million, including costs for potential adaptive management actions. The operation, maintenance, repair, replacement, and rehabilitation (OMRR&R) costs for plan features are estimated at $427 million.

4.2 RECOMMENDATIONS

Recommendations are divided into tiers by the level of uncertainty regarding conditions for ecological success and long-term sustainability including the need for additional study.

- Tier 1 includes features that have been developed to a feasibility level of detail and are not dependent on a freshwater diversion. Tier 1 features are recommended for construction through the WRDA 2007 Section 7013 authority upon the identification of a non-Federal sponsor.
- Tier 2 includes features with feasibility level detail that are dependent upon salinity conditions but may be sustainable without the implementation of a freshwater diversion. If future conditions and further analysis indicate that favorable conditions for ecological success and long term sustainability exist (as defined in the adaptive management plan[3]), then these projects may be constructed. Tier 2 features would be constructed through the WRDA 2007 Section 7013 authority upon the identification of a non-Federal sponsor.
- Tier 3A includes further study of the Violet, Louisiana Freshwater Diversion under the WRDA 2007 Section 3083 authority. The non-Federal cost-share responsibilities for the Violet, Louisiana Freshwater Diversion would be consistent with the 75 percent/25 percent Federal/non-Federal cost share identified in Section 3083 of WRDA 2007, together with such other items of cost-share responsibilities as may be identified in the Feasibility Report for the project, as approved by the decision of the Chief of Engineers. Presently, as identified in the 1984 Chief's Report for *Mississippi and Louisiana Estuarine Areas Freshwater Diversion to Lake Pontchartrain and Mississippi Sound Feasibility Study*, the 25 percent non-Federal share of the cost of the design and implementation of the Violet, Louisiana Freshwater Diversion project is allocated 80 percent to the State of Louisiana and 20 percent to the State of Mississippi. It is not anticipated that this allocation will change as a result of completing the feasibility study for the project; however, if it does, the change in allocation will be addressed in the study, as approved by the decision of the Chief of Engineers.
- Tier 3B includes any features that are dependent on freshwater diversion, and features in Tier 2 that future conditions and further analyses indicate are not sustainable. Subsequent to the completion of Tier 3A, Tier 3B features would be constructed through the WRDA 2007 Section 7013 authority upon the identification of a non-Federal sponsor.

Table 4-1 provides the FIP feature descriptions by tier and Figure 4-1 depicts the FIP.

[3] Average annual salinity: fresh marsh: <1.1 parts per thousand (ppt); intermediate marsh: <4.1 ppt; brackish marsh: <8.3 ppt, and swamp <4.0.

Table 4-1. Implementation Table[1]

Measure	Description
TIER 1 RECOMMENDED FOR CONSTRUCTION (CONTINGENT UPON IDENTIFICATION OF NON-FEDERAL SPONSOR) Total Investment Cost: $1,308,000,000 Total Average Annual Costs: $54,591,000 Total MAMP Costs: $104,131,000 Total OMRR&R Costs: $209,503,000 Average Annual OMRR&R Costs: $3,141,000 Total Benefits: 2,414 AAHUs October 2011 Price Levels	
LS1	45,000 linear feet (8.5 miles) of shoreline protection beginning at the terminus of the Bayou Dupre supplemental shoreline project, extending around Proctor Point to the West of Shell Beach supplemental funding shoreline protection.
MRGO1	3,850 feet (0.75 miles) of new foreshore protection between MRGO miles 56.6 and 57.4. This stone protection feature is embedded within the limits of MRGO7.
MRGO6	8,132 linear feet (1.5 miles) of new, non-continuous foreshore protection between MRGO miles 36.0 and 34.4, immediately east of the existing stone closure of the MRGO. MRGO6 ties into an existing foreshore dike immediately downstream.
BS1	Approximately 50,637 linear feet (9.5 miles) of protection along the southeast shore of Lake Borgne from the Biloxi Marsh Shoreline Protection Project (PO-72) south of Point aux Marchettes extending north to Malheureax Point.
BS2	Approximately 30,750 linear feet (5.8 miles) of artificial oyster reef development between Eloi Point and the mouth of Bayou La Loutre.
ES1	20,530 linear feet (3.8 miles) of shoreline protection from the south shore of Lake Pontchartrain to the existing Bayou Chevee shoreline protection feature.
ES2	30,750 (5.8 miles) linear feet of shoreline protection in Lake Pontchartrain between Chef Menteur Pass and The Rigolets.
ES3	69,900 linear feet (13.2 miles) of foreshore protection along Lake Borgne between Alligator Point and The Rigolets.
BR1	Approximately 54.1 acres of ridge restoration on the south bank of Bayou La Loutre. 400,000 cubic yards of silty sand material would be required.
EM2	1,095 acres of marsh nourishment on Hog Island, located between the west and east mouth of the West Pearl River using 1.3 million cubic yards of dredged material.
EM3	861 acres of marsh restoration and 180 acres nourishment bounded by Highway 433, Little Lagoon, Salt Bayou and Highway 90 using 4.1 million cubic yards of material.
EM4	2,625 acres of marsh restoration and 1,455 acres of nourishment bounded by Salt Bayou, the West Pearl River, the Rigolets, and Highway 80. Approximately 9.2 million cubic yards of material would be required.
HM1	757 acres of marsh restoration and nourishment of 973 located in the Hopedale area using 4.5 million cubic yards of dredged material.
TM1	798 acres of marsh restoration and 223 acres of marsh nourishment south of Bayou La Loutre in the Terre aux Boeufs area using 3.8 million cubic yards of material.
TM2	770 acres of marsh restoration and 3,396 acres of marsh nourishment in the vicinity of Lake Ameda. Approximately 8.8 million cubic yards of material would be required.
TM7	2,255 acres of marsh restoration and 2,144 acres of adjacent marsh nourishment to the east of Bayou Terre aux Boeufs using 12.4 million cubic yards of material.

Table 4-1. Implementation Table[1]

Measure	Description
TM8	1,511 acres of marsh restoration on the east side of Bayou Terre aux Boeufs in the vicinity of Delacroix. 9.7 million cubic yards of material would be required.
MRGO2	One time repair of approximately 21,630 linear feet (4.1 miles) of existing foreshore protection between Mile 44.5 and 40 of the MRGO.
MRGO3	One time repair of approximately 26,650 linear feet (5 miles) of existing foreshore protection between approximately Mile 56 to 51 of the MRGO.
MRGO4	One time repair of approximately 11,770 linear feet (2.2 miles) of existing retention dike between MRGO Miles 36.6 to 37.1 and MRGO Miles 33.9 to 32.9.
SHELL BEACH	Recreation feature to be constructed following repair of MRGO2. 343 lf of boardwalk into the MRGO, 805 lf of shoreline boardwalk, 5 picnic shelters (two handicap accessible), interpretive signage, bathrooms, parking, solar lighting and plantings.
TIER 2 RECOMMENDED FOR CONSTRUCTION IF CONDITIONS FAVORABLE FOR ECOLOGICAL SUCCESS AND SUSTAINIBILITY ARE DOCUMENTED Total Investment Cost: $390,232,700 Total Average Annual Costs: 15.531,700 Total MAMP Costs: $45,701,000 Total OMRR&R Costs: $18,318,000 Average Annual OMRR&R Costs: $251,700 Total Benefits: 5,694 AAHUs October 2011 Price Levels	
CC4-A	400 acres of cypress restoration in the Bienvenue Triangle. Approximately 2.6 million cubic yards of material to be obtained from Mississippi River.
CC4 (Sites 2,3,4)	1,065 acres of cypress swamp restoration in the open water areas adjacent to the Forty Arpent Levee north of Paris Road using 7.8 million cubic yards of material.
CM2	795 acres of marsh restoration and 190 acres of marsh nourishment north of Paris Road using approximately 4.7 million cubic yards of material.
CM5	245 acres of marsh restoration and 70 acres of nourishment in the area north of Bayou Bienvenue and Paris Road using 1million cubic yards of material.
LM4	225.5 acres of marsh restoration and nourishment of 54.8 acres in the portion of the Golden Triangle bordered by the GIWW, the IHNC Surge Barrier, and the MRGO. Approximately 1.2 million cubic yards of material are required.
BAYOU REC	Recreation feature associated with CC4-A. 100 linear feet of platform, 995 linear feet of boardwalk into the swamp, 4 picnic shelters, interpretive signage, bathrooms, parking, solar lighting and vegetative plantings in the Bienvenue Triangle.
TIER 3 RECOMMENDED FOR FURTHER STUDY Estimated Total Investment Costs for Tier 3B: $1,194,150,000 Estimated Total MAMP Costs for Tier 3B: $36,561,000 Estimated Total OMRR&R Costs for Tier 3B: $198,806,000 Estimated Average Annual OMRR&R Costs: $2,618,000 Estimated Total Benefits for Tier 3B: 29,872 AAHUs Estimated costs do not include construction of the Violet, Louisiana Freshwater Diversion. October 2011 Price Levels	
Tier 3A	

Table 4-1. Implementation Table[1]

Measure	Description
VIOLET	The Violet, Louisiana Freshwater Diversion as authorized in WRDA 2007 Section 3083. A freshwater diversion would enhance and sustain the benefits of the FIP. Additional study would be carried out under WRDA 2007 Section 3083 and subject to the cost-share provisions in that authority.
Tier 3B	
EM1	1,175 acres of marsh restoration and 2,830 acres nourishment bounded by Lake Pontchartrain, Chef Menteur, and the levee using 8.1 million cubic yards of material.
LM1	3,253 acres of marsh restoration and nourishment of 1,064 acres in the Golden Triangle, south of the IHNC Surge Barrier using 14.3 million cubic yards of material.
LM2	225 acres of marsh restoration and 2,628 acres of marsh nourishment in the area between Proctor Point and the MRGO using 4.5 million cubic yards of material.
LM3	911 acres of marsh restoration and 950 acres nourishment in South Lake Borgne north of Lena Lagoon in the area bounded by the lake, Bayou St. Malo, MRGO, and Doulets Canal using 6.4 million cubic yards of material.
BM1	8,000 acres of marsh nourishment along the south shore of Lake Borgne using 11 million cubic yards of material.
MRGO5	202 acres of marsh restoration using 3.0 million cubic yards of material located behind 13,685 linear feet (2.5 miles) of vinyl sheet pile wall to establish the shoreline.
MRGO7	110 acres of marsh restoration using 1.65 million cubic yards of material adjacent to 9,700 linear feet (1.8 miles) of vinyl sheet pile wall.
MRGO8	236 acres of marsh restoration using 3.5 million cubic yards of material adjacent to 17,785 linear feet (3.3 miles) of vinyl sheet pile wall and 14,225 linear feet (2.6 miles) of new foreshore protection between approximate channel miles 51.0 and 48.3.
CM1	1,240 acres of marsh nourishment south of Paris Road between cypress restoration feature CC3 and the Chalmette Loop Levee using 1.5 million cubic yards of material.
CM3	300 acres of marsh restoration and 215 acres of marsh nourishment north of Bayou Dupre and south of MRGO using 1.6 million cubic yards of borrow material.
CM4	97.5 acres of marsh restoration and 128.5 acres of marsh nourishment south of Bayou Dupre using 600,000 cubic yards of dredged material.
CC1	1,020 acres of swamp restoration and 935 acres nourishment north of the existing Violet Canal along the Forty Arpent levee using 6.0 million cubic yards of material.
CC2	250 acres of cypress swamp restoration and 250 acres of swamp nourishment to the northeast of CC1 using 1.7 million cubic yards of material.
CC3	370 acres of swamp restoration and 790 acres nourishment along the Forty Arpent Levee south of Paris Road using 3.7 million cubic yards of material.
CC5	1,120 acres of swamp restoration and 1,550 acres nourishment south of the Violet Canal along the Forty Arpent Levee and the Chalmette Loop Levee. 7.8 million cubic yards of borrow material would be required.
CC6	2,568 acres of swamp nourishment in the Central Wetlands southwest corner. 5.2 million cubic yards of borrow material would be required.
Note 1. Measures are listed in order of priority for Tiers 1 and 2 as described in detail in Section 2.13.	

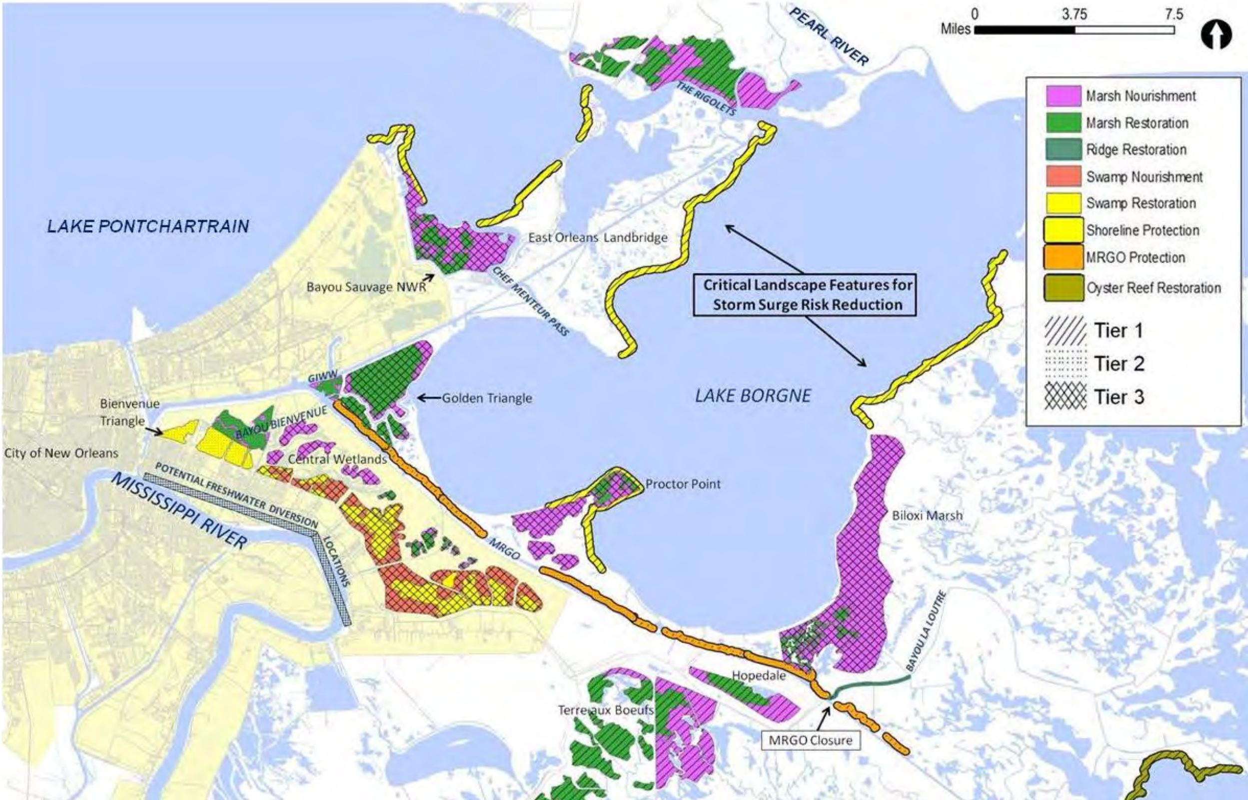


Figure 4-1: Federally Identified Plan

4.2.1 Monitoring and Adaptive Management

The Monitoring and Adaptive Management Plan (MAMP) for the study describes a systematic approach to reduce and address some of the uncertainties associated with the study. The MAMP for this study has developed decision criteria, also referred to as AM ecological success criteria, to determine if and when AM opportunities should be implemented. These criteria are described in Table 4-2 and are based on the monitoring of indicators. Indicators are applicable to all tiers.

Cost estimates have been developed for the MAMP and are presented in Table 4-3. For cost estimating purposes, the maximum cost-shared period of monitoring was assumed for all features. Some projects, such as marsh restoration, may require less than ten years of post-construction monitoring to determine ecological success. Once ecological success has been established, monitoring would cease. Other features, such as ridge restoration and cypress swamp restoration, may require longer monitoring periods to determine ecological success. The need for additional monitoring would be assessed at the end of the cost-shared period, and any additional monitoring would be a 100% non-Federal responsibility.

Table 4-2. Adaptive Management Threshold and Trigger Matrix

Indicator	Threshold	Ecological Success Criteria	Response Options
Salinity	Threshold set by Snedden and Steyer, in review- Figure 4	Trigger set if marsh types change 2 classes (fresh to brackish) across years or if swamp/fresh meet salinity threshold	Alter freshwater input. Potential options include: bank gapping, salinity barriers, diversion operation, or freshwater management through other projects in the area potentially including Borgne Barrier, Bonne Carre Spillway, Small Diversion at Convent Blind River, Maurepas Swamp Diversion
Plant Mortality – emergent marsh and (plantings)	Threshold set by marsh collapse expert panel; (plantings – 70% survival at year 1)-Table 3	Trigger set at low range of marsh collapse thresholds	Control salinity and or inundation. Potential methods include nourishment to enhance elevation, diversion operation or other method of altering freshwater input into the system, and managed habitat switching (replant with vegetation type suitable for observed conditions- i.e. replant previous brackish marsh area with saline marsh species types)
Land/Water Ratio	Threshold set by WVA	Trigger set if land lost episodic (marsh dieback)	Enhance elevation
Elevation	Threshold set by high inundation depth	Trigger set when elevation by marsh type less than reference	Enhance elevation
Oyster Recruitment	Threshold set on sufficient oyster reef development to protect identified marsh	Presence/absence of oyster settlement at 2-3 years	Seed with juveniles/stock adults
Water Quality	TBD by NMFS consultation in PED	TBD by NMFS consultation in PED	Evaluate options for increasing freshwater input and hydrologic restoration measures such as bank gapping and salinity barriers

Table 4-3 Summary of MAMP Costs for the MRGO Ecosystem Restoration Project
(October 2011 Price Levels)

Category	Tier 1	Tier 2	Tier 3B	Project Total for MAMP
Set-up and Implementation of the MAMP for the Project				
Monitoring Planning and Management	$510,349	$231,977	$185,581	$927,907
Data Collection	$11,478,487	$3,586,244	$2,868,995	$17,933,727
Database Management	$487,733	$221,697	$177,357	$886,787
AM Planning Program Set-up	$1,052,700	$478,500	$382,800	$1,914,000

Table 4-3 Summary of MAMP Costs for the MRGO Ecosystem Restoration Project (October 2011 Price Levels)

Category	Tier 1	Tier 2	Tier 3B	Project Total for MAMP
Management of AM Program	$438,625	$199,375	$159,500	$797,500
Assessment	$412,308	$187,413	$149,930	$749,650
Decision Making	$271,948	$123,613	$98,890	$494,450
Stakeholder Program Set-up	$437,604	$199,375	$159,500	$796,479
Stakeholder Involvement During Construction	$175,450	$79,750	$63,800	$319,000
Stakeholder Involvement Post Construction	$175,450	$79,750	$63,800	$319,000
Potential AM Actions				
Potential AM Action-Wetland Nourishment	$86,935,475	$39,516,125	$31,612,900	$158,064,500
Potential AM Action- Cultural Data Recovery	$1,754,500	$797,500	$638,000	$3,190,000
TOTAL	**$104,130,628**	**$45,701,318**	**$36,561,054**	**$186,393,000**
Cost Share				
Federal-65%	$67,684,908	$29,705,856	$23,764,685	$121,155,450
Non-Federal-35%	$36,445,720	$15,995,461	$12,796,369	$65,237,550

4.3 PROJECT COST

4.3.1 Cost and Schedule Risk Analysis

A formal risk analysis study was performed to develop contingency for the total project cost. The risk analysis was performed to determine a true contingency cost required for cost estimating based on the risk items associated with the project. The contingencies are determined by qualifying and quantifying all potential cost risks and producing a frequency spectrum and probability range for applied risk costs. The cost contingency is within the 80-percent confidence interval determined by this statistical analysis. The potential cost risks identified indicate how to avoid unforeseen escalation of project costs and may be used as a valuable tool in all phases of project study, design, and construction planning and estimation.

Within the risk analysis, it was noted that the project scope for this effort is fairly confident in design and quantities. Primary factors contributing to cost and schedule risk include: revisions to the borrow plan/borrow availability (due to the uncertainties associated with final pit depths resulting from water quality analyses, unidentified cultural resources and pipelines, and borrow availability for adaptive management); uncertainties associated with freshwater diversion implementation; uncertainties related to funding stream; hydraulic cutterhead dredge availability; and fuel cost variation.

The quantitative impacts of risk factors on project plans are analyzed using professional judgment, empirical data, and analytical techniques. Risk factor impacts are quantified using probability distributions (density functions). The probabilistic distribution functions are used to describe the characteristic population (tendencies) of the risk factor inputs. The following elements were addressed in the risk factor quantification process: maximum possible value; minimum possible value; most likely value (the statistical mode), if applicable; nature of the probability density function used to approximate risk factor uncertainty; mathematical correlations between risk factors; and affected cost estimate and schedule elements.

It was recognized that the various features carry differing degrees of risk as related to cost, schedule, design complexity, and design progress. A risk register was developed that records risk concerns and potential impacts to the current cost and schedule estimates. The risk register supports decisions related to event likelihood, impact, and the resulting risk levels for each risk event used to develop cost and schedule contingencies.

The cost contingency is calculated as the difference between the 80-percent confidence interval cost forecast and the base cost estimate. Each option-specific contingency is then allocated based on the dollar-weighted relative risk of each feature. Standard deviation is used as the feature-specific measure of risk for contingency allocation purposes. A larger portion of the cost contingency is allocated to features with relatively higher estimated cost uncertainty using this approach.

For schedule contingency analysis, the option schedule contingency is calculated as the difference between the 80-percent confidence interval option duration forecast and the base schedule duration. These contingencies are used to calculate the time value of monetary impacts of project delays that are included in the presentation of total cost contingency. The resulting time value of money, or added risk escalation, is then added into the contingency amount to reflect the USACE standard for presenting the ―total project cost” for the fully funded project amount.

4.3.2 Federally Identified Plan Costs

Table 4-4 provides the Project First Costs (Constant Dollar Costs at the current price level) for the FIP. These scheduled costs follow the construction implementation schedule provided in the Engineering Appendix for this study.

Table 4-4. Project First Costs for FIP (In October 2011 $1,000)

Cost Category	Cost	Contingency	Total	Federal Responsibility	Non-Federal Responsibility
Lands And Damages	$75,888	$23,172	**$99,060**		**$99,060**
Relocations	$0	$0	**$0**		
Fish & Wildlife Facilities (Plantings)	$109,532	$26,945	**$136,477**	$88,710	$47,766

Table 4-4. Project First Costs for FIP (In October 2011 $1,000)					
Fish & Wildlife Facilities Adaptive Management	$90,754	$53,998	**$144,752**	$94,088	$50,663
Recreation Facilities	$3,566	$877	**$4,443**	$2,221	$2,221
Beach Replenishment	$1,783,352	$438,705	**$2,222,056**	$1,543,396	$678,659
Planning, Engineering & Design (PED)	$78,675	$19,354	**$98,030**	$63,719	$34,310
PED Adaptive Management	$22,063	$13,128	**$35,191**	$22,874	$12,316
Construction Management	$107,894	$26,542	**$134,435**	$87,382	$47,052
Construction Management (Adaptive Management)	$6,083	$3,620	**$9,703**	$6,306	$3,396
Baseline Total Cost:	$2,277,807	$606,340	**$2,884,147**	$1,908,700	$975,446

Table 4-5. Project First s for Tier 1 (In October 2011 $1,000)			
Cost Category	**Total**	**Federal Responsibility**	**Non-Federal Responsibility**
Ecosystem Restoration Construction	$1,147,768	$ 746,049	$ 401,719
MAMP	$104,131	$67,685	$36,446
Recreation Facilities	$2,786	$1,393	$1,393
TOTAL	$1,254,685	$815,127	$439,558

Table 4-6. Project First Costs for Tier 2 (In October 2011 $1,000)			
Cost Category	**Total**	**Federal Responsibility**	**Non-Federal Responsibility**
Ecosystem Restoration Construction	$322,823	$193,694	$112,988
MAMP	$45,701	$29,706	$15,995
Recreation Facilities	$2,006	$1,003	$1,003
TOTAL	$370,530	$224,403	$129,986

Table 4-7. Project First Costs for Tier 3B (In October 2011 $1,000)			
Cost Category	**Total**	**Federal Responsibility**	**Non-Federal Responsibility**
Ecosystem Restoration Construction	$1,076,597	$699,788	$376,809
MAMP	$36,561	$23,765	$12,796
Recreation Facilities	$0	$0	$0
TOTAL	**$1,113,157**	**$723,553**	**$389,605**

Table 4-8.
Incremental Cost Schedule – Tentatively Selected Plan (October 2011 Price Levels, $1,000's)

Item	FY14	FY15	FY16	FY17	FY18	FY19	FY20	FY21	Sub-Totals
01 Real Estate	$8,255	$8,255	$8,255	$8,255	$8,255	$8,255	$8,255	$8,255	**$66,040**
06 Fish / Wildlife	$19,849	$2,225	$0	$0	$19,748	$9,465	$5,170	$8,657	**$65,114**
06 Fish /Wildlife / AM	$0	$0	$0	$0	$0	$0	$0	$0	**$0**
14 Recreation Fac	$1,861	$0	$0	$0	$2,583	$0	$0	$0	**$4,444**
17 Beach Rep	$278,553	$183,965	$16,159	$76,104	$414,537	$133,614	$173,399	$180,430	**$1,456,761**
30 PED	$12,197	$8,412	$965	$3,511	$18,544	$4,596	$7,062	$9,196	**$64,483**
31 PED AM									
31 S&A	$17,743	$11,418	$1,287	$5,025	$21,840	$6,704	$10,513	$11,121	**$85,651**
31 S&A AM									
Annual Total	$338,458	$214,275	$26,666	$92,895	$485,507	$162,634	$204,399	$217,659	$1,742,493

Item	FY22	FY23	FY24	FY25	AM	Total
01 Real Estate	$8,255	$8,255	$8,255	$8,255		***$99,060***
06 Fish/Wildlife	$26,018	$0	$17,506	$27,838		***$136,476***
06 Fish/Wildlife/AM	$0	$0	$0	$0	$144,752	***$144,752***
14 Recreation Fac	$0	$0	$0	$0		***$4,444***
17 Beach Rep	$151,044	$18,088	$287,597	$308,567		***$2,222,057***
30 PED	$7,050	$942	$12,155	$13,399		***$98,029***
31 PED AM					$35,191	***$35,191***
31 S&A	$10,057	$1,302	$17,881	$19,543		***$134,434***
31 S&A AM					$9,703	***$9,703***
Annual Total	**$241,650**	**$215,015**	**$238,480**	**$110,601**	**$189,646**	***$2,884,146***

4.4 COST SHARING AND AGENCY RESPONSIBILITIES

I further recommend Federal and Non-Federal Sponsor responsibilities and cost sharing requirements as set forth in the following paragraphs.

Ecosystem Restoration Plan, Tiers 1, 2 and 3B: Before the ecosystem restoration plan for Tiers 1, 2 and 3B can be implemented, a non-Federal sponsor would need to be identified and a cost sharing agreement executed in accordance with the cost-sharing provisions outlined below.

Despite extensive discussions with the State of Louisiana, a non-Federal sponsor has not been identified for the MRGO Ecosystem Restoration plan. The non-Federal share will bear 35 percent of the costs of implementing the ecosystem restoration plan and 50 percent of recreation facilities. The non-Federal sponsor is responsible for providing all lands, easements, rights-of-way, utility or public facility relocations, and dredged or excavated material disposal areas and performance of all relocations required for the project (LERRDs), and 100 percent of the costs of operation, maintenance, repair, rehabilitation, and replacement (OMRR&R). The value of LERRDs will be credited toward the non-Federal cost share.

Mississippi River-Gulf Outlet Ecosystem Restoration project:

Federal implementation of the recommended project for Tier 1, Tier 2 and Tier 3B would be subject to the non-Federal sponsor agreeing to comply with applicable Federal laws and policies, including but not limited to:

Provide 35 percent of total ecosystem restoration costs as further specified below:

a. Provide 35 percent of total ecosystem restoration costs as further specified below:

1. Provide the non-Federal share of design costs allocated by the Government to ecosystem restoration in accordance with the terms of a design agreement entered into prior to commencement of design work for the ecosystem restoration features;

2. Provide, during the first year of construction, any additional funds necessary to pay the full non-Federal share of design costs allocated by the Government to ecosystem restoration;

3. Provide all lands, easements, and rights-of-way, including those required for relocations, the borrowing of material, and the disposal of dredged or excavated material; perform or ensure the performance of all relocations; and construct all improvements required on lands, easements, and rights-of-way to enable the disposal of dredged or excavated material all as determined by the Government to be required or to be necessary for the construction, operation, and maintenance of the ecosystem restoration features;

4. Provide, during construction, any additional funds necessary to make its total contribution for ecosystem restoration equal to 35 percent of total ecosystem restoration costs;

b. Provide 50 percent of total recreation costs as further specified below:

1. Provide the non-Federal share of design costs allocated by the Government to recreation in accordance with the terms of a design agreement entered into prior to commencement of design work for the recreation features;

2. Provide, during the first year of construction, any additional funds necessary to pay the full non-Federal share of design costs allocated by the Government to recreation;

3. Provide all lands, easements, and rights-of-way, including those required for relocations, the borrowing of material, and the disposal of dredged or excavated material; perform or ensure the performance of all relocations; and construct all improvements required on

lands, easements, and rights-of-way to enable the disposal of dredged or excavated material all as determined by the Government to be required or to be necessary for the construction, operation, and maintenance of the recreation features;

4. Provide, during construction, any additional funds necessary to make its total contribution for recreation equal to 50 percent of total recreation costs;

c. Provide, during construction, 100 percent of the total recreation costs that exceed an amount equal to 10 percent of the Federal share of total ecosystem restoration costs;

d. Provide the non-Federal share of that portion of the costs of mitigation and data recovery activities associated with historic preservation, that are in excess of 1 percent of the total amount authorized to be appropriated for the project;

e. Not use funds provided by a Federal agency under any other Federal program, to satisfy, in whole or in part, the non-Federal share of the cost of the project unless the Federal agency that provides the funds determines that the funds are authorized to be used to carry out the project;

f. Prevent obstructions or encroachments on the project (including prescribing and enforcing regulations to prevent such obstructions or encroachments) such as any new developments on project lands, easements, and rights-of-way or the addition of facilities which might reduce the outputs produced by the ecosystem restoration features, hinder operation and maintenance of the project, or interfere with the project‘s proper function;

g. Not use project or lands, easements, and rights-of-way required for the project as a wetlands bank or mitigation credit for any other project;

h. Keep the recreation features, and access roads, parking areas, and other associated public use facilities, open and available to all on equal terms;

i. Comply with all applicable provisions of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970, Public Law 91-646, as amended (42 U.S.C. 4601-4655), and the Uniform Regulations contained in 49 CFR Part 24, in acquiring lands, easements, and rights-of-way required for construction, operation, and maintenance of the project, including those necessary for relocations, the borrowing of materials, or the disposal of dredged or excavated material; and inform all affected persons of applicable benefits, policies, and procedures in connection with said Act;

j. For so long as the project remains authorized, operate, maintain, repair, rehabilitate, and replace the project, or functional portions of the project, including any mitigation features, at no cost to the Federal Government, in a manner compatible with the project‘s authorized purposes and in accordance with applicable Federal and State laws and regulations and any specific directions prescribed by the Federal Government;

k. Give the Federal Government a right to enter, at reasonable times and in a reasonable manner, upon property that the non-Federal sponsor owns or controls for access to the project for the purpose of completing, inspecting, operating, maintaining, repairing, rehabilitating, or replacing the project;

l. Hold and save the United States free from all damages arising from the construction, operation, maintenance, repair, rehabilitation, and replacement of the project and any betterments, except for damages due to the fault or negligence of the United States or its contractors;

m. Keep and maintain books, records, documents, or other evidence pertaining to costs and expenses incurred pursuant to the project, for a minimum of 3 years after completion of the accounting for which such books, records, documents, or other evidence are required, to the extent and in such detail as will properly reflect total project costs, and in accordance with the standards for financial management systems set forth in the Uniform Administrative Requirements for Grants and Cooperative Agreements to State and Local Governments at 32 Code of Federal Regulations (CFR) Section 33.20;

n. Comply with Section 221 of Public Law 91-611, Flood Control Act of 1970, as amended (42 U.S.C. 1962d-5), and Section 103 of the Water Resources Development Act of 1986, Public Law 99-662, as amended (33 U.S.C. 2213), which provides that the Secretary of the Army shall not commence the construction of any water resources project or separable element thereof, until the non-Federal sponsor has entered into a written agreement to furnish its required cooperation for the project or separable element;

o. Comply with all applicable Federal and State laws and regulations, including, but not limited to: Section 601 of the Civil Rights Act of 1964, Public Law 88-352 (42 U.S.C. 2000d) and Department of Defense Directive 5500.11 issued pursuant thereto; Army Regulation 600-7, entitled "Nondiscrimination on the Basis of Handicap in Programs and Activities Assisted or Conducted by the Department of the Army"; and all applicable Federal labor standards requirements including, but not limited to, 40 U.S.C. 3141- 3148 and 40 U.S.C. 3701 – 3708 (revising, codifying and enacting without substantial change the provisions of the Davis-Bacon Act (formerly 40 U.S.C. 276a et seq.), the Contract Work Hours and Safety Standards Act (formerly 40 U.S.C. 327 et seq.), and the Copeland Anti-Kickback Act (formerly 40 U.S.C. 276c et seq.);

p. Perform, or ensure performance of, any investigations for hazardous substances that are determined necessary to identify the existence and extent of any hazardous substances regulated under the Comprehensive Environmental Response, Compensation, and Liabil-ity Act (CERCLA), Public Law 96-510, as amended (42 U.S.C. 9601-9675), that may exist in, on, or under lands, easements, or rights-of-way that the Federal Government determines to be required for construction, operation, and maintenance of the project. However, for lands that the Federal Government determines to be subject to the navigation servitude, only the Federal Government shall perform such investigations unless the Federal Government provides the non-Federal sponsor with prior specific written direction, in which case the non-Federal sponsor shall perform such investigations in accordance with such written direction;

q. Assume, as between the Federal Government and the non-Federal sponsor, complete financial responsibility for all necessary cleanup and response costs of any hazardous substances regulated under CERCLA that are located in, on, or under lands, easements, or rights-of-way that the Federal Government determines to be required for construction, operation, and maintenance of the project;

r. Agree, as between the Federal Government and the non-Federal sponsor, that the non-Federal sponsor shall be considered the operator of the project for the purpose of CERCLA liability, and to the maximum extent practicable, operate, maintain, repair, rehabilitate, and replace the project in a manner that will not cause liability to arise under CERCLA.

Violet, Louisiana Freshwater Diversion Project:

The non-Federal cost-share responsibilities for the Violet, Louisiana Freshwater Diversion would be consistent with the 75 percent/25 percent Federal/non-Federal cost share identified in Section 3083 of WRDA 2007, together with such other items of cost-share responsibilities as may be identified in the Feasibility Report for the project, as approved by the decision of the Chief of Engineers. Presently, as identified in the 1984 Chief's Report for *Mississippi and Louisiana Estuarine Areas Freshwater Diversion to Lake Pontchartrain and Mississippi Sound Feasibility Study*, the 25 percent non-Federal share of the cost of the design and implementation of the Violet, Louisiana Freshwater Diversion project is allocated 80 percent to the State of Louisiana and 20 percent to the State of Mississippi. It is not anticipated that this allocation will change as a result of completing the feasibility study for the project; however, if it does, the change in allocation will be addressed in the study, as approved by the decision of the Chief of Engineers.

4.5 OPERATION AND MAINTENANCE

The OMRR&R for this plan shall be a non-Federal sponsor responsibility. OMRR&R includes re-nourishment and invasive species control for marsh and swamp features. The first event for brackish marsh was determined by the calendar year of predicted marsh collapse in the WVA. Marsh collapse is when the observed condition of a defined area loses a significant amount of marsh through erosion or inundation resulting in a ‗collapse' where the remaining marsh is lost at an accelerated rate. The predicted marsh collapse in brackish marsh habitat occurs in calendar year 2058 (or target year 44) for this study under the medium RSLR condition. Target year 39 (calendar year 2053) is used for OMRR&R to precede the predicted marsh collapse event in target year 44 for brackish marsh.

The amount of marsh lost that would need to be replaced during an O&M event was calculated by taking the difference of the peak amount of marsh created and or nourished and the amount of marsh left in a particular target year. For brackish marsh habitat, the target year 39 is used. For swamp habitat, target year 35 is used.

For shoreline protection features, a maintenance event is assumed to be needed in year 5 as the majority of the settlement occurs fairly quickly after construction. Additional maintenance events would occur at 10 year intervals after the first maintenance event. Since the initial construction for existing features MRGO 2, MRGO 3 and MRGO 4 is a maintenance event, the initial lift at year 5 would not be needed. These would be maintained at 10 year intervals after the initial event. Table 4-10 summarizes OMRR&R costs by tier.

Table 4-9.
OMRR&R Costs by Tier (October 2011 Price Levels)

	Marsh and Swamp Re-nourishment	Invasive Species Control	Shoreline Protection	Total
Tier 1	$136,582,000	$5,671,000	$67,250,000	**$209,503,000**
Tier 2	$17,352,000	$966,000	$0	**$18,318,000**
Tier 3B	$194,686,000	$4,120,000	$4,062,500	**$198,806,000**
			FIP TOTAL	**$426,627,000**

4.6 INSTITUTIONAL REQUIREMENTS

The WRDA of 1986 comprehensively reestablished and redefined the Federal interest in water resources development and, in recognition of the limitations on Federal financial resources, instituted requirements for proportionately greater non-Federal cost-sharing in USACE projects.

4.7 MRGO ECOSYSTEM RESTORATION PLAN: VIEWS OF THE STATE OF LOUISIANA

The State of Louisiana has been involved in the development of the ecosystem restoration plan. The plan has been formulated to be consistent with Louisiana's Comprehensive Master Plan for a Sustainable Coast (Master Plan). For example, the 2007 State Master Plan specifically recommended restoration of wetlands and swamps in the Central Wetlands and Golden Triangle areas, which is included in the FIP. The Master Plan was developed with intensive public input and was unanimously adopted by the Louisiana Legislature.

In a letter dated August 12, 2010, the State of Louisiana expressed “its continuing support of the Mississippi River Gulf Outlet Ecosystem Restoration Project” and declared “full support for the Mississippi River Gulf Outlet Ecosystem Restoration Program" (See Figure 4-2). It states that “the State of Louisiana and the Coastal Protection and Restoration Authority wholeheartedly endorse this and other Corps' hurricane protection and ecosystem restoration efforts…”

However, this letter also expresses the State of Louisiana‘s view that the Mississippi River Gulf Outlet Ecosystem Restoration Project should be undertaken at full Federal expense and that the state should have no financial obligations with respect to the Mississippi River Gulf Outlet Ecosystem Restoration Project.

Implementation of the ecosystem restoration plan would require identification of a non-Federal sponsor and execution of a cost sharing agreement. As of the date of this report, USACE has not received a letter of intent from the State of Louisiana to serve as the non-Federal sponsor to cost share in implementation of the ecosystem restoration plan. The USACE will continue to coordinate with the State of Louisiana in the development and implementation of the restoration plan.

4.8 VIOLET, LOUISIANA FRESHWATER DIVERSION PROJECT, VIEWS OF THE STATE OF MISSISSIPPI AND THE STATE OF LOUISIANA

Section 3083 of WRDA 2007, citing the Corps of Engineers feasibility study entitled —Mississippi and Louisiana Estuarine Areas: Freshwater Diversion to Lake Pontchartrain Basin and Mississippi Sound" dated 1984, authorizes the Corps of Engineers to design and implement a project for the diversion of freshwater at or near Violet, Louisiana for the purposes of reducing salinity in the western Mississippi Sound, enhancing oyster production and promoting the sustainability of coastal wetlands. Section 3083 identifies the State of Louisiana and the State of Mississippi as non-Federal sponsors for the non-Federal 25% share of the design and implementation of the Violet, Louisiana Freshwater Diversion project. Although Section 3083 does not expressly allocate the increment of the non-Federal 25 percent cost share attributable to each sponsor, the cited 1984 Feasibility Study and subsequent Report of the Chief of Engineers dated May 1986, stipulates that each State will be responsible for the recreational features built within its respective jurisdiction and that the State of Louisiana shall bear 80 percent of the Non-Federal Sponsor's 25 percent cost share and that the remaining 20 percent of the non-Federal 25 percent cost share shall be borne by the State of Mississippi.

The State of Mississippi, along with the State of Louisiana, has been actively involved in the development of the Violet, Louisiana Freshwater Diversion project. The final recommendations for the plan addressed in this report include a recommendation for additional analysis, design and implementation of the Violet, Louisiana Freshwater Diversion as authorized by WRDA 2007 Section 3083. This is consistent with MSCIP and the State of Mississippi's desire to freshen the Mississippi Sound and sustain oyster production.

In a letter dated September 20, 2010 the Mississippi Department of Marine Resources (MDMR) declared its full support for the Freshwater, Louisiana Diversion project (See Figure 4-3) and its understanding of its non-Federal cost sharing obligation. The State of Mississippi's letter also states its desire that the USACE, to the fullest extent possible, seek full Federal funding for the project. .

Before the Violet, Louisiana Freshwater Diversion can be implemented, the USACE will require a letter of intent to serve as the non-Federal sponsor and a self-certification of the non-Federal sponsor's financial capability from both the State of Mississippi and the State of Louisiana, including a clear statement of each State's willingness and ability to provide its required cost share and other items of local cooperation for the project, as described in this report. Prior to the commencement of construction by USACE, Federal law requires that both States execute a binding written agreement wherein they agree to provide all of the non-Federal obligations for the construction, operation, maintenance, repair, rehabilitation and replacement of the Violet, Louisiana Freshwater Diversion project. USACE will continue to coordinate with the State of Mississippi and the State of Louisiana in the development and implementation of the Violet, Louisiana Freshwater Diversion project.

CPRA
Coastal Protection and
Restoration Authority of Louisiana

August 12, 2010

Colonel Edward Fleming
New Orleans District
US Army Corps of Engineers
PO Box 60267
New Orleans, LA 70160-0267

Dear Col. Fleming:

The State of Louisiana is pleased to offer its continuing support of the Mississippi River Gulf Outlet Ecosystem Restoration Project as authorized in the Water Resources Development Act of 2007. This program is a vital step in rehabilitating the natural system of coastal Louisiana that serves to protect the economic and energy security of both the state and nation, the safety of more than 2 million Louisiana residents, the ecological balance of the Gulf region, and the survival of a unique culture.

This letter, while not legally binding on the State in any way and not an obligation of future funds appropriated by the State Legislature, declares our full support for the Mississippi River Gulf Outlet Ecosystem Restoration Program. The State understands that the Corps interprets WRDA 2007 to require a 35% non-Federal cost share for construction elements. However, the State disagrees with this interpretation. Rather, the State assert the Congressional intent is for the Mississippi River Gulf Outlet Ecosystem Restoration Project to be undertaken at **full Federal expense**, pursuant to Sections 7012(b) and 7013 of the Water Development Resources Act of 2007 (Pub. L. 110-114) referencing Emergency Supplemental Appropriations Act for Defense, the Global War on Terror, and Hurricane Recovery, 2006 (Pub. L. 109-234). Therefore, the State respectfully submits that it has **no** financial obligations (including but not limited to cost share, land rights acquisitions, operations and maintenance obligations) as non-Federal sponsor with respect to the Mississippi River Gulf Outlet Ecosystem Restoration Project.

The State of Louisiana and the Coastal Protection and Restoration Authority whole-heartedly endorse this and other Corps' hurricane protection and ecosystem restoration efforts, and we look forward to working with Corps on the implementation of this important project.

Sincerely,

Garret Graves
Chair
Coastal Protection Restoration Authority

1051 North 3rd Street Capitol Annex Bldg. Suite 138 | Baton Rouge, LA 70802 | Phone: 225.342.3968 Fax: 225.342.5214

Figure 4-2. State of Louisiana Letter

STATE OF MISSISSIPPI
Haley Barbour
Governor

MISSISSIPPI DEPARTMENT OF MARINE RESOURCES
William W. Walker, Ph.D., Executive Director

September 20, 2010

Colonel Edward Fleming
New Orleans District
US Army Corps of Engineers
PO Box 60267
New Orleans, LA 70160-0267

Dear Col. Fleming:

The State of Mississippi is happy to offer its continued support of the Mississippi River Gulf Outlet Ecosystem Restoration Project – Violet Diversion as authorized in the Water Resources Development Act of 2007. The Violet Diversion is a program vital to rehabilitating the natural system of coastal Mississippi and Louisiana that serves to protect the economic and energy security of both states, the nation and provides a salinity regime essential for fishery habitat vital to both coastal Mississippi and Louisiana.

The Violet Diversion project has been developed as a component of a plan to restore the areas in Louisiana affected by the Mississippi River Gulf Outlet (MRGO) navigation channel and to improve salinity conditions in estuaries of southeast Louisiana and southwestern Mississippi. Selection of the Tentatively Selected Plan that identifies a 7,000 cubic feet per second capacity freshwater diversion from the Mississippi River at Violet, Louisiana, meets the objectives of the Congressional authority. The project includes monitoring and adaptive management features to help ensure projected benefits are achieved.

Section 3083 of the Water Resources Development Act of 2007 (Public Law 110-114) authorizes the Violet Freshwater Diversion. The project has an estimated total cost of approximately $400 million. In accordance with that Congressional authority, the Violet feature would be cost shared at a ratio of 75% federal and 25% non-federal. The Corps has proposed that the State of Louisiana provide 20%, and the State of Mississippi 5% of the total project costs. This allocation was recommended by the Office of Management and Budget in a letter dated August 10, 1989, for the Bonnet Carre' Freshwater Diversion project, the benefits of which will be achieved by the Violet Diversion. Further, the Governors of Mississippi and Louisiana voiced support for the allocation of costs in letters dated September 21, 1990 and July 13, 1992, respectively.

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Figure 4-3. State of Mississippi Letter

4.9 REAL ESTATE

4.9.1 Estates

It is Corps of Engineers policy to acquire fee simple title for ecosystem restoration projects. Two reasons for such requirement is to reduce the risk that incompatible uses on project land will occur after project construction, and to ensure that ownership rights vested in the project are clear and enforceable. It should be noted that this is a planning document and the necessary estates are subject to change dependent upon project needs; in the event that the project would require the acquisition of an estate that is not proposed herein, a revised real estate plan will be prepared. It is the opinion of the project delivery team that the estates proposed herein provide sufficient rights to the Government to construct the project and also protect the interests of the Government.

4.9.2 Navigation Servitude

The Navigation Servitude will not be asserted for ecosystem restoration projects and therefore will not apply.

4.9.3 Fee (Standard Estate)

It is recommended that for Ecosystem Restoration projects that in order to protect project benefits, Fee (including mineral rights) be acquired from the private landowners.

"The fee simple title (described in Schedule A), is subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines."

It is assumed that all borrow material will be obtained from sites owned by the State or the Federal government. Therefore, only a Grant of Particular Use may need to be obtained for borrow areas.

4.9.4 Project Partnership

After extensive discussions with the State of Louisiana, a non-Federal sponsor has not been identified for implementation of the MRGO Ecosystem Restoration Plan authorized by Section 7013 of WRDA 2007 (Tiers 1, 2 and 3B). For design and implementation of the Violet, Louisiana Freshwater Diversion project, Section 3083 of WRDA 2007 identifies the State of Louisiana and the State of Mississippi as a joint non-Federal sponsors. The obligations of the non-Federal sponsor for both projects includes a requirement that the sponsor provide all real estate interests required for each project implemented under the plan, i.e., all lands, easements, rights of way, relocations, and any other interests, including suitable borrow and dredged or excavated material disposal areas, and performing all necessary relocations (LERRDs**)**. The non-Federal cost-share responsibilities for the Violet, Louisiana Freshwater Diversion would be consistent with the 75 percent/25 percent Federal/non-Federal cost share identified in Section 3083 of WRDA 2007, together with such other items of cost-share responsibilities as may be identified in the Feasibility Report for the project, as approved by the decision of the Chief of Engineers. Presently, as identified in the 1984 Chief's Report for *Mississippi and Louisiana Estuarine Areas Freshwater Diversion to Lake Pontchartrain and*

Mississippi Sound Feasibility Study, the 25 percent non-Federal share of the cost of the design and implementation of the Violet, Louisiana Freshwater Diversion project is allocated 80 percent to the State of Louisiana and 20 percent to the State of Mississippi. It is not anticipated that this allocation will change as a result of completing the feasibility study for the project; however, if it does, the change in allocation will be addressed in the study, as approved by the decision of the Chief of Engineers.

In accordance with Section 103(c)(4) of WRDA 1986, development of the recreation facilities proposed as part of the FIP would be cost-shared 50 percent Federal and 50 percent non-Federal. The non-Federal sponsor is responsible for providing any separable lands required for public access, health, and safety, with crediting for the value of those lands toward the sponsor's 50 percent share for the recreation facilities. Operation, maintenance, replacement, repair and rehabilitation (OMRR&R) costs are the responsibility of the non-Federal sponsor.

4.9.5 Real Estate Cost Estimates

Acquisition Costs: The total Real Estate costs for the FIP are $99,060,000 (October 2011 Price Levels). The gross appraisal for LERRDs is on file and is being reviewed at the Division level. Refer to Exhibit B in the Real Estate Plan for the charts of accounts estimate.

Based on preliminary research, it is assumed that approximately 1900 private ownerships are impacted by the FIP and will require the acquisition of new right of way. Also in the project area are lands owned by U.S. Fish and Wildlife Services: the Bayou Sauvage National Wildlife Refuge. Any areas owned by the State of Louisiana will require a Special Use Permit to be obtained.

4.9.6 Public Law (PL) 91-646 Relocations

All acquisition of private property for this project will be done in accordance with the provisions of Public Law 91-646, as amended. It is anticipated at this time that the project will not displace any persons, businesses or farms.

4.9.7 Relocation of Facilities

Due to the nature of the work to be done, it is assumed that there will not be any facility/utility relocations. Any existing oil and gas well sites will be avoided by the project footprint.

4.9.8 Acquisition Schedules

Following is an estimated acquisition schedule for the entire plan:

Task	Task Duration
Obtain all title information	3 years
Obtain all mapping information	3 years
Obtain all appraisals	3 years
Negotiate and issue all rights-of-entry	8 years
Condemnation	3 years

- Activities would be done concurrently.

4.9.9 Landowner Concerns

During public scoping meetings, most landowners were in favor of the project given the direct benefits it would provide to the ecosystem; however, the public has not yet had the opportunity to provide comments in regards to fee acquisition instead of the originally proposed non-standard estates. It is our opinion that most landowners will not be in favor of selling fee interests. We expect that many acquisitions will be accomplished through condemnation.

4.10 FEDERALLY IDENTIFIED PLAN SUMMARY

The federally identified plan would restore and protect approximately 57,472 acres of habitat in the study area, including 14,123 acres of fresh and intermediate marsh; 32,511 acres of brackish marsh; 10,318 acres of cypress swamp; 466 acres of saline marsh; and 54 acres of ridge habitat. The federally identified plan also identifies 71 miles of shoreline protection including 5.8 miles of oyster reef restoration. The federally identified plan is the National Ecosystem Restoration Plan.

Based on 2012 price levels, the Project First Cost of the FIP is estimated at $2.9 billion (October 2011 Price Levels). The Project First of Tiers 1 and 2 is estimated at $1.3 billion and $325 million, respectively (October 2011 Price Levels). The Project First Cost of the Monitoring and Adaptive Management Plan (MAMP) is $190 million, including costs for potential adaptive management actions (October 2011 Price Levels). The Project First Cost of the MAMP for Tiers 1 and 2 are $104 million and $46 million, respectively (October 2011 Price Levels). The operation, maintenance, repair, replacement, and rehabilitation (OMRR&R) costs for the FIP is $427 million (October 2011 Price Levels). The OMRR&R costs for plan features in Tiers 1 and 2 are estimated at $210 and $18 million, respectively (October 2011 Price Levels).

Recommendations are divided into tiers by the level of uncertainty regarding conditions for ecological success and long-term sustainability, including the need for additional study.

- Tier 1 includes features that have been developed to a feasibility level of detail and are not dependent on a freshwater diversion. Tier 1 features are recommended for construction through the WRDA 2007 Section 7013 authority upon the identification of a non-Federal sponsor.
- Tier 2 includes features with feasibility level detail that are dependent upon salinity conditions but may be sustainable without the implementation of a freshwater diversion. If future conditions and further analysis indicate that favorable conditions for ecological success and long term sustainability exist (as defined in the adaptive management plan), then these projects may be constructed. Tier 2 features would be constructed through the WRDA 2007 Section 7013 authority upon the identification of a non-Federal sponsor.
- Tier 3A includes further study of the Violet, Louisiana Freshwater Diversion under the WRDA 2007 Section 3083 authority. The non-Federal cost-share responsibilities for the Violet, Louisiana Freshwater Diversion would be consistent with the 75 percent/25 percent Federal/non-Federal cost share identified in Section 3083 of WRDA 2007, together with such other items of cost-share responsibilities as may be identified in the Feasibility Report for the project, as approved by the decision of the Chief of Engineers. Presently, as identified in the 1984 Chief's Report for *Mississippi and Louisiana Estuarine Areas Freshwater Diversion to Lake Pontchartrain and Mississippi Sound Feasibility Study*, the 25 percent non-Federal share of the cost of the design and implementation of the Violet, Louisiana Freshwater Diversion project is allocated 80

percent to the State of Louisiana and 20 percent to the State of Mississippi. It is not anticipated that this allocation will change as a result of completing the feasibility study for the project; however, if it does, the change in allocation will be addressed in the study, as approved by the decision of the Chief of Engineers

- Tier 3B includes any features that are dependent on freshwater diversion, and features in Tier 2 that future conditions and further analyses indicate are not sustainable. Subsequent to the completion of Tier 3A, Tier 3B features would be constructed through the WRDA 2007 Section 7013 authority upon the identification of a non-Federal sponsor.

The recommendations contained herein reflect the information available at the time and current Department of the Army policies governing the formulation of individual projects. They do not reflect programming and budgeting priorities inherent in the formulation of National Civil Works construction program nor the perspective of higher review levels within the Executive Branch. Consequently, the recommendations may be modified before they are transmitted to Congress as proposals for implementation funding. However, prior to the transmission to Congress, the state, federal agencies, and other parties will be advised of any modifications and will be afforded the opportunity to comment.

Edward R. Fleming
Colonel, U.S. Army
District Engineer

5 LIST OF PREPARERS

Name	Job Description/Experience/ Education/Registration	Subject Matter
Britsch, Del	Geologist/27 years/Ph.D./Reg.Prof.Geol.	Geology,Sediment Sources,Subsidence, Land Loss
Broussard, Darrel	Project Manager/20 years/B.S. Physics, MBA	Sr. Project Manager
Broussard, Richard	Lead Civil Engineer/Technical Manager (MVN)/ 33 years/ BSCE, University of New Orleans/ EI in LA	Dredging for navigation, flood control, coastal restoration and foreshore protection
Boyce, Mayely	Assistant District Council (MVN)/3 years/J.D/M.E.M., Duke University	Legal Review
Carson, Joshua	Environmental Scientist (PBS&J) 3 years/ B.S. in Biology, Baldwin-Wallace College	Project Manager
Chaisson, Angela	Senior Project Manager/Senior NEPA Specialist (URS), 26 years/B.S., Wildlife Resources, West Virginia University/Certified Wildlife Biologist, The Wildlife Society	Independent Technical Review of EIS Sections
Conner, J.V.	Senior Ecologist (URS) 45 years/Ph.D. Tulane University	Wildlife, Noise
Darville, Jennifer	Technical Editor and Writer/MVN 10 years/M.A. English, University of New Orleans	Technical Writer/Editor/Document Administration
Deloach, Pamela	Project Engineer/26 years/B.S. Civil Engineering – University of Alabama	Engineering Team Leader
DeMarcay, Gary	Archaeologist (MVN) 24 years/MA Anthropology, Texas A&M University	Cultural Resources
Esmail, Muna	Senior Environmental Engineer (URS) / 11 years / B.S. Civil Engineering, Tulane University	Air Quality
Feldmeier, Paula		
Goh, Yong	Sr. Project Scientist/environmental specialist 24 years, Soil Scientist, soil morphologist, Louisiana State University.	Soils
Lanford, Caroline	Lead Planner / 11 years/ M.U.R.P University of New Orleans/American Institute of Certified Planners (AICP)	Plan Formulation, Project Management Support
LeBlanc, Jim	Sr. Environmental Scientist/ 31 years /B.S. Marine Science, Nicholls State University	Coastal Vegetation Resources; Plankton Resources
Marler, Bradley	Senior Project Scientist, 22 years, M.S. Wildlife Ecology/Fisheries Management – Mississippi State University	Barrier Islands, URS Internal Technical Review
Martinez, Jonathan	Environmental Planner (URS)/9 years B.S. Forestry and Ecosystem Management – Louisiana State University	Environmental Lead / Water Quality and Scenic Streams
Mccaffrey, Kelly	Landscape Architect (MVN)/9 years/ B.L.A.Landscape Architecture – Mississippi State University	Aesthetics/Visual Resources
Miller, Gregory	Senior Planner (MVN) /22 years/ B.S. in Marine Science and International Business from The University of Alabama, and M.A. in Marine Affairs from the University of Rhode Island.	Plan Formulation, Project Management, Public Involvement
Muller, Brandon	Wildlife Biologist (URS)/6 years B.S. Wildlife and Fisheries Management – Louisiana State University	Aquatic/Fisheries Resources, Commercial Fisheries, Oyster Resources, Water Bottoms and Benthic Resources, and Essential Fish Habitat

Name	Job Description/Experience/ Education/Registration	Subject Matter
Napolitano, Matthew	Economist, 17 years/ BS Economics, University of Pennsylvania, MBA Tulane University	Economics
Parker, Thomas	Environmental Resource Specialist (MVN) 2 Years/ B.A. Biology, University of Colorado at Denver	Endangered Species and Biological Assessment
Perez, Andrew	Outdoor Recreation Planner, 11 years/ M.U.R.P. – University of North Carolina	Recreation Specialist
Qualls, Ying	Environmental Scientist / 20 years / B.A. City & Regional Planning / University of Louisiana Lafayette	Barrier Reef Resources
Reidenauer, Jeffrey	Senior Project Manager/Senior NEPA Specialist (URS), 24 years/Ph.D. and M.S., Biological Oceanography, Florida State University, B.S., Marine Biology, Fairleigh Dickenson University/Certified Senior Ecologist, Ecological Society of America/Professional Wetland Scientist, Society of Wetland Scientists	Independent Technical Review of EIS Sections
Richardson, Jerica	Archaeologist (MVN) 13 years/BA Anthropology, Mississippi State University	Environmental Justice
Stiles, Sandra	Chief, Ecological Planning and Restoration Section/ MVD RTS Environmental Compliance /26 years/B.S. Animal Science at Oklahoma State University	Environmental Manager/Biologist
Spalding, Elizabeth	Senior Staff Scientist II (PBSJ)/11 years experience in Louisiana coastal ecosystem assessment and restoration/ M.S. Biology–University of New Orleans and B.S. degrees in Biology and Business – Indiana University	Estuarine Ecology: Flora and Fauna
Taylor, Ron	Hydraulics Engineer, 9 years/B.S. Civil Engineering University of New Orleans PE-LA	Functional Team Leader Engineering; Hydraulic Engineering
Whalen, Dan	Economist/36 years/BS Economics University of New Orleans	Economics
Winer, Harley	Coastal/Hydraulic/Civil engineer (PBSJ)/21 yrs/ Ph.D. U of Florida/ PE- LA, MS, AL, FL	Hydraulic Engineering

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Applicable USACE Engineering Regulations		
Publication Number	Title	Publication Date
ER 1-1-11	Progress, Schedules, and Network Analysis Systems	15 Jun 95
ER 1-2-2	Water Resources Policies and Authorities Substantive Congressional Contacts	01 Jul 91
ER 5-1-9	Assignment and Transfer of Project Responsibilities	15 Mar 96
ER 5-1-11	USACE Business Process	01 Nov 06
ER 11-1-321	Army Programs Value Engineering	28 Feb 05
ER 11-2-101	Army Programs – Civil Works Activities CH 1-24	01 Aug 64
ER 25-1-98	Publications in the Federal Register	10 May 96
ER 200-1-4	Environmental Compliance Policies-Formerly Utilized Sites Remedial Action Program (FUSRAP) – Site Designation, Remediation Scope, and Recovering Costs	30 Aug 03
ER 200-1-5	Policy for Implementation and Integrated Application of USACE Environmental Operating Principles and Doctrine	30 Oct 03
ER 200-2-2	Procedures for Implementing NEPA	04 Mar 88
ER 200-2-3	Environmental Compliance Policies	30 Oct 96
ER 360-1-1	Public Affairs	1 Apr 91
ER 415-1-11	Biddability, Constructabilty, Operability, and Environmental Review	1 Sept 94
ER 1105-2-100 Amendment 1, Appendix G Amendment 2, Appendix F Amendment 1, Appendix D	Planning Guidance Notebook	22 Apr 00 30 June 04 31 Jan 07 30 June 04
ER 1110-1-12 Change 1	Quality Management	21 July 06 30 Sept 06
ER 1110-1-263	Chemical Data Quality Management for Hazardous, Toxic, Radioactive Waste Remedial Activities	30 Apr 98
ER 1110-1-300	Cost Engineering Policy and General Requirements	26 Mar 93
ER 1110-1-8156	Policies, Guidance, and Requirements for Geospatial Data and Systems	30 Sept 05
ER 1110-1859	Engineering and Design, DrChecks	10 May 2001
ER 1110-2-401	Operation, Maintenance, Repair, Replacement, and Rehabilitation Manual for Projects and Separable Elements Managed by Project Sponsors	30 Sept 94
ER 1110-2-1150	Engineering and Design for Civil Works Projects	31 Aug 99
ER 1110-2-1302	Civil Works Cost Engineering	31 Mar 94

Applicable USACE Engineering Regulations		
Publication Number	Title	Publication Date
ER 1110-2-1403	Studies by Coastal, Hydraulic and Hydrologic Facilities and Others	1 Jan 98
ER 1110-2-1496	Coastal Field Data Collection	30 Apr 90
ER 1110-2-1407	Hydraulic Design for Coastal Shore Protection Projects	30 Nov 97
ER 1110-2-1450	Hydrologic Frequency Estimates	31 Aug 94
ER 1110-2-1451	Acquisition of lands Downstream from Spillways for Hydrologic Safety Purposes	10 Aug 78
ER 1110-2-1460	Hydrologic Engineering Management	7 July 89
EM 1110-2-6056	Standards and Procedures for Referencing Project Elevation Grades to Nationwide Vertical Datums (Draft)	31 Dec 10
ER 1110-2-8153	Technical Project Sedimentation Investigations	30 Sept 95
ER 1110-2-8154	Water Quality and Environmental Management for Corps Civil Works Projects	31 May 1995
ER 1110-2-8160	Policies for Referencing Project Elevation Grades	01 Mar 09
ER 1165-2-27	Establishment of Wetlands Areas in Connection with Dredging	18 Aug 89
ER 1165-2-132	Hazardous, Toxic, and Radioactive Waste (HTRW) Guidance for Civil Works Projects	26 June 92
EC 1165-2-206	Delegation of Review, Approval, and Signature Authority for Project Cooperation Agreements for Specifically Authorized Projects	30 Jan 04
ER 1165-2-501	Civil Works Ecosystem Restoration Policy	30 Sept 99
EC 1165-2-211	Incorporating Sea-Level Change Considerations in Civil Works Programs	1 July 09
MSC Regulations	DIVR 415-2-3, Alterations to Federally Constructed Floodwater Retaining Works	2 Mar 98
MSC Regulations	DIVR 1100-1-4031 Policy on River Diversions	23 Mar 11

7 ACRONYMS AND ABBREVIATIONS

AAHU	Average Annual Habitat Unit
ADCIRC	ADvanced CIRCulation (wind and wave modeling system)
ASA(CW)	Assistant Secretary of the Army for Civil Works
ATR	Agency Technical Review
CE/ICA	Cost Effectiveness/Incremental Cost Analysis
CIAP	Coastal Impact Assistance Program
CPRA	Coastal Protection and Restoration Authority (State of Louisiana)
CWPPRA	Coastal Wetlands Planning, Protection, and Restoration Act
DEIS	Draft Environmental Impact Statement
EA	Environmental Assessment
EFH	Essential Fish Habitat
EIS	Environmental Impact Statement
FIP	Federally Identified Plan
FONSI	Finding of No Significant Impact
FWOP	Future Without Project
FWP	Future With Project
GIS	Geographic Information System
GIWW	Gulf Intracoastal Waterway
HSDRRS	Hurricane and Storm Damage Risk Reduction System
HTRW	Hazardous, Toxic, and Radioactive Waste
IPET	Interagency Performance Evaluation Taskforce
IHNC	Inner Harbor Navigation Canal
IWR	Institute of Water Resources
LACPR	Louisiana Coastal Protection and Restoration
LCA	Louisiana Coastal Area (Ecosystem Restoration Study, 2004)
LDEQ	Louisiana Department of Environmental Quality
LDNR	Louisiana Department of Natural Resources
LDWF	Louisiana Department of Wildlife and Fisheries
MDEQ	Mississippi Department of Environmental Quality
MDMR	Mississippi Department of Marine Resources
MRGO	Mississippi River Gulf Outlet
MR&T	Mississippi River and Tributaries
MsCIP	Mississippi Coastal Improvements Program
MVD	USACE Mississippi Valley Division
MVN	USACE New Orleans District
NAVD	North American Vertical Datum
NEPA	National Environmental Policy Act
NER	National Ecosystem Restoration
NMFS	National Marine Fisheries Service

NOAA	National Oceanic and Atmospheric Administration
NRCS	Natural Resources Conservation Service
O&M	Operation and Maintenance
OMRR&R	Operation and Maintenance, Repair, Replacement and Rehabilitation
PED	Preconstruction Engineering and Design
PDT	Project Delivery Team
SAD	USACE South Atlantic Division
SAM	USACE Mobile District
SAV	Submerged Aquatic Vegetation
SSDS	Social Science Data and Software
USACE	U.S. Army Corps of Engineers
USEPA	U.S. Environmental Protection Agency
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
WCRF	Wetlands Conservation and Restoration Fund
WRDA	Water Resources Development Act
WVA	Wetland Value Assessment

8 GLOSSARY

Alternatives or alternative plans. Combinations of **management measures** that collectively meet study goals and objectives within the defined study **constraints**.

Constraint. A limitation or restriction on plans. Planning constraints may not be absolute restrictions but rather something to minimize or avoid.

Damage. This term from the Congressional language is interpreted to mean damage to real property.

Eustatic sea level rise. Change in global average sea level brought about by an increase in the volume of the world ocean [Intergovernmental Panel of Climate Change (IPCC) 2007b]. See also relative sea level rise.

IWR-PLAN. A decision support software program that assists with plan formulation by combining user-defined solutions to planning problems and calculating the effects of each combination, or ―plan.” The program can assist with plan comparison by conducting cost effectiveness and incremental cost analyses, identifying the plans which are best financial investments and displaying the effects of each on a range of decision variables.

Locally Preferred Plan. A plan requested by the non-Federal sponsor that deviates from the National Ecosystem Restoration Plan.

Management measures. A feature (a structural element that requires construction or assembly on-site) or an activity (a nonstructural action) that can be combined with other management measures to form alternative plans.

Marsh creation. A type of management measure that creates marsh in open water and nourishes the surrounding existing marsh. Marsh creation will include vegetative plantings. See also marsh nourishment.

Marsh nourishment. A type of management measure that nourishes existing marsh and decreases the depth of nearby open water. See also **marsh creation**.

National Ecosystem Restoration (NER) Plan. For ecosystem restoration projects, a plan that reasonably maximizes ecosystem restoration benefits compared to costs, consistent with the Federal objective. The selected plan must be shown to be cost effective and justified to achieve the desired level of output.

Natural features. This term from the Congressional language is interpreted to mean those features that serve a primarily ecosystem restoration purpose rather than features that primarily serve another purpose such as levees or floodwalls.

Opportunities. Desirable conditions to be achieved.

Period of analysis. The time horizon for which project benefits, deferred construction costs, and operation, maintenance, repair, rehabilitation, and replacement costs are analyzed. For this study, the period of analysis is from 2011 to 2065.

Problems. Undesirable conditions to be solved.

Reduce or prevent damage from storm surge. This phrase from the Congressional language is interpreted as –hurricane and storm damage risk reduction” as used in LACPR. This interpretation is consistent with LACPR, e.g. we cannot prevent, we can only reduce risk, and hurricane and storm damage risk results from factors in addition to storm surge including but not limited to waves.

Relative sea level rise. Sea level rise measured by a tide gauge with respect to the land upon which it is situated. Relative sea level rise occurs where there is a local change in the level of the ocean relative to the land, which might be due to ocean rise and/or land level subsidence. See also **eustatic sea level rise**.

Risk. A measure of the probability and severity of undesirable consequences (including, but not limited to, loss of life, threat to public safety, environmental and economic damages).

Uncertainty. Uncertainty is the result of imperfect knowledge concerning the present or future state of a system, event, situation, or (sub) population under consideration. There are two types of uncertainty: aleatory and epistemic. Aleatory uncertainty is the uncertainty attributed to inherent variation which is understood as variability over time and/or space. Epistemic uncertainty is the uncertainty attributed to our lack of knowledge about the system (e.g., what value to use for an input to a model or what model to use). Uncertainty can lead to lack of confidence in predictions, inferences, or conclusions.

Wetland Value Assessment (WVA). A quantitative habitat-based assessment methodology used to determine wetland benefits of restoration measures. The WVA quantifies changes in fish and wildlife habitat quality and quantity that are expected to result from a proposed wetland restoration project. The results of the WVA, measured in Average Annual Habitat Units (AAHUs), can be combined with cost data to provide a measure of the effectiveness of a proposed project in terms of annualized cost per AAHU gained. In addition, the WVA methodology provides an estimate of the number of acres benefited or enhanced by the project and the net acres of habitat protected/restored.