US Army Corps
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Mobile District

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Mississippi Coastal Improvements Program (MsCIP)
Hancock, Harrison, and Jackson Counties, Mississippi

Appendix K Plan Formulation

FOREWORD

This document is one of a number of technical appendices to the Mississippi Coastal Improvements Program (MsCIP) Comprehensive Plan and Integrated Feasibility Report and Environmental Impact Statement.

The *Mississippi Coastal Improvements Program (MsCIP) Comprehensive Plan Integrated Feasibility Report and Environmental Impact Statement* provides systems-based solutions and recommendations that address: hurricane and storm damage reduction, ecosystem restoration and fish and wildlife preservation, reduction of damaging saltwater intrusion, and reduction of coastal erosion. The recommendations contained in the Main Report/EIS also provide measures that aid in*:* greater coastal environmental and societal resiliency, regional economic re-development, and measures to reduce long-term risk to the public and property, as a consequence of hurricanes and coastal storms. The recommendations cover a comprehensive package of projects and activities, which treat the environment, wildlife, and people, as an integrated system that requires a multi-tiered and phased approach to recovery and risk reduction, irrespective of implementation authority or agency.

The MsCIP Study Area

The purpose of the Comprehensive Plan Report is to present, to the Congress of the United States, the second of two packages of recommendations (i.e., the first being the “interim” recommendations funded in May 2007, and this “final” response, as directed by the Congress), directed at recovery of vital water and related land resources damaged by the hurricanes of 2005, and development of recommendations for long-term risk reduction and community and environmental resiliency, within the three-county, approximately 70 mile-long coastal zone, including Mississippi Sound and its barrier islands, of the State of Mississippi.

The USACE has taken a system wide approach in formulating the Mississippi Coastal Improvements Program (MsCIP) Comprehensive Plan to ensure that both the MsCIP and the Louisiana Coastal Protection and Restoration (LaCPR) efforts are fully coordinated and develop complementary plans for the restoration of the U.S. Gulf coastal region as an integrated system.

In addition, the planning effort has taken a "top down" comprehensive planning approach, beginning with development of a Comprehensive Plan to address the overall water resources problems and opportunities of the region. Building off of the comprehensive identification of problems and opportunities, the planning effort then proceeded to develop site specific problems, opportunities and solutions that contribute to accomplishing the Comprehensive Vision for the restoration and protection of the Mississippi Gulf Coast. The results of this effort are a comprehensive regional plan that addresses hurricane and storm damage reduction and environmental restoration needs, as well as recommending a variety of site specific projects for either immediate implementation or for further investigation and subsequent implementation.

The analyses presented in this Plan Formulation Appendix support recommendations for approval of the Comprehensive Plan and for immediate implementation for a variety of water resource development projects that were developed through the comprehensive planning process. The Plan Formulation Appendix also supports recommendations for additional study for those components of the Comprehensive Plan which require additional investigations prior to identifying a specific recommendation for construction.

This appendix, the Main Report/EIS, and all other appendices and supporting documentation, were subject to Independent Technical Review (ITR) and will be presented for an External Peer Review (EPR). Both review processes will have been conducted in accordance with the Corps "Peer Review of Decision Documents" process, has been reviewed by Corps staff outside the originating office, conducted by a Regional and national team of experts in the field, and coordinated by the National Center of Expertise in Hurricane and Storm Damage Protection, North Atlantic Division, U.S. Army Corps of Engineers.

This Plan Formulation Appendix presents problem areas identified by stakeholders and residents of the study area, a summary of the approach used in analyzing problems and developing recommendations directed at assisting the people of the State of Mississippi in recovery, recommended actions and projects that would assist in the recovery of the physical and human environments, and identification of further studies and immediate actions most needed in a comprehensive plan of improvements for developing a truly resilient future for coastal Mississippi.

The MsCIP also developed and employed risk-based concepts which engaged stakeholders and allowed for informed decision making. The MsCIP planning process made extensive use of public and agency involvement, which introduced ideas, provided feedback, and gave first-hand accounts of the damages suffered as a result of the disaster. In an effort to demonstrate reliable public service professionalism, the public, state and local government input received at public workshops was also used to identify the degree of importance placed on environmental issues and to give indication of the likely Locally-Preferred Plans, should those be pursued as options to more cost-effective recommendations, consistent with Federal guidelines.

The results of the planning process (as expressed in the Systems of Accounts tables):

- identify cost-effective solutions,
- provide the best choices based on an extensive set of criteria, and
- identify the trade-offs made during the evaluation of alternatives.

The System of Accounts tables present the culmination of technical analyses, public input, and systematic evaluation. The selected alternatives stand out in their ability to fulfill the Congressional authorization and the needs of the nation.

This appendix contains detailed technical information used in the analysis of existing and future without-project conditions, in the development of problem-solving measures, and in the analysis, evaluation, comparison, screening, and selection of alternative plans. Each appendix functions as a complete technical document, but is meant to support one particular aspect of the feasibility study process. However, because of the complexity of the plan formulation process used in this planning study, the information contained herein should not be used without parallel consideration and integration of all other appendices, and the Main Report/EIS that summarizes all findings and recommendations.

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1 THE MSCIP PLANNING PROCESS – REACHING BEYOND THE TRADITIONAL PROCESS

The process of developing technically sound, environmentally sensible, cost-effective, publicly acceptable, and comprehensive solutions to the problems caused by the hurricanes of 2005, and with the potential to be caused by future events, required a thorough, and highly iterative process. This process had to incorporate both traditional planning requirements (which have served the nation well), as well as a more direct process of identifying and fully discussing potential risks and consequences of any given action, in a way that all might participate in, and understand the full meaning of.

This Appendix follows the plan formulation process in its applied sequence, and each step of this process must be fully laid out, to understand how the study team formulated plans, screened measures and alternatives, and arrived at a cost-effective, environmentally beneficial, and technically sound package of recommendations.

Plan formulation for the Comprehensive Plan utilized the highly-successful process discussed in Corps of Engineers' Engineering Regulation 1105-2-100 (also known as the "Planning Guidance Notebook"), with the addition of a number of new tools required in this specific study effort, including an extensive set of tools and evaluative and screening processes involving the potential risks and consequences of any action.

The directive language for the Mississippi Coastal Improvements Program included the requirement to address not only hurricane and flood (storm) damage, but also coastal erosion, fish and wildlife preservation and recovery, and salt water intrusion. Additionally, the study language also specified a different approach toward identification of a plan, in that it specifically directed that the report "shall recommend a cost-effective project", and furthermore, that the report "shall not perform an incremental benefit-cost analysis...and shall not make project recommendations based on maximizing net national economic development [NED] benefits..". This guidance demanded that the study team both develop an approach that met those mandates, while not deviating significantly from the traditional Federal planning process.

The MsCIP planning process uses the familiar Corps and NEPA study processes, which compare and contrast measures and alternatives for a full range of anticipated impacts and effects, with the former also requiring a "System of Accounts" analysis. Because the study area is so large and diverse, the mandates so broad, and the consequences of exceedance or failure so potentially catastrophic, the study effort also required that the Plan Formulation process be more iterative and risk-aware than is usually the case. The process had to be capable of re-visiting each and every assumption and piece of data, and modifying the measures developed as solutions, so as to create the most cost-effective package of potential options for review by decision-makers. This is also reflected in the study recommendations. Cost-effectiveness was determined by comparison of implementation costs to that of the damage reduction benefits each measure would provide.

The MsCIP study utilized an additional evaluative tool to address risks and consequences of potential alternatives, by use of a Risk-Informed Decision Framework (RIDF), to allow comparison of highly disparate factors affected by plan implementation, particularly those factors that were not dealt with well under the traditional Corps planning process. A key component of this process was the "weighing-in" of the public and other decision-makers, which reflect the factors most important to them, in deciding what might be done to address identified problems. Most notable among these factors were the potential risks (including residual risks), to population, environmental recovery and preservation, cultural, aesthetic and historic resources, and other factors that remain very difficult to compare and contrast. The Risk-Informed Decision Framework process is discussed in great detail in the RIDF Appendix.

The MsCIP process integrated a highly inclusive public and agency involvement process. This process was critical in the conduct of plan formulation activities, in that it introduced ideas, provided feedback, and gave first-hand accounts of the damages suffered as a result of the disaster. Public input (which included local and State governmental input) received at these public workshops was also used to define the "weight" of factors discussed above (such as the degree of importance they placed on environmental issues) examined in the Risk and Consequences analysis of potential plans, and to give indication of the likely direction of Locally-Preferred Plans, should those be pursued as options to more cost-effective recommendations.

Finally, the tentative recommendations derived by this process and presented in the Comprehensive Plan may be used as guidelines concerning the most cost-effective solutions, the best choices for a given set of criteria, and the trade-offs required. These are the tools required by local government and residents in the selection of plans that best meet their needs, and the needs of the nation.

1.1 The Traditional Federal Planning Process

The traditional Federal planning process has served this nation well. It has allowed the development of thousands of water resource projects that have prevented billions of dollars in damages, and saved countless lives. Unfortunately, it has also not always addressed the difficult-to-evaluate elements of risk and consequences, both of failure, and also of residual risk not addressed by projects, in situations both where the design event is exceeded, and also where different choices are made that may affect future conditions. It has also not necessarily accommodated the values of residents and decision makers in the analysis and selection process, in particular in weighting factors, which are of particular importance to concerned interests other than economic factors.
Recent guidance has reinforced the need to utilize methods capable of evaluating factors that resist quantification by traditional means, as part of the plan formulation and selection process. This includes means by which a study team might evaluate the trade-offs inherent in any design, those of residual risks inherent in each design, and also those of factors that are difficult to evaluate and prioritize under the traditional process.

The six traditional Planning Steps include:

1) Identifying Problems and Opportunities
2) Inventorying and Forecasting Resources
3) Formulating Alternative Plans
4) Evaluating Effects of Plans
5) Comparing Alternatives
6) Selecting the Recommended Plan

1.1.1 The MsCIP Comprehensive Plan – The Planning Process

The planning process utilized in the MsCIP study was a highly iterative process, which actually went beyond that done in the traditional six-step Corps feasibility study planning process. This was required, due to the fact that new problems or data were constantly being identified, but also because analysis of comprehensive plans, such as a "Lines of Defense" (LOD), constantly brought new problems and opportunities to light, requiring modification of, or development of, new measures; and the analysis, evaluation, and comparison that this requires.

A key element of the modified planning process utilized for the MsCIP study also included an additional sub-step of forecasting and analyzing not only one future "without-project" scenario, but a series of potential future scenarios, including highly speculative future re-development, and relative sea level rise scenarios.

In addition, and as discussed above, the addition of a RIDF, which evaluates the risks and consequences of a certain action, required additional sub-steps to be inserted in this process.

The sequence of steps developed for the MsCIP effort (*with additional sub-steps or iterative steps italicized*) can be shown in figure 1 and included:

1) Identifying Problems and Opportunities (*or Further Refined)*
1a) Constraints Identified (*or Further Refined)*
2) Inventory and Forecast Resources *(and Define Multiple Future Without-Project Scenarios)*
3) Preliminary Measures Developed for Each Problem Area (*followed in later iterations by formulation of true alternative plans*)
4) Evaluation of Effects of Measures (*followed later by Alternative Plans*)
5) Comparing Measures (*followed in later iterations by comparison of Alternatives*)
5a) Measure Screening by Traditional Initial Screening Criteria - Technical, Environmental and Economic Feasibility (*followed in successive iterations by screening by progressively more rigorous criteria)*
5b) Refinement of Measures - Development of Data at Higher Level of Detail, on Remaining Plans, in concert with development of data on other impact areas such as cultural, environmental, etc. effects.
5c) Development of metrics, units of measure, etc., for Risk Evaluation
5d) "Weighting" of Risk metrics by residents of coastal Mississippi
5e) Risk-Informed Decision-Making with Refined Data
5f) Final presentation of measure and/or alternative outcomes, including benefits, costs, risks, and consequences, to decision-making population
6) Selection and Presentation of Recommendations.

It must be pointed out that addition of these sub-steps, additional iterations, and inclusion of risk-based analysis is not an exclusive process, but a complementary process, that ensures a more rigorous identification of risks and consequences, and also greater inclusion of the public in a decision-making process.

The plan formulation process actually began during the Interim Phase of study, with development of a comprehensive list of problem areas, consisting of single or multiple problems associated with a given site or resource, and identified as having been caused or exacerbated by the hurricane events of 2005. Each of the problems identified were related to one of the four key areas of: a) hurricane storm damage, b) coastal zone erosion, c) damage to fish and wildlife resources, and d) saltwater intrusion.

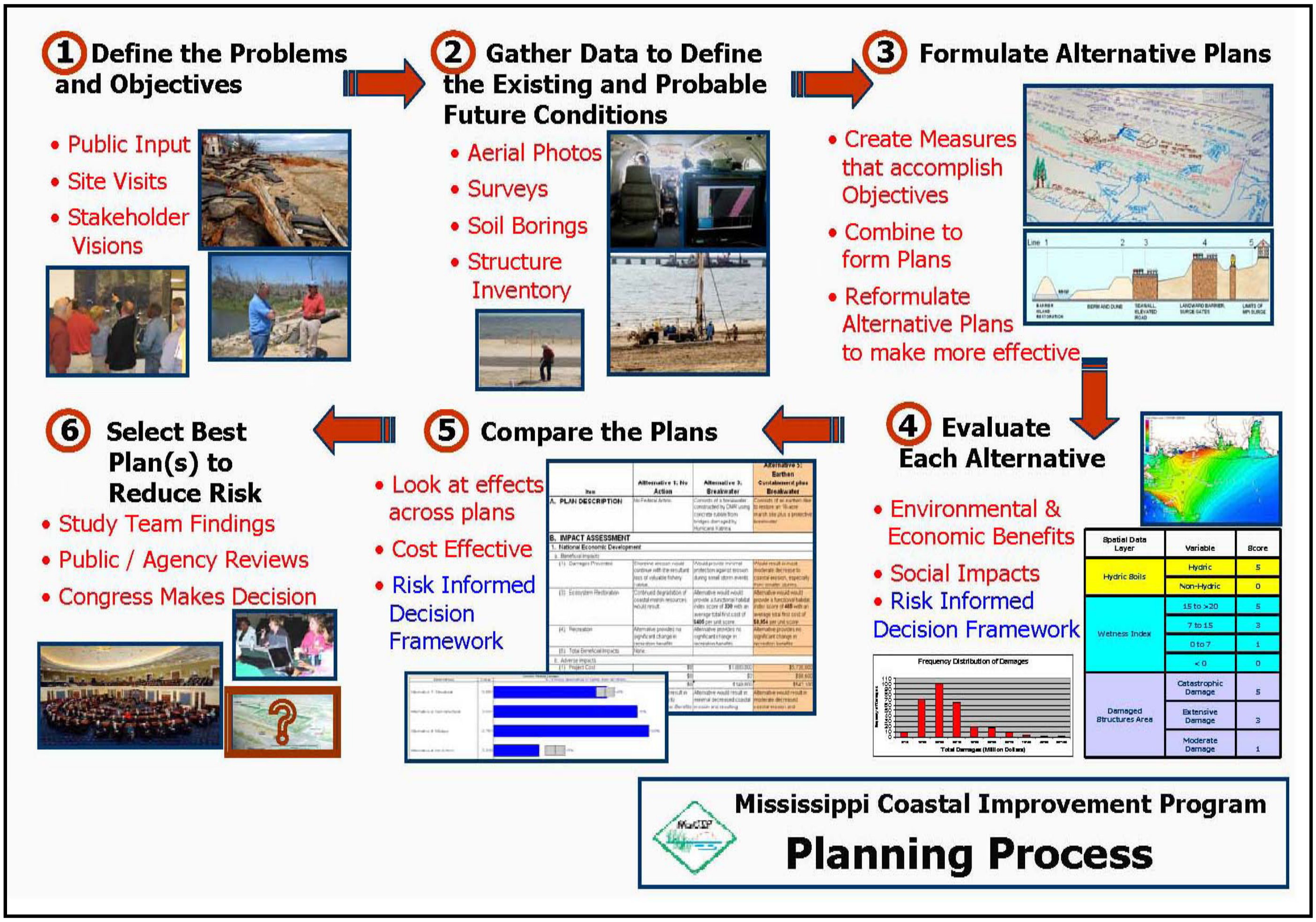


Figure 1 The MsCIP Planning Process

1.1.2 Internal Technical Review and External Peer Review

Internal Technical Review (ITR) was lead and coordinated by the Corps' National Center of Coastal Storm Damage Reduction Expertise, at the North Atlantic Division. ITR involved the use of experts in many fields, from multiple disciplines, and located in numerous parts of the country. ITR was conducted as a completely separate enterprise from internal technical review quality control, and quality assurance. No member of the ITR team was involved in any aspect of the study effort but that of independent technical review of products.

ITR consisted of multiple levels of review, at several points in the process. Details on the timing, sequencing, and disciplines engaged, are contained in the ITR / External Peer Review (EPR) Appendix.

The EPR was coordinated by the Corps' Baltimore District. No member of the District was involved in this wholly-external review process. The EPR process was lead by the Battelle Corporation, a private company with expertise in this particular requirement. Battelle staff chose the members of the EPR team from the ranks of academia, private concerns, and other sources of particular expertise. At no time were the names of credentials of any member of the EPR team shared with any member of the study team, but all EPR team members represent highly qualified individuals in those specific fields of endeavor. EPR was also conducted as a completely separate enterprise from internal technical review quality control, quality assurance, or independent technical review. No member of the EPR team was involved in any aspect of the study effort but that of external peer review of products.

EPR consisted of a single level of review. Details on the timing, sequencing, and disciplines engaged, can be found in ITR / EPR Appendix.

1.1.3 Introduction to Addressing Risks and Consequences

The approach chosen by the study team on the MsCIP Comprehensive Plan effort was a multi-layered assessment, evaluation, and presentation of risk, uncertainties, and consequences.

Risks and uncertainties were evaluated and incorporated into numerous technical analyses, such as the degree of uncertainty the coastal engineer felt about wave heights, surge heights, or storm behavior. Risks and uncertainties were also accounted for in the technical analysis of ecosystem functions values, and long-term project performance. Risks and uncertainties were also evaluated for a variety of economic indicators, and for multiple future without-project scenarios, including those of relative sea level rise, and of multiple future re-development scenarios.

The MsCIP Comprehensive Plan phase of study utilized an additional evaluative tool to address risks and consequences of potential alternatives, by use of a “RIDF”, which allowed comparison of highly disparate factors affected by plan implementation, particularly those factors that were not dealt with well under the traditional Corps planning process. A key component of the RIDF process was the “weighing-in” of the public and other decision-makers, which reflected the factors most important to them, in deciding what might be done to address identified problems. Most notable among these factors were the potential risks (including residual risks), to population, environmental recovery and preservation, cultural, aesthetic and historic resources, and other factors that remain very difficult to compare and contrast. The Risk-Informed Decision Framework process is discussed in great detail in the RIDF Appendix.

In addition, the team also spent a great deal of effort evaluating the risks, uncertainties, and consequences of any given action, outside that framework, so that complete and unbiased information on those factors could be presented and evaluated, by the broadest possible group. Information on risks, uncertainties, and consequences (including that of residual risk), is presented in both the table of factors used in the RIDF process, but also as a separate System of Accounts category, for full disclosure in that process, also. Key in this recognition of risks, uncertainties, and consequences, was also the recognition of multiple future without-project scenarios, most importantly those addressing uncertainties in the behavior of human beings and political realities within the study area, and those of uncertainties regarding sea level changes and subsidence.

1.1.3.1 Accommodating Uncertainty in Future Re-Development Through Scenario Testing

Field surveys were conducted to observe structure and content characteristics, where damages occurred, and the magnitude of damages incurred by Hurricane Katrina. The magnitude of structures that sustained significant damage, 50% or more structural damage and would have to completely rebuilt, was significant. It was estimated from the field surveying of structures that 32,446 structures within the study area sustained this level of damage; 9,555 in Hancock County, 16,528 in Harrison County, and 6,363 in Jackson County.

Given the magnitude of the long-term rebuilding effort, two re-development scenarios were identified. The first scenario is the full redevelopment of structures as existed pre-Hurricane Katrina to exactly what they were before the storm (i.e. if a structure was a residence before it will rebuild as a residence, a condominium will rebuild as a condominium, etc.). The second scenario includes the full re-development of the study area to its pre-Katrina levels but differs slightly from the first re-development scenario with respect to the coast line, which would see commercial re-develop. This scenario is based on observations of re-building efforts in other counties and states along the Gulf Coast and Florida Panhandle following Hurricane Ivan in 2004. Those re-development efforts suggest that a large portion of the beach front and back bay areas may re-develop to condominium structures. In addition to condominiums, current Mississippi law allows casinos to be built in these counties on land within 100-feet of the Mississippi Sound.

These re-development scenarios are intended to determine the level of risk of future surge events depending on the types of development that might be seen in the future. They were coupled with various levels of relative sea level rise and evaluated to determine the extent of plan performance, expected annual damages, and residual damages of flood damage reduction measures using the Hydrologic Engineering Center - Flood Damage Analysis (HEC-FDA) Monte Carlo Simulation program. More detail on these scenarios can be found in the Economic Appendix to this report.

1.1.3.2 Accommodating Uncertainty in Future Sea Level Rise Through Scenario Testing

Systematic long-term tide elevation observations suggest that the elevation of oceanic water bodies is gradually rising and this phenomenon is termed ‘sea level rise.’ The rate of rise is neither constant with time nor uniform over the globe. Present estimates of recent (over about the last 100 years) global average, or eustatic, sea level rise are varied but the average value is about 2 millimeters per year. Sea level is rising due to global warming, and there is uncertainty as to the future rate of sea level rise, how much sea level will rise at any particular location, what the primary drivers of global warming really are, and whether the rate of rise will be relatively constant or accelerate. Regardless of these uncertainties, more than half of the world’s population lives near the sea, and sea level rise is a phenomenon which requires society’s sustained attention and requires planning with consideration to the needs and protection of future generations.

Preliminary analysis of available data suggests a 20th century relative sea level rise of nine inches along the Mississippi coast. Relative sea level rise is what an observer standing on the shoreline over a long period would observe and includes the combined effects of land subsidence (or uplift) and the rise of sea level in and of itself. For the last twenty five years, the climate change community has also been arguing that sea level rise will accelerate in the 21st century, though to date, there is no clear confirmation that acceleration is actually taking place, and the rates at which sea level rise is predicted to accelerate have been somewhat inconsistent. There is therefore some uncertainty as to the future prevailing natural environment which a proposed project must function within. Society relies on project performance. Therefore, it is important to recognize that sea level has been rising, and it’s prudent (and required by USACE regulations) to recognize inherent uncertainties by exploring the ramifications of varying levels of possible relative sea level rise scenarios on project performance. This present study employs sensitivity analysis to do so. Sensitivity analysis is nothing more than an exercise where one changes an assumption and examines how outputs change accordingly. There are two primary assumptions that are modified in this program. The first is the magnitude of the relative sea level rise over the evaluation period. This program examines the implications to project performance for existing sea level; expected (i.e. moderate, or ‘central value’) relative sea level rise of about 2 feet; and high relative sea level rise of about 3.4 feet. Changes to these inputs provide a sense of project robustness (i.e. how well does the project perform over a range of uncertain futures?) and vulnerability (i.e. if a future materializes whereby the project would fail, how bad would the failure be?). Additionally, project performance is evaluated at a lifetime of 50 years; changes to the project lifetime provides insight as to the value over time of the initial investment, and whether an investment might be better delayed into the future, or whether more significant investments might be required in the future than might be expected, amongst other considerations. Numerous outputs are examined according to these alternative scenarios, including expected annual damages, damages reduced, and the annual probability of a surge level being exceeded.

2 IDENTIFYING PROBLEMS AND OPPORTUNITIES

Problem areas and sites, and opportunities associated with those sites, were solicited from, and then discussed, with members of the public, state, local, and other Federal agencies, representatives of industry and commerce, and resource agencies concerned with study area resources, at the series of open meetings, at individual meetings, and through other open forums. The meetings also included web-casts intended on reaching those that could not physically attend one of the in-field meetings.

2.1 Problems

Hurricane-caused problems were also investigated in a series of on-going site investigations conducted in partnership with local representatives, to ensure a complete grasp on the nature of all identified problems, and to ensure development of a full range of suitable measures and plans to deal with the identified problems. The general nature of ***problems*** identified by the study team, State, County, and City officials, residents, and agency staff, included:

- Hurricane-induced storm surge and wave damage to structures and infrastructure within a specific site/problem area;
- Hurricane-induced storm surge and wave damage to structures and infrastructure within the entire three-county study area (analyzed as both specific areas, depending on the siting of the measure, but also as an entirety as a specific problem area);
- Hurricane-induced storm surge and wave damage to specific ecosystems/sites/problem areas within the identified three-county area;
- Hurricane-induced storm surge and wave damage to the entirety of all ecosystems within the entire three-county study area (analyzed as both specific areas, depending on the siting of the measure, but also as an entirety as a specific problem area);
- Hurricane-induced saltwater intrusion within the Mississippi Sound ecosystem and associated coastal environments;
- Hurricane-induced erosion of specific coastal wetlands and coastal infrastructure.

To facilitate the gathering of information, several workshops and public meetings were held in each county. Lists of the identified problems from each meeting are provided in Tables 1 through 15.

Table 1.

Coastal-wide Stakeholder Input: Coordination with Local Communities

Item#	Name
1	Coastal Mississippi Hurricane Evacuation Plan
2	Coastal Mississippi Artificial Reef Project for Remediation of 2005 Hurricane Damage

Table 2.

Coastal-wide Stakeholder Input: Regional Coordination Workshops

Item#	Name
3	Wetland area buy-outs
4	Barrier Islands - Restoration
5	USE selected levels of rip-rap instead of bulkheads for erosion control
6	Replace structures with marshes.
7	Provide 100 acres of oyster reef restoration
8	Work with State to authorize transfer of development rights in state statut
9	Include repair standards in building codes
10	Dredge access channels to existing public marine industry and recreatio
11	Review main drainage systems to determine where improvements are most necessary and will decrease future erosion and/or failure issues
12	Improve comprehensive retention/detention systems in each entity to reduce rainfall-related flooding.
13	Form a monitroing network network that will survive and function throughout a major storm to provide data that is critical to emergency managers
14	Provide an incentive for replacing failing septic systems in rural areas to improve water quality along bayous and bays.
15	Implement a barrier or check valve system to isolate freshwater detention from saltwater inundation during surge events.
16	Add wetlands along main drainage systems in each location to increase capacity of the systems during rainfall and surge flooding events.
17	Complete snagging/clearing, etc. to restore the capacity of existing drainage.
18	Repair existing bulkheads or other structural drainage components that were damaged during the storm to reduce future failures during similar events.
19	Maximize Beneficial Use of Dredge Materials
20	Consider brown water system to minimize demand on ground and surface waters and limit saltwater intrusion.
21	Re-establish Benchmark Information Coastal-wide
22	Relocate wastewater treatment facilities out of the surge-prone areas
23	Inspect and Rehabilitate Wastewater and Piping Systems
24	Develop additional Offshore Breakwaters or Sand Dunes where determined most Beneficial through Modeling
25	Barrier Islands - Combat invasive species
26	Consider all archaeological sites in planning process Many significant coastal sites are eroding and need to be preserved.
27	Barrier Islands - Sensitivity towards barrier islands
28	Barrier Isalands - Remove hazardous materials
29	Barrier Islands - Develop Baseline Flora-Fauna Studies
30	Barrier Islands - Protect From Spills
31	Barrier Islands - Evaluate Sediment Transport - Ensure sand minimg does not Impact Islands
32	Barrier Island - Indicate NPS boundaries on project maps
33	Marsh Restoration where Feasible This can be done in conjunction with private and government dredging projects
34	Partnership Efforts with Louisiana to Marsh Island Areas

Table 3.

Coastal-wide Stakeholder Input: Public Workshops

Item#	Name
35	Barrier Islands - Restoration (to a natural setting)
36	Allow nature to dictate wetlands vs. beach to a greater degree.
37	Provide protection for public facility (i.e., WW treatment plants).

Table 4.

Hancock County Stakeholder Input: Study Team Coordination

38	Bay St. Louis Downtown HSDR
39	Cowand Point Seawall Erosion Control
40	Hancock County Beach Ecosystem Restoration and HSDR
41	Clermont Harbor Seawall HSDR and Erosion Control
42	Hancock County Comprehensive HSD - Ecosystem Restoration
43	Jackson Wetland Restoration
44	Bayou Caddy Shore Protection and Ecosystem Restoration
45	St. Louis Bay Comprehensive Ecosystem Restoration
46	Lakeshore Beach Ecosystem Restoration
47	Clermont Lake Ecosystem Restoration
48	Hancock County Communities Flood Damage Reduction
49	WhiteÆs Road Evacuation Route Protection

Table 5.

Hancock County Stakeholder Input: Regional Coordination Workshops

50	Biloxi Marshes Comprehensive Ecosystem Restoration
51	Magnolia Branch Ecosystem Restoration
52	Jordan River Shores Ecosystem Restoration. . Buy out landowners, return hydrology, begin mitigation, prohibit new/more development
53	Pearlington Ecoystem Restoration - Buy-out homeowners and return hydrology
54	Shoreline Park buyout

Table 6.

Hancock County Stakeholder Input: Public Workshops

55	Restore more natural freshwater flows by closing the MRGO
56	Remove storm debris (i.e., demolition debris carried in by surge retreat) from aquatic environments. Restore traditional shrimping and fishing areas rendered un-trawlable by storm debris.
57	Ferries to Temporarily Replace Bridges.
58	Restore all Hancock (all cosatal MS) marshes damaged by storm
59	Restore Hancock County Beaches to Pre-Katrina conditions
60	Widen Hancock County Beaches, jump-start dunes
61	Preserve Bayou Caddy Area
62	Protect Hancock County wetlands from filling for development
63	Construct a N/S rail link connecting Port Beinville Industrial Park to the Norfolk and Southern Railroad through Stennis Buffer. Hurricanes cause CSXT rail outages which cost > $20,000/day

Table 7.

Hancock County Stakeholder Input – Additional Input from Regional Coordination Workshops

Item#	**Name**
64	Open the east Pearl River channel so it can be used by commercial marine traffic from Port Bienville
65	Pursue the development of additional breakwater structures in low-use areas.

Table 8.

Harrison County Stakeholder Input: Study Team Coordination

66	Mississippi Coastal Pump Station Inundation Protection
67	Mississippi Coastal Urban Communities HSDR
68	Mississippi Coastal Barrier Island Restoration
69	Mississippi Coastal Improvement and Hurricane Storm Damage Reduction Program
70	WhiteÆs Road Evacuation Route Protection
71	WhiteÆs Road Evacuation Route Protection
72	Harrison County Beach Ecosystem Restoration and Erosion Control
73	Long Beach Harbor HSDR
74	Highway 90 û Rodeburg to St. Charles St. HSDR and Flood Control
75	Pass Christian Harbor HSDR
76	Biloxi Point Flood Damage Reduction
77	Cedar Lake Road Flood Damage Reduction
78	Gulfport Commercial Harbor
79	Turkey Creek Watershed Improvements
80	Turkey Creek Flood Damage Reduction
81	North Gulfport Interior Drainage
82	Long Beach Interior Drainage HSDR (includes Canals 2 - 3)
83	Harrison County Industrial Seaway Harbor of Refuge
84	Tchoutacabuffa River Flood Damage and Watershed Improvement
85	Courthouse Road Wetlands Ecosystem Restoration and Preservation
86	Deer Island Ecosystem Restoration
87	DÆIberville Wetlands Ecosystem Restoration
88	Biloxi Back Bay Watershed Management and Ecosystem Restoration

Table 9.

Harrison County Stakeholder Input: Regional Coordination Workshops

Item#	**Name**
89	West Ship Island. Continue to re-nourish the north shore of the island east and in front of Fort Massachusetts, a national historic site.
90	Evaluate Dredging and Channelization when preparing flood controls from rain events to consider impact for storm surge in costal zone.
91	Extend South Side of Deer Island. Extend 200 yards to repair breach in island and restore original footprint of island.
92	Deer Island enhancements. Cap shell middens on western side of the island and restore top soil in maritime live oak forest
93	New Sewage Treatment Plant in Woolmarket Lagoon Area - Move the Woolmarket Lagoon to north of I10 north of the area. would protect the citizens by moving the sewage from the flood prone areas:
94	Flood-Proof Existing Infrastructure
95	Enhance Lee and Bayview Docks for commercial shrimpers.
96	Enhance Maine Street Docks for commercial shrimpers.
97	Acquire wildlife corridors in lands that repeatedly flood
98	Develop Concrete Staging Center in Industrial Canal. Develop Harrison county industrial canal artificial reef staging area to stockpile concrete debris for oyster reef and other useful projects.
99	Restore or enhance Mississippi oyster reefs.
100	Open hw 90 Bridges quickly
101	Utilize HW 90 bridge as artificial reef material
102	Provide Compensation for Persons in Flood-prone Areas to Relocate. Areas prone to flooding, such as Eagle Point, should be offered buy-outs.
103	Economic Development of Downtowns. Orderly expansion of municipal harbors along with revitalization of downtowns would provide green space; non-water dependent retail, and a manageable beach blvd. (NOT HW 90).
104	Turkey Creek: Mt. Pleasant UME Audubon site 41, Tidal Creek restoration of flood plain.
105	Complete the purchase of “optional” Cat Island for inclusion into Gulf Islands Nationals Seashore
106	Rebuild the Harrison County boardwalk with concrete to accommodate pedestrians, BICYCLES, and possibly street vendors.
107	Provide inland marine vessel storm shelter location with adequate moorings.

Table 10.

Harrison County Stakeholder Input: Public Workshops

108	Restore grassbeds in MS Sound
109	Retention/Detention basin to hold runoff while waiting for surge to go down from Brickyard Bayou.
110	Surge gates along Biloxi Bay to help ease drainage areas during storm events
111	Wiers (low level dams) within estuaries to control water flow
112	Purchase riparian buffers, wetland areas.
113	Reconsider dioxin cleanup on navy base post Katrina.
114	Long Beach Interior Drainage HSDR (includes ôCanals 2 - 3)
115	Reduce toxic exposure which exacerbates storm damage – Dioxin, Creosote, Titanium Dioxide, Gypsum.
116	Turkey Creek watershed Greenway
117	Forrest Height Levee :- Restore; Vegetate with native species; Footbridges; Nature trail atop
118	Dredge shoaled channels hinfering storm evacuation
119	Dredge shoaled marinas

Table 11.

Harrison County Stakeholder Input: Additional Input from Regional Workshops

Item#	**Name**
120	Deer Island re-nourishment of south side.
121	Provide protection of public infrastructure from flooding, surges and sedimentation.
122	Possibly add height to the existing beach elevation and redevelop lost dune vegetation.
123	Flood-proof low-lying sewer treatment plants. Lift stations and wells and their electrical and electronic controls.
124	Construct reservoir or detention system to provide storage for rain events to reduce or prevent flooding along coastal rivers.

Table 12.

Jackson County Stakeholder Input: Study Team Coordination

125	West End Landing Coastal Erosion
126	Front Beach Blvd. Ecosystem Restoration and Erosion Control
127	Front Beach Road Wetlands
128	Shearwater Bridge Erosion Control
129	East Beach Road Ecosystem Restoration
130	Belle Fontaine Marsh
131	Pascagoula Beach Blvd. Restoration
132	Beach Park Storm Damage Reduction
133	Beach Boulevard Erosion Control
134	Pascagoula Breakwater HSDR
135	Chicot Road Flood Damage Reduction
136	Monster Ditch/Ocean Springs Flood Damage Reduction
137	West Bayou/Rhodes Bayou Flood Damage Reduction
138	Upper Bayou Cassotte Flood Damage Reduction
139	Biloxi Back Bay
140	Davis Bayou Ecosystem Restoration
141	Grand Batture Island Ecosystem Restoration
142	Greenwood Island Ecosystem Restoration
143	West Pascagoula Delta Flood Damage Reduction and Ecosystem Restoration/Study
144	Jackson County Marsh Outlet Ecosystem Restoration
145	Upper Old Fort Bayou Comprehensive Flood Damage Reduction
146	Old Spanish Trail Comprehensive Flood Damage Reduction/Drainage
147	Old Spanish Trail Comprehensive Flood Damage Reduction
148	Old Spanish Trail Comprehensive Flood Damage Reduction
149	Gautier Hurricane Storm Damage Reduction and Ecosystem Restoration
150	Franklin Creek Floodplain Restoration/Franklin Creek and Pecan Hydrology Project
151	Gautier Hurricane Storm Damage Reduction and Ecosystem Restoration
152	Gautier Hurricane Storm Damage Reduction and Ecosystem Restoration/Ladnir Rd

Table 13.

Jackson County Stakeholder Input: Regional Coordination Workshops

Item#	Name
153	Bayou Chico Beach HSDR/Bayou Chico Bulkhead Rehabilitation
154	Round Island Ecosystem Restoration/Round Island Lighthouse Relocation
155	Upper Old Fort Bayou Comprehensive Flood Damage Reduction/C. Byrd Road Drainage
156	Upper Old Fort Bayou Comprehensive Flood Damage Reduction/C. Byrd Road Drainage
157	Pascagoula beaches, offshore breakwater/dunes/reefs/marshes to dissipate wave energy
158	Restore natural drainage ways upper Bayou Castelle (vic Fishhawk Rd, Meadow Dale Dr., Longwod Dr, and Bayou Castelle Dr)
159	Restore natural drainage ways upper Sioux Bayou (vic Laville Subdivision and Westgate Subdivision)
160	Restore natural drainage ways upper Mary Walker Bayou (vic Northwood Hills, Rolling Meadows, and Bayou Oaks subdivisions)
161	Robert Hiram Bridge (Gautier) Hurricane evacuation route. Wetlands restoration, drainage
162	Graveline Rd Bridge at Shepard St Park (County)
163	W River Delta restoration. Bulkhead western channel. Beneficial use. Wave protection for subdivisions.
164	Bennett Bayou tidal marsh restoration
165	Pascagoula Beach Restoration. Dunes, grasses, trees, with intermittent pockets of sand beach
166	W Land Lake Pascagoula. Dredge to recover retention qualities and install new drainage pipes to north.
167	New Drainage Channel West Side of Martin Rd Bridge
168	Study same as 58
169	11th St Bridge and Drainage Canal. Bridge is failing and canal walls are caving in.
170	Drainage improvements - same as 166
171	Old Mobile Hwy Bridge Failing
172	Bridge at Old Mobile Highway and Hospital Road is damaged
173	Restore Bates St Drainage to Open Water
174	Inspection & Rehabilitation of Sewer and Storm Piping for Pascagoula
175	Relocate Pascagoula WWTP out of surge area
176	Re-establish benchmarks Pascagoula city-wide
177	Pascagoula brown water system study
178	Pascagoula Beach Blvd. Restoration (Boardwalk, beach, and marsh addition along Pascagoula front beach)
179	11th St Bulkhead Rehab
180	Pascagoula main drainage system restoration including additional wetland side storage. City-wide retention/detention system. Drain barrier valve system.
181	C. Byrd Road Drainage

Table 14.

Jackson County Stakeholder Input: Public Workshops

Item#	**Name**
182	Ebb and flow of Intracoastal veins from the MS Sound to rebuild property with the erosion in the bayous near potential project #66.
183	Use jetties to prevent sediment flow clogging channels
184	Cedar Point/West River-Restore beaches, sand, work, sediment management in this area
185	Ecosystem restoration along Hwy 90, Jackson County
186	Dredge/clear area in front of beachfront outfalls.
187	Hydraulic lifting boardwalk/sidewalk as component of seawall/boardwalk improvements.

Table 15.

Jackson County Stakeholder Input: Additional Input from Regional Workshops

188	Improve the Jackson-county seawall. Provide additional county-wide seawall construction, boardwalks, beach construction, marsh construction, or a combination of these elements
189	Gautier improvements to drainage. Same as B.
190	Gautier, drainage improvements. Same as C
191	Bayou Outlets on the Mississippi Sound that require actions to remove deposited siltation
192	Gautier improvements to drainage. Same as D.
193	Dredge Davis & Simmons Bayous to include all connecting bayous to help prevent flooding.
194	Rebuild and enlarge Marsh Island
195	Divert water from Escatawpa River into Bayou Cumbest to restore freshwater flow to the bayou and improve water quality.

Table 16 presents a synopsis of system-wide and county problems and related needs identified by stakeholders during the workshops and public meetings. These problems and related needs are the basis for the plan formulation process.

Table 16
Examples of Stakeholder Input: Coordination with Local Communities

Stakeholder Identified Problems	Stakeholder Identified Needs
• Loss of life and human injury due to ineffective communication • Insufficient capacity at storm shelters	• Coastal Mississippi Hurricane Evacuation Plan
• Storm surge damages and environmental degradation due to development in low lying areas	• Wetland Area Buyouts
• Erosion and intrusion of salt water	• Barrier Island Restoration • Restore or enhance Mississippi Oyster Reefs • Freshwater Diversion
• Erosion and storm damage	• Widen beaches, jump start dunes (Hancock, Harrison, and Jackson Counties)
• Storm surge flooding caused damage to structures and infrastructure	• Provide protection for public facilities • Surge gates along Biloxi and St Louis Bays • Seawalls, levees and ring levees (Forrest Heights Levee, etc.) • Hurricane and Storm Damage Reduction at population centers (Gautier, Ocean Springs, etc.) • Flood proof Existing Infrastructure
• Storm surge caused sedimentation in wetland areas	• Restore wetland functions (Grand Bay Swamp, Hancock County Marsh, etc.) • Restoration of Pine Savannah • Complete snagging and clearing to increase flood water conveyance

Additional details on specific problems are provided within the appropriate appendices. For storm damage reduction and erosion control formulation and screening processes, these discussions are contained in the Engineering Appendix. For ecosystem restoration and saltwater intrusion reduction formulation and screening processes, these discussions are contained in the Environmental Appendix. The results of each evaluation and screening process are summarized in the following chapters, and are presented as a Comprehensive Plan of "tentative recommendations" in the Main Report.

2.2 Opportunities

Comprehensive, ***system-wide opportunities*** were identified during the MsCIP planning process to guide the development and evaluation of solutions to the region's water resource problems. An overall theme of Comprehensive Plan opportunities is not merely to reverse the harm done by the hurricanes of 2005, but as importantly to promote the long-term future sustainability of physical, human, and environmental resources within the study area. Comprehensive, system-wide opportunities include:

- Assist in sustainable redevelopment of hurricane damaged physical, environmental, and human resources within the MsCIP study area;
- Reduce the susceptibility of residential, commercial, and public structures and infrastructure to hurricane induced storm damages within the three-county (Hancock, Harrison, and Jackson) MsCIP study area;
- Assist in the recovery and long-term sustainability of coastal wetlands that support important fish and wildlife resources within the study area;
- Accelerate the recovery and assist in the long-term sustainability of maritime forest environments that suffered hurricane induced damages;
- Restore barrier island environments that suffered hurricane induced storm damages in a manner that promotes long-term sustainability of their fish and wildlife resources;
- Reduce saltwater intrusion within the Mississippi Sound coastal environment;
- Assist in the recovery of coastal ecosystems and infrastructure damaged by erosion during the hurricane events of 2005 and support programs that promote long-term erosion reduction and limit erosion potential during future hurricane events.

2.3 Planning Goals and Objectives

In response to the Federal Goal, as established by Congress, the following goals were established for the MsCIP by the Corps of Engineers Project Development Team (PDT), cooperating agencies and affected public. The system-wide goals established for this study were developed in clear recognition of the linkages between structural and nonstructural storm damage reduction and ecosystem restoration opportunities. System-wide goals are intended to address the coastal landscape of the entire Gulf Region, including the area specifically evaluated in the LaCPR program. MsCIP system-wide goals identified in the Comprehensive Plan effort include the following:

- Identify measures to minimize risk to loss of life and safety caused by hurricane and storm surge;
- Recommend cost-effective measures for restoration of nationally and regionally significant environmental resources within a context of long-term sustainability;
- Recommend cost-effective measures to reduce damages from hurricanes and storms without encouraging re-development in high-risk areas;
- Recommend cost-effective measures to mitigate damages caused by saltwater intrusion into nationally significant ecosystems;
- Recommend cost-effective measures to restore eroded coastal resources as part of a system-wide approach to develop a resilient coastline;
- Identify other water resource related programs and activities integral to the development of a comprehensive system-wide plan.

The system-wide objectives established for this study provide specific targets to measure progress towards achieving the comprehensive goals outlined above. Projects formulated as part of the Comprehensive Plan were evaluated based on their ability to contribute to achieving the targets established in these objectives. System-wide objectives include the following:

- Reduce loss of life caused by hurricane and storm surge by 100%;
- Reduce damages caused by hurricane and storm surge by $150M-$200M annually;
- Restore 10,000 acres of fish and wildlife habitat including coastal forests, coastal wetlands, wet pine savannah, submerged aquatic sea grasses, oyster reefs, and beaches and dunes by the year 2040;
- Manage seasonal salinities within the western Mississippi Sound such that optimal conditions for oyster growth (surrogate for other aquatic resources, 15 ppt during summer months) are achieved on an annual basis by 2015;
- Reduce erosion to barrier islands, mainland, and interior bay shorelines by 50%;
- Create opportunities for collaboration with local, state, and Federal agencies to facilitate implementation of programs and activities that maximize the use of resources in achieving the comprehensive goal.

2.3.1 Planning Considerations: Environmental Justice

On February 11, 1994, President Clinton issued EO 12898, *Federal Actions to Address Environmental Justice in Minority and Low-Income Populations*. The EO is designed to focus attention of Federal agencies on the human health and environmental conditions in minority communities and low-income communities. Environmental Justice Analyses are performed to identify potential disproportionately high and adverse impacts from proposed actions and to identify alternatives that might mitigate these impacts.

2.3.1.1 Historic and Existing Conditions

Data from the U.S Department of Commerce, Census of Population and Housing were used for this Environmental Justice analysis. The population in 1990 for Mississippi was 2,573,216. Minority populations included in the census are identified as Black or African American, American Indian and Alaska Native, Asian, Native Hawaiian and other Pacific Islander, Hispanic, of two or more races, and other. Mississippi is only second to the District of Columbia as having the largest Black or African American population. Poverty status, used in this coastal Mississippi report to define low-income status, is reported as the number of persons with income below poverty level. The 2005 Census defines the poverty level as $9,973 of annual income, or less, for an individual, and $19,971 of annual income, or less, for a family of four. In 2005, Mississippi ranked number one out of the 50 states for individuals living below the poverty level in the past 12 months. Unfortunately, Mississippi had 21.3% of its population living in poverty in 2005.

Coastal Mississippi has a lower percentage of minority residents than the State of Mississippi and the U.S. In 2000 (the most up-to-date data available), 79.6 percent of the population was white and 16.3 percent was black. All other racial groups combined totaled approximately 4.1 percent of the population, while 2.2 percent were of Hispanic origin. In Mississippi, 61.4 percent of the population was white, 36.3 percent was black, 2.3 percent was of another minority racial group, and 1.4 percent was of Hispanic origin. For the U.S., 75.1 percent of the population was white, 12.3 percent was black, and 12.6 percent was of other minority racial groups. Approximately 12.5 percent of the U.S. population was Hispanic.

The Census Bureau bases the poverty status of families and individuals on 48 threshold variables, including income, family size, number of family members under the age of 18 and over the age of 65, and amount spent on food. In 1997, approximately 14.6 percent of the residents were classified as living in poverty, lower than the State of Mississippi but slightly higher than the poverty rate for the U.S. as a whole.

2.3.1.2 Post-Hurricane Conditions

As of 2006, the population in Mississippi was 2,910,540 – of this 135,940 individuals live in Jackson County, 193,810 live in Harrison County, and at this time a population count for Hancock County was not available. Hurricane Katrina drew focus on the number of residents unable to flee the Gulf coast due to lack of funds. There is a longstanding legacy of unfair and disproportionate harmful exposures to low income, predominantly African American communities in much of Mississippi. Predominantly in the Biloxi area but also in other coastal Mississippi communities, there was a large population of Asian Americans that depended upon fishing for their livelihood. Adverse impacts from Hurricane Katrina have resulted in a large number of these individuals leaving the area.

Environmental Justices have resulted from years of industrial activity and waste disposal practices that hit these communities harder than higher income, predominantly white communities. Impacted areas, such as superfund facilities, are located more often in low-income areas and therefore are at greater risk to post-Katrina exposure. As clean-up proceeds and rebuilding begins, every effort must be made to remedy these environmental injustices through full clean-up, fair rebuilding practices and full partnership with affected communities. Over 30,000 families are being helped through Administration on Children and Families Temporary Assistance for Needy Families (TANF) program by the provision of short-term, non-recurrent cash benefits to families who traveled to another State from the disaster designated States. The hurricane-damaged States of Mississippi, Louisiana, and Alabama also received additional funding for the TANF program to provide assistance and work opportunities to needy families ($69 million for loan forgiveness and $25 million in contingency funds for State Welfare Programs.)

Counties along the Mississippi Gulf coast lost a sizeable share of their white residents and homeowners immediately following Hurricane Katrina, while other Gulf Coast metropolitan areas, especially those that gained residents, experienced little overall shifts in their demographic profiles. Coastal counties of Mississippi, which include Gulfport-Biloxi and Pascagoula metropolitan areas, in contrast to New Orleans, were left with a population that had a larger share of minority residents, a lower level of homeownership, and no significant decline in poverty. In essence, while the poor and less well-off residents of New Orleans bore the greatest brunt of Katrina, the storm had a more egalitarian effect on the population of coastal Mississippi. Our examination of the data for other hurricane impacted areas in the Gulf Coast region reveals that while a great deal of population shifting had occurred, only minor changes have taken place in the race and ethnic, economic and socio-demographic profiles for most of these areas.

Each and every measure or alternative examined in the MsCIP study was evaluated for its potential for adverse impacts to minority and/or low-income populations, in adherence with EO 12898. In no case was there any identified negative impact to any of these communities in regards to human health and environmental conditions, from any proposed actions or projects.

Because no plans for structural or non-structural protection of residences or businesses, either in-place or as acquisition and relocation have been vetted by community leaders or the public at more than a concept level, it is impossible to say whether or not any of these measures, as ultimately acted on over the long-term, would genuinely have a significant effect, either positive or negative, on low-income or minority populations.

In fact, the realities of living in a high hazard area, which grows more hazardous as one approaches the shoreline, will supersede the effect of any plans or projects pursued under any outside authority. The reality is that most low-income populations, some of whom are also minorities, will have a hard time rebuilding in high hazard areas simply due to the cost of homeowners or business insurance, which will be a requirement of the vast majority of lending institutions. In the more than two years since the hurricanes of 2005, the majority of rebuilding has been undertaken by those that can selfinsure their homes or businesses, and also afford to rebuild with their own resources, something the vast majority of low income families cannot do. Therefore, the economic nature of communities along the coast of Mississippi is being changed largely by the economics of those that can afford to rebuild and insure their properties, versus those that cannot.

And, while some structural measures might protect areas in which low-income residents might rebuild, those measures would only provide damage reduction for surge events, and not wind. The cost of insurance against wind damage, which would continue to be a requirement of lending institutions, may continue to drive the economics of whether one can or cannot afford to rebuild traditional residences or businesses, within the highest hazard zones.

Non-structural measures intended for acquisition and removal of the most risky structures would tend to affect all residents or businesses located in those zones, low-income and high-income alike. However, well-armored structures, such as high-rise concrete complexes, would advisedly be the most survivable of those that might exist in the most high hazard zones. But, the choice of income level of those that would be able to afford to live in those complexes will also likely be driven by the economics of those that can or cannot afford to do so. Whether or not some of those complexes can afford to contain apartments that have low rental rates, will be a choice of local government, which controls zoning ordnances and land-use and development decisions. Ultimately, the plan adopted for the Mississippi coast will not be a plan forced on them by the Corps or other Federal agencies, but a plan coordinated, discussed, and finally adopted by the numerous entities and individuals that will live with that plan, the residents and local government of coastal Mississippi.

3 Discussion on Technical Analyses: Planning and Engineering Methodologies and Approaches

The technical analyses undertaken by the MsCIP study team involved the development of methodologies and application of models, over a broad spectrum of disciplines. These include economics, environmental resources, plan risk evaluation and decision-making, coastal engineering, design and cost estimating, real estate, geotechnical investigations, Geographic Information Systems (GIS) application, saltwater/freshwater interface and saltwater intrusion remediation analysis, erosion and sediment transport analysis, sediment source analysis, hydrology and hydraulics, public involvement, and plan formulation.

Details on each of these technical functions and evaluative efforts are given in each of their respective appendices; however, a general discussion of the process each engaged in, in the development of measures and alternatives, is provided in following sections of this report.

3.1 Planning Models

Planning models used in the development, evaluations, and screening of measures, are provided in Table 17, below. A more complete discussion on all the models used throughout this study, as well as quality control and quality assurance procedures can be found in the Modeling Appendix.

Table 17.

MsCIP Planning Models

Model	Description/Purpose	Use in MsCIP
Spatial Decision Support System (SDSS)	GIS based decision system to identify & evaluate potential sites	Selection of potential Wetland restoration sites
AL/MS Gulf Coast Tidal Fringe Hydrogeomorphic Model (HGM)	Perform functional assessment of tidal fringe wetlands	Evaluate positive/negative impacts to tidal fringe wetlands
MS Wet Pine Savannah HGM Model	Perform functional assessment of wet pine savannah habitats	Evaluate positive/negative impacts to wet pine savannah habitats
Functional Habitat Unit (FHI) Spreadsheet	Assess the environmental Values of beach and dune habitat	Evaluate positive/negative impacts to beach and dune habitats

3.2 Environmental Resources Analysis and Evaluation

The analysis of existing and future "without-project" resources, and the development, evaluation, and screening of measures and alternatives dealing with ecosystem degradation and restoration, are discussed in general terms below, and in more detail in the Environmental Appendix.

The environmental team initially defined the overall comprehensive natural system and its condition after the hurricane season of 2005. This detailed discussion is found in Chapter 1 of the Environmental Appendix. A comprehensive list of ecosystem-related problem areas consisting of single or multiple problems associated within a given site was compiled with assistance from members of the public, state, local, and other Federal agencies, representatives of industry and commerce, and resource agencies concerned with study area resources, at a series of open meetings and on-site meetings. These areas were first identified as having been caused or exacerbated by the 2005 hurricane events identified with: a) coastal erosion; b) damage to fish and wildlife resources; and c) saltwater intrusion. The vast areas initially identified for study of ecosystem damage are shown in Figures 2 - 4. The areas are color designated based on their ability to be restorable. The red designation shows areas that are highly likely to be able to be restored to their historical habitats and in contrast the blue designation shows areas that are possible but very difficult to be able to be restored.

After an initial screening of problem areas to determine their link to the hurricanes of 2005, a list of potential problem-solving measures was developed for each problem area. This list of problem areas and sites damaged by the hurricanes of 2005 was then screened based on the input of the inter-disciplinary study team's understanding of each site's ability to either heal on its own, unaided by human intervention, or:

- by its national and/or regional significance in regards to the type of ecosystem it represents;
- the need for assistance to restore vital hydrologic links;
- the need to manually remove blockages created by hurricane-deposited debris that was impacting function;
- the need to remove excess sediment deposited by the hurricanes that had changed the nature of the land's surface and resulted in degraded function and value;
- the need to remove invasive species that had entered the area since the hurricanes and caused displacement of native plant species (and potentially wildlife depending on native species), degrading function of the ecosystem; or

- the need to plant native species vital to restoration of a significant ecosystem and restoration of its functions and values.

The following four models were utilized by the MsCIP environmental PDT to evaluate existing and future without-project conditions within the three-county study area:

- Mississippi and Alabama Gulf Coast Tidal Fringe Hydrogeomorphic (HGM) model;
- Wet Pine Savannah HGM model,
- SDSS; and
- Functional Habitat Index (FHI) Model.

The methodology used for riparian and coastal wetlands is the HGM, developed by the USEPA, NOAA, Corps, and USFWS, calibrated for wetlands ecosystems found in coastal Mississippi, as used in many prior studies (Schaffer 2007). HGM is a science-based quantitative and replicable methodology that establishes functions ands values at a variety of sites and reference points that are then used to establish functional values for sites within the area be analyzed. HGM was applied at a landscape-level, using numerous reference sites in the area in the establishment of without-project conditions. The HGM model was used for the functional assessment of tidal fringe wetlands and wet pine savannahs within the study area.

Because HGM has not been calibrated for use in coastal maritime forest analysis in this area, an alternative methodology was used for the small number of beach, dune, and/or coastal maritime forest sites evaluated. The methodology chosen for this application was FHI. Functional production was quantified as an output that the fauna could potentially use. Functions evaluated in the matrix included substrates, habitat types, stabilization, and vegetation. In order to reduce subjectivity, the output was identified as an indirect or direct benefit. The “No Action” effort for a given project still has a FHI score even though there is no work proposed for the area. The FHI tables quantify expected biological output by linking biophysical benefits (termed functions) to specific restoration activities. The term biophysical, in this case, refers to the living and non-living components and processes of the ecosphere. Adding all of these outputs together from the table, and then multiplying by the acreage, provides an FHI score. A FHI model was used in the assessment of existing and future without-project conditions for coastal dune environments. This model is based on collaboration between resource agencies involved in past restoration projects.

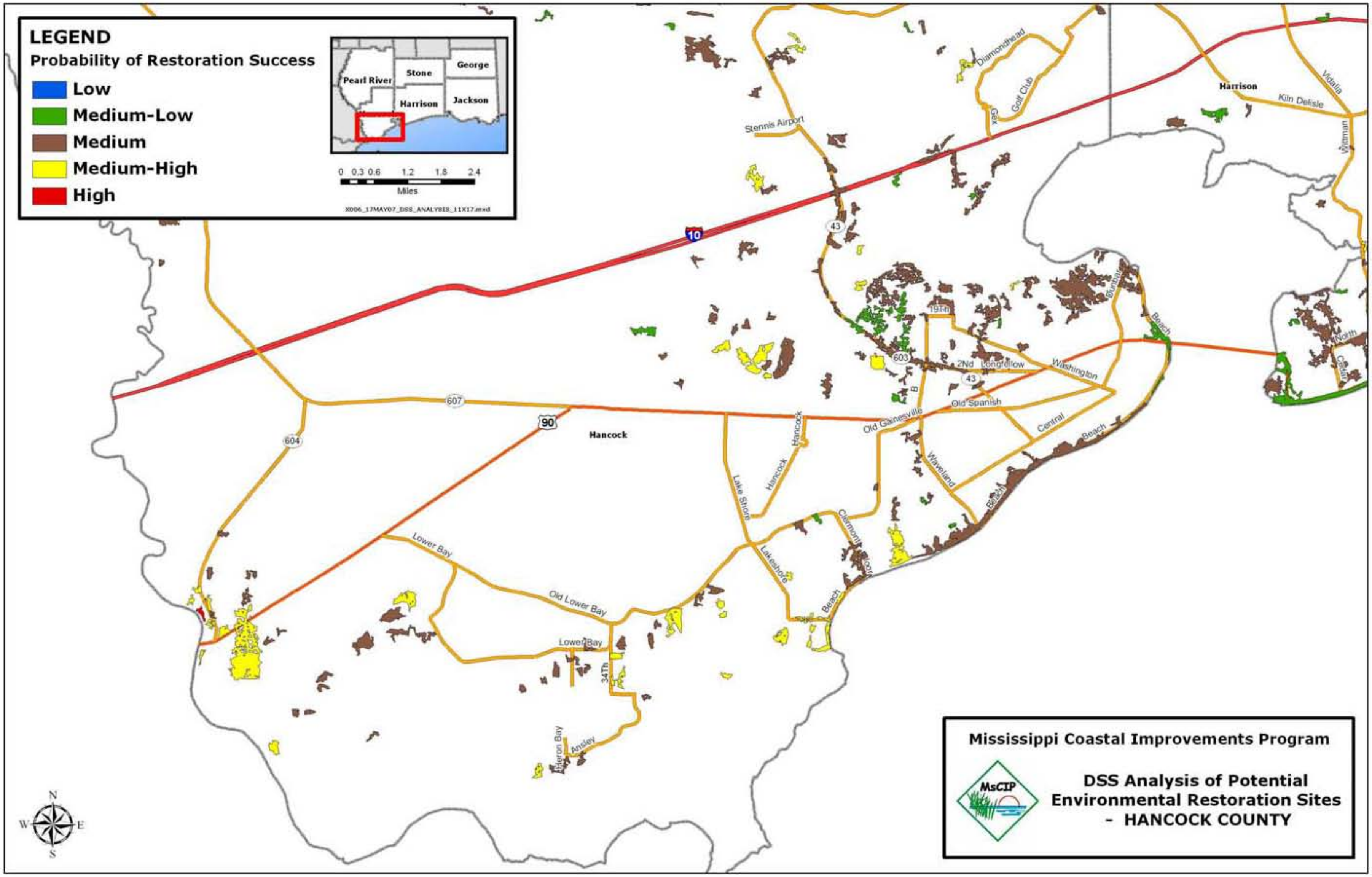
The SDSS tool allowed the Corps, Mobile District, working in cooperation with the USFWS and MDMR, to identify and prioritize potential wetland restoration areas throughout coastal Mississippi. A subset of potential restoration sites were identified by the SDSS tool and then ground-truthed by the MsCIP environmental team, including ERDC, Corps, MDMR, and USFWS. This interagency team allowed us to both confirm the accuracy of the SDSS results and to collect additional on-site information pertinent to restoration efforts. There are some major benefits in using the SDSS approach to wetland restoration. First, it allows for the relatively rapid assessment of the large number of restoration sites across the wide study area. Second, potential sites can be evaluated and restored in a watershed or landscape context, which allows us to comprehensively evaluate the overall natural system. This approach can maximize the benefits of wetland restoration, as opposed to simply restoring wetlands where convenient or where property is available. Essentially use of this SDSS tool allowed the MsCIP environmental PDT to assess the entire coastline as a holistic natural system; thus, the team was more effectively able to analyze needs in coastal Mississippi.

The SDSS effort resulted in the following products:

1. A Model Builder based SDSS tool, which can be subsequently edited and applied to other areas along coastal Mississippi in the future as funding becomes available;

2. Maps, such as aerial photography, topographic, soil layers, etc., depicting areas in the study region that have a high probability of being successfully restored into wetland functions that buffer and/or store stormwater, and provide suitable habitat for fish and wildlife; and

3. Photograph documentation and data sheets containing information on ground-truthed potential restoration sites.



1 **Figure 2. Hancock County Ecosystem Resources**

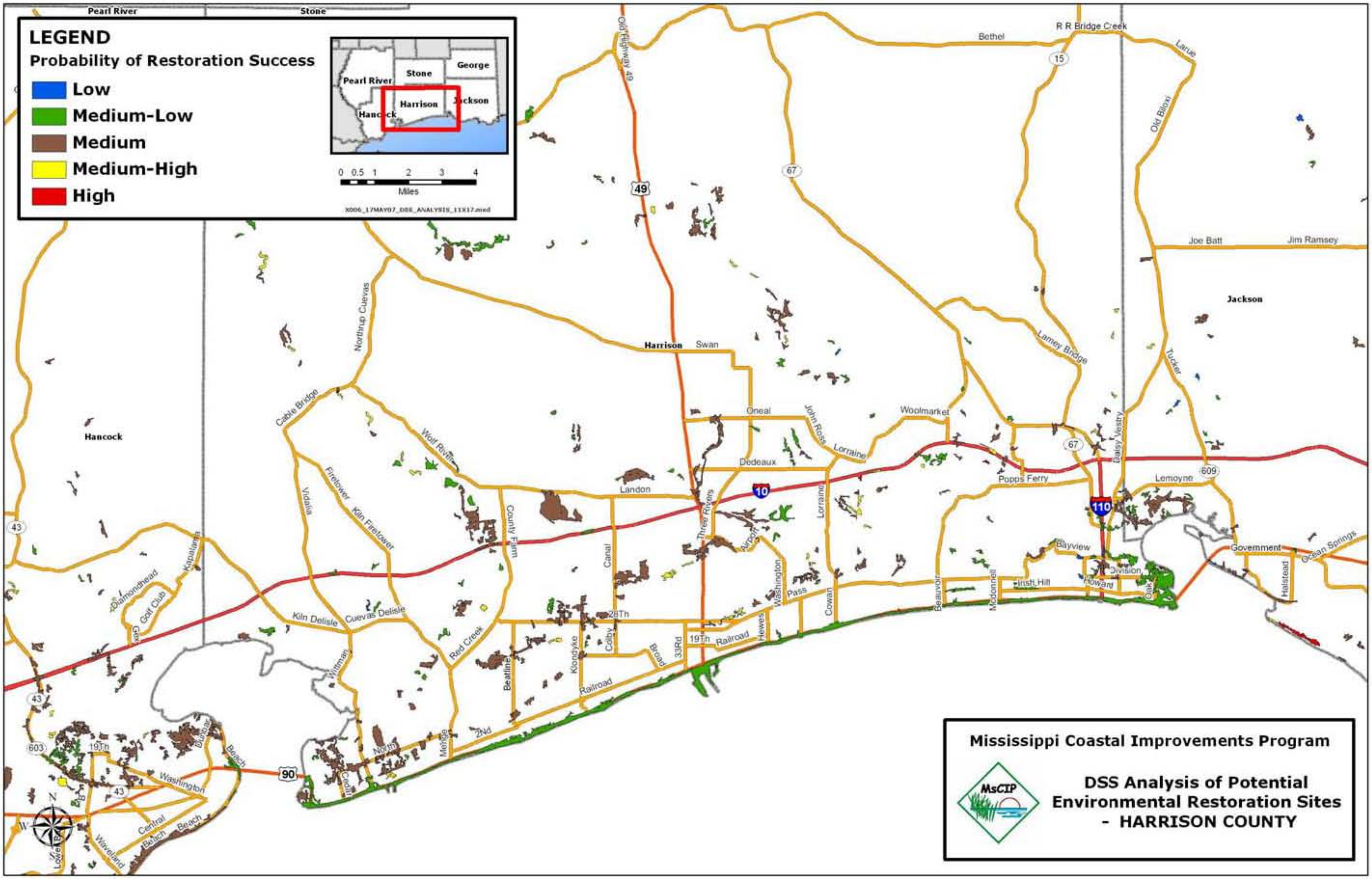
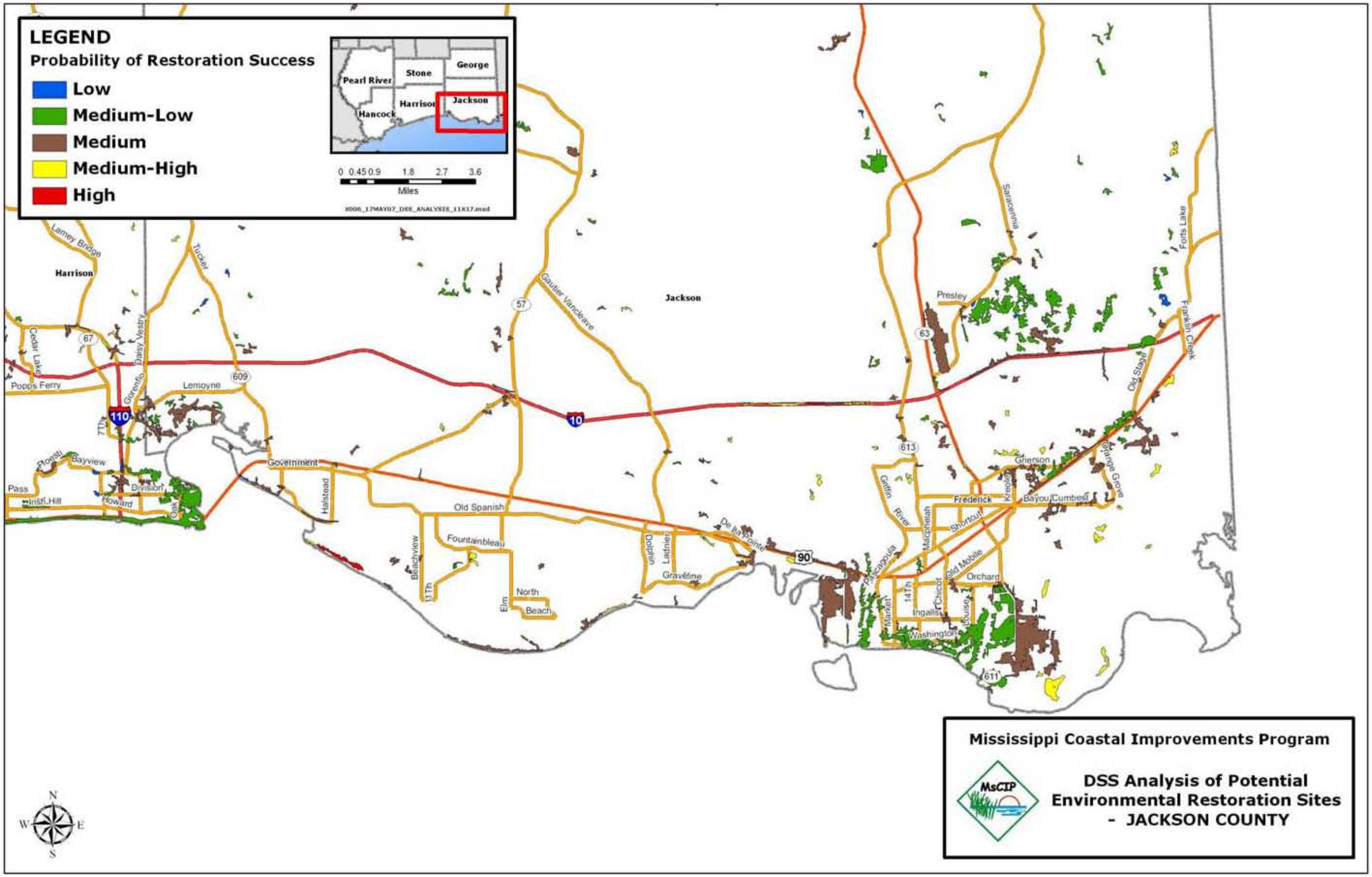


Figure 3. Harrison County Ecosystem Resources



1 **Figure 4. Jackson County Ecosystem Resources**

A FHI model was used in the assessment of existing and future without-project conditions for coastal maritime/beach-dune environments. This model is based on its use in the Corps' 2003 Section 204: Beneficial Use of Dredged Material at Deer Island, Harrison County, Mississippi Combined Planning and Design Report. The end product of the without-project conditions analysis was a set of functional scores for each problem area or site, which are presented in the Environmental Appendix.

A cost-effectiveness analysis was conducted for each of the measures and alternatives that were formulated for ecosystem restoration. The analyses followed the methodologies established in the Corps Institute for Water Resources (IWR) publications, Evaluation of Environmental Investment Procedures Manual, Interim: Cost-Effectiveness and Incremental Analyses, May 1995, IWR Report #95-R-1 and Cost Effectiveness Analysis for Environmental Measuring: Nine Easy Steps, October 1994, IWR Report 94-PS-2. The nine steps outlined in the cited IWR report have become the standard practice for identifying what are known as "Best Buy" ecosystem restoration measures, or those measures that yield the greatest 'bang for the buck' at various levels of output.

The IWR Measure model was developed based on these nine steps and is the preferred Corps model for the evaluation for ecosystem restoration measures. For the MsCIP Comprehensive Report and Integrated Programmatic EIS, Congressional Authority stated, "…but shall not perform an incremental benefit-cost analysis to identify the recommended project…." Following this authorization, only the first five steps of the nine easy steps, which are bolded below, were used in the IWR Plan evaluation, resulting in the identification of cost-effective plans for restoration purposes. The nine steps are:

- Formulation of combinations:
  Step 1 - Display Outputs and Costs
  Step 2 – Identify Combinable Management Measures
  Step 3 – Calculate Outputs and Costs
- Cost-Effective Analysis:
  Step 4 – Eliminate Economically Inefficient Solutions
  Step 5 – Eliminate Economically Ineffective Solutions
- Development of Incremental Cost Curve
  Step 6 – Calculate average costs
  Step 7 – Recalculate average costs for additional output
- Incremental Cost Analysis:
  Step 8 – Calculate incremental costs
  Step 9 – Compare successive outputs and incremental costs

3.3 Engineering Analyses

This section describes in very general terms the methods used to evaluate various elements and attributes of a "lines of defense concept". This concept involves multiple lines that include structural, environmental, and nonstructural features to accomplish the planning objectives. The lines are arranged in increasing levels of risk reduction from off-shore to in-shore up to the maximum possible intensity storm event that the team evaluated as possible for coastal Mississippi. This concept would utilize existing barriers such as the barrier islands, roadways, and railroad embankments as shown in Figure 5. Detailed descriptions of objectives, methods, and results are described in the Engineering Appendix.

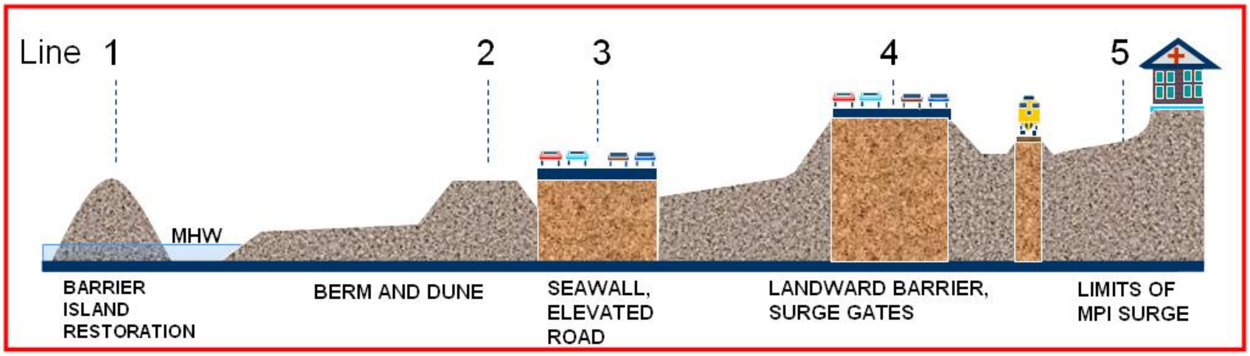


Figure 5 Lines of Defense Concept

3.3.1 Coastal Process Modeling

The purpose of this analysis is to evaluate the physical performance of the beach and dune system for anticipated future without-project and alternative with project conditions and to estimate the economic costs and benefits of each. The coastal processes modeling analysis employed the engineering-economic model Beach-fx (Gravens et al. 2007). Beach-fx relies on a shore response database to evaluate the beach and dune line of defense (line of defense two). The beach and dune analysis was evaluated considering the environmental forcing as characterized by plausible variants of the 71 historical tropical storm events that impacted the study area between 1886 and 2001.

The models applied to evaluate beach profile response to storms and project induced shoreline change are SBEACH (Larson and Kraus 1989) and GENESIS (Hanson and Kraus 1989). SBEACH is a numerical model for simulating storm-induced beach change that has been applied at numerous projects. SBEACH takes as input the storm time series (wave heights, wave periods, and total water elevations) and the initial profile definition, as well as other descriptors of the beach (e.g., grain size) and model parameters, and produces as output, the estimated beach profile at the end of the storm, as well as cross-shore profiles of erosion, maximum wave height, and total water elevation including wave setup. This information is extracted from the SBEACH output by post-processing routines and stored in the shore response database (SRD). The storm time series input is derived from a pre-computed surge response database developed by the Dredging Research Program (DRP) and the Wave Information Studies (WIS) database.

3.3.1.1 Hurricane Surge Modeling

A team of Corps of Engineers, FEMA, NOAA, private sector and academic researchers have been working toward the definition of a new system for estimating hurricane inundation probabilities. The findings and recommendations of this Risk Assessment Group are documented in a White Paper on Estimating Hurricane Inundation Probabilities (Resio 2007). The approach recommended by the group was a modified Joint Probability Method (JPM) referred to as the JPM with Optimal Sampling (JPM-OS). Generally, the approach involves wind and pressure field analysis and modeling; offshore and nearshore wave modeling, and storm surge modeling. For a full description, see Resio (2007). The general modeling approach is illustrated in Figure 6.

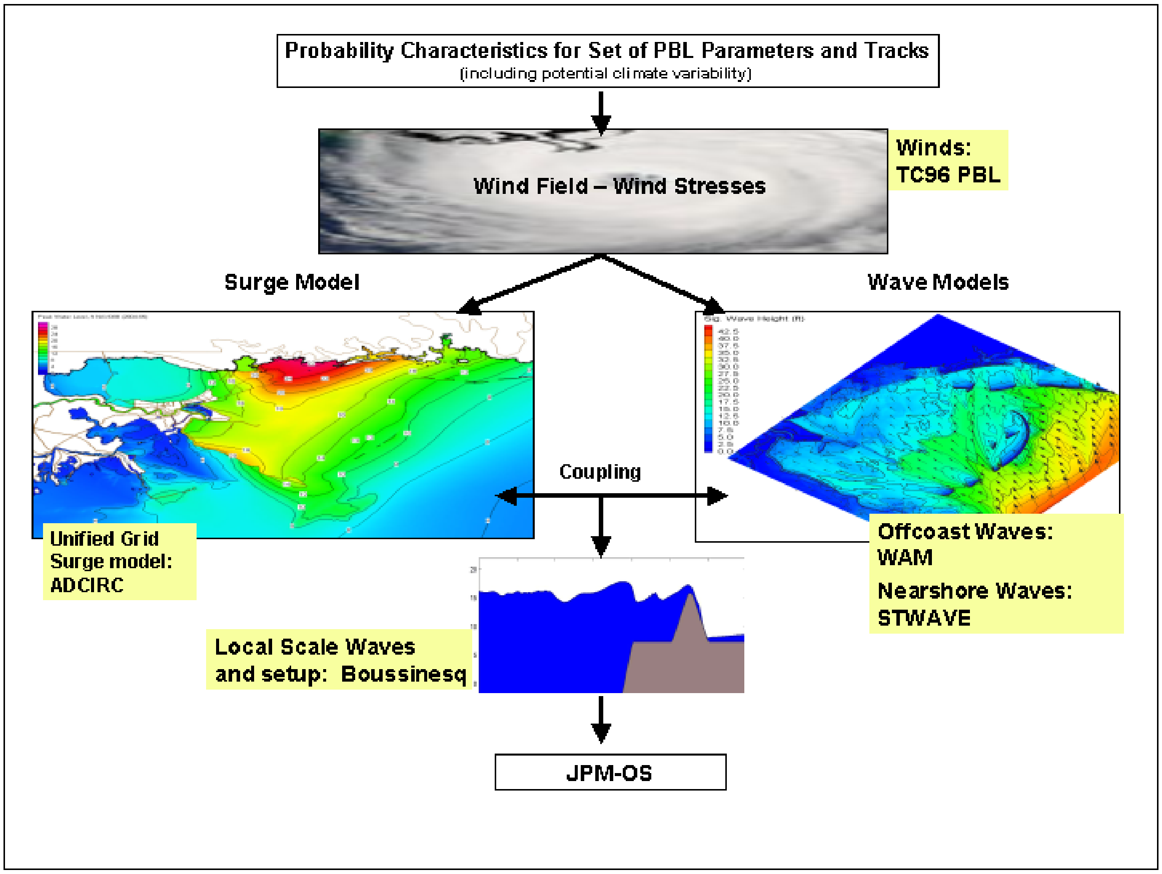


Figure 6. Diagram of modeling system for coastal inundation applications

Tropical cyclone surface wind and pressure fields were computed using the Planetary Boundary Layer Model, a.k.a. the TC-96 model. The wind and atmospheric wave fields were applied in (a) STWAVE to generate offshore and nearshore wave spectra and (b) ADCIRC generate bulk sea surge identities. These models were used iteratively to account for nearshore radiation stress transformation, and the resulting surge stage signature was modified for local shore feature effects based on limited application of the Boussinesq model COULWAVE.

Resulting storm surge surface envelopes were statistically sampled to derive surge stage-frequency relationships at a number of locations along the Mississippi Coastline. These relationships describe the stage for events with an annual chance of occurrence between 1 in 25 (or 4%) and 1 in 1000 (0.1%).

3.3.1.2 Stage-Frequency Curves

Stage-frequency curves are a foundational product for the present storm damage reduction design and analyses. The stage-frequency curves are the primary engineering inputs to economic flood damage analyses, and represent the static water surface elevation for non-structural flood damage reduction measures and levee crest height determination.

Stage-frequency curves describe the annual chance of occurrence of the surge still water elevation. The curves are composite curves, composed of both observed information (USACE tide gage observations at Gulfport, Biloxi, and Pascagoula) for more common events, and synthetic information (surge envelopes derived from statistical analysis of historic storm properties and imposition of those properties on the coastal environment through hydrodynamic wave and surge models) for more rare events. The composite and synthetic portions of the curves were joined graphically. Given the focus on hurricane surge damage Curves were developed for 62 locations in the vicinity of the coastline, and another 18 locations in Mississippi Sound in the vicinity of the Barrier Islands. Stage frequency curves with uncertainty were developed for the without project condition; for the Line of Defense 3 condition; and for the Line of Defense 4 condition.

Uncertainty to plus and minus one standard deviation about the observed portion of the stage-frequency curves were developed using the method of order statistics. Uncertainty to one standard deviation about the synthetic portion of the stage frequency curve was based on a Gumbel distribution. Uncertainty limits were also joined graphically.

3.3.1.3 Flood Damage Reduction Analyses

The Hydrologic Engineering Center's Flood Damage Analysis (HEC-FDA) program uses risk and uncertainty analysis methods for evaluating flood damage and flood damage reduction alternatives. The program relies on hydrologic, hydraulic, and economic data input. Uncertainties in these data are input and used by the model for computing expected annual damages. Version 1.2.3b dated August 2007 was used. This is a customized version of the modeling platform which provides for input of user-specified stage-frequency uncertainty. The Engineering Appendix describes the model and its application.

FDA models were developed for each coastal Mississippi County: Hancock, Harrison, and Jackson counties). Each county represents a planning unit, and each was further delineated into planning sub-units (PSU). There are ten PSU's in Hancock County, 19 in Harrison County, and 26 in Jackson County.

3.3.1.4 Levee Crest Elevation Determination

Levee heights were initially established based on interpretation of early hydrodynamic model output. A range of heights were conceptually designed and cost-height function was developed. The adequacy of a given levee height is related to social acceptability, cost-effectiveness, the desired level of protection, and local hydraulic and geotechnical performance requirements.

Hydraulic performance for purposes herein is predicated on limiting the average overtopping flow rate to a given threshold. The adopted threshold, based on application of limited mean estimates of coincident frequency significant wave height, peak period, and still water elevations, is 0.01 cubic feet per second per foot of levee. Wave heights, periods, and still water surface elevation frequency functions were provided by ERDC based on the hydrodynamic modeling program output. Such estimates are based on consultation with New Orleans District and are considered preliminary in accordance with draft levee certification regulations. Where required, wave properties are translated to the levee toe using the CEDAS program, which is also used to determine the required crest freeboard above the still water elevation for overtopping. Hydraulic performance evaluations are ongoing and are contained in Section 2.14 of the Engineering Appendix.

3.3.1.5 Regional Sediment Budget

This study evaluated the existing regional sediment transport magnitudes and directions for the Mississippi and Alabama barrier islands fronting Mississippi Sound and the mainland coast, including an analysis of historical long-term barrier island migration. A conceptual sediment budget was developed through a review of existing studies and is included in Section 2.12 of the Engineering Appendix. This budget formed the framework for the historical and calculated sediment budgets. Next, a historical sediment budget was developed through analysis of bathymetric and shoreline position change through time in consideration of engineering activities (navigation channel construction, etc.) and significant storm events were also documented. A calculated sediment budget was developed based on STWAVE and GENESIS modeling for the Gulf and Bay shorelines of the barrier islands as well as the mainland coast. The final sediment budget was formulated from all these intermediate budgets.

3.3.1.6 Wetlands, Landscape Features, and Storm Surge

A literature review that documents studies that have measured and modeled storm surge elevations with the goal of understanding how landscape features and vegetation modify the surge elevation was conducted. A sensitivity study of a degraded and restored Biloxi marsh utilizing STWAVE was also performed.

3.3.1.7 Interior Drainage

Drainage on the interior of the ring levee would be collected at the levee and channeled to culverts placed in the levee at the locations shown above. The culverts would have flap gates on the seaward ends to prevent backflow when the water in Mississippi Sound is high. An additional closure gate would also be provided at every culvert in the levee for control in the event the flap gate malfunctions. A typical section is shown below in Figure 7.

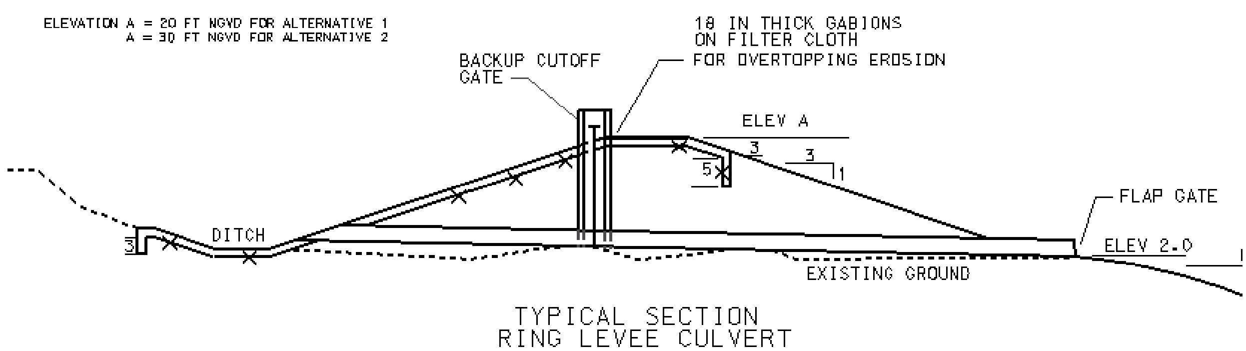


Figure 7. Typical Section at Culvert

In addition, pumps would be constructed near the outflow points to remove water from the interior during storm events occurring when the culverts were closed because of high water in the sound.

Flow within the levee interior was determined by subdividing the interior of the leveed areas into major sub-basins and computing flow for each sub-basin by USGS computer application WinTR55. The method incorporates soil type and land use to determine a run-off curve number. The variation in soil types, hydrologic soil groups, and major sub-basins was accounted for.

Peak flows for the 1-yr to 100-yr storms were computed. Levee culverts were then sized to evacuate the peak flow from a 25-year rain in accordance with practice for new construction in the area using Bentley CulvertMaster application. During periods of high water in Mississippi Sound, pumps would be required to evacuate rainfall. Pump sizes were determined for the peak flow resulting from a 10-yr rainfall based on an evaluation of rainfall observed during hurricane and tropical storm events as presented in two sources. The first is "Frequency and Areal Distributions of Tropical Storm Rainfall in the US Coastal Region on the Gulf of Mexico" US Dept of Commerce, Environmental Science Services Administration, ESSA Technical Report WB-7, Hugo V Goodyear, Office Hydrology, July 1968. The second is "National Hurricane Research Project Report No. 3, Rainfall Associated with Hurricanes (And Other Tropical Disturbances)", R.W. Schoner and S.

Molansky, 1956, Weather Bureau and Corps of Engineers. This decision was also based on coordination with the New Orleans District.

During some hurricane events, when the gates are shut, and rainfall exceeds the average 10-yr intensity over the basin, some ponding from rainfall will occur. Detailed modeling of all the interior sub-basins for all the areas was not possible for this report; therefore the exact extent of the ponding for extreme events is not precisely defined. The design rationale is based on the minimum facility concept, and economic tradeoffs between induced flooding and pumping provisions were not examined. Further studies will detail the requirement for the appropriate ponding areas, pump sizes, or buyouts in the affected areas.

3.3.1.8 Structural Damage Reduction - Engineering

Hurricanes are commonly recurring hazards for coastal Mississippi. The central Gulf coast region has one of the highest rates of occurrence in the U.S. Development along the Mississippi coastline at relatively low elevations in many areas has created a landscape that is highly susceptible to storm damage. The two bays that divide the coastline of the three counties also aggravate the potential for inland flooding due to storm surge. The influence that landfall location for hurricanes may impart on storm surge is based on physical reasons and dictates why western Mississippi might register higher stages for a given hurricane than elsewhere along the Mississippi Coast. While the central coast of Mississippi has the highest topography, major hurricanes such as Camille in 1969 and Katrina in 2005 still produced surges that devastated this highly developed area. Approximately half of the coast of Mississippi including all of Harrison County has man-made beaches with high-value real estate immediately landward of the beaches. Essentially all of the structures facing the Sound were completely destroyed in Katrina.

Sea level rise and land surface subsidence have been taken into account as part of this study and the two together are reported as “relative sea level rise”, which accounts for both as a single value. Both factors play into the gradual rise in sea level compared to the land surface, over the period of analysis, or planning horizon.

The MSCIP Study incorporated many geotechnical considerations into the structural and environmental appendices of the report. All embankments in support of the various lines of defense were modeled for alignment footprint and quantities using Microstation CADD 3D and INROADS software. The basic design templates assumed side slopes of 1 vertical to 3 horizontal with a 15 foot crest for normal embankments and some greater than 75 feet in support of major roads. Access through the levees was provided by earthen ramps where the embankment heights were small relative to the existing ground and a small elevation gradient could be accommodated. Areas where the levee height differentials were too great or site conflicts prevented access ramps, then tunnels with closure gates were provided. All utility removals and reinstallations excavations were incorporated into the cost estimate for the individual feature. Materials to be used in the embankment and levee structures were assumed to be obtained from commercial sources with 10 miles of any given project. No formal geotechnical investigations were performed for this study. Geotechnical investigations will be performed for any project carried forward for feasibility design.

3.4 Non-structural Analysis

The nonstructural analysis for this study was performed as directed by Section 73 of the WRDA of 1974, and as prescribed in ER1105-2-100 and the Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies (March 1983). Section 73 specifically requires consideration of nonstructural alternatives in all flood damage reduction studies. These alternatives can be considered independently or in combination with other measures.

All nonstructural measures reduce flood damages without significantly altering the nature or extent of flooding. Damage reduction from nonstructural measures is accomplished by changing the use made of the floodplains, or by accommodating existing uses to the flood hazard. Examples are flood proofing, relocation of structures, flood warning and preparedness systems (including associated emergency measures), and regulation of floodplain uses.

The foundation of the technical analyses for nonstructural formulation was based upon five primary sources of data and associated models:

1) Tax assessor's databases from the three counties (Jackson, Harrison, and Hancock) that were further refined by the Mobile PDT,

2) FEMA databases for the National Flood Insurance Program that included Flood Insurance Rate Mapping, post Katrina damage assessments and GIS mapping, FEMA's model of the Advisory Base Flood Elevation mapping and associated topographic GIS layers,

3) The FEMA HAZUS model and databases for damageable structures in the project area,

4) Information and data gleaned from NOAA post-Katrina reports, and

5) Information on historic districts and buildings located in the project area from the National Park Service. Other databases from local communities and the US Census were used to describe local conditions, public buildings, housing resources, and current land use regulations (i.e. zoning, NFIP and building codes).

The nonstructural analysis was based in part upon research of proven nonstructural methods applied within coastal areas of the USA and determination of the relative surge inundation and wave hazards of the various coastal areas. Field observations of the damages to elevated and non-elevated structures and community facilities supported several aspects of the formulation process. FEMA data and flood zone mapping for the National Flood Insurance Program and post-Katrina damage reports supplied information on the location and extent of high-hazard flood zones that defined the division between areas suitable (safe) for floodproofing by elevation and those areas only suitable for permanent acquisition.

Several established computer programs were used to collect and analyze the parcel data and GIS mapping from the above sources including Microsoft Excel, Microsoft Access, and ESRI ArcMap Versions 9.1 and 9.2. These computer programs were used to create the database spreadsheets that supported the formulation of the various nonstructural measures and plans as well as the basis for the nonstructural cost models. The ArcMap programs were used to create the nonstructural graphic plans for the various measures and combinations of measures displayed in the Nonstructural Appendix.

The formulation and analysis of applicable nonstructural measures was based upon the Corps' Engineering Regulation 1105-2-100, The Corps Planning Manual (IWR Report 96-R-21), applicable sections of Corps regulations regarding real estate acquisitions (ER 405-1-12 and CFR, Title 49, Part 24) and public buildings and facilities relocations (EFARS Appendix Q - Relocations, Alterations, Vacations and Abandonments October 1984), provisions of the Uniform Act (PL 91-646) and various floodproofing regulations from the FEMA National Flood Insurance Program as well as applicable sections of the Mississippi State Code (Title 17-1-17) regarding local land use, zoning and regulation capabilities.

3.5 Economic Analysis

This section describes the methodology for the evaluation of economic impacts of potential solutions for the Mississippi Gulf Coast under the Mississippi Coastal Improvements Program (MsCIP) Comprehensive Report. It is intended to be an outline of the process used to determine the economic impacts that are fully detailed throughout this report and in the Economic Appendix. The methodology was developed to seamlessly fit into the six step planning process and current Corps guidance. The six step planning process, as defined by the Engineering Regulation (ER) 1105-2-100; Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies (U.S. Water Resources Council 1983), referred to as the P&G, is:

1. Identify Problems and Opportunities
2. Inventory and Forecast Conditions
3. Develop Alternatives
4. Evaluate Alternatives
5. Compare Alternatives
6. Select the Recommended Plan

The Mississippi Gulf Coast is a complex system that is made up of a diverse blend of ecological and human habitats. Given those complexities, a fluid and flexible process was needed to evaluate and aggregate the benefits of potential measures and measures. The process incorporates data collection, forecasting techniques, scenario planning, cost effective evaluation using state of the art modeling techniques, and the communication of both benefits and risks associated with potential measures and measures. Figure 8 outlines the process used for this analysis.

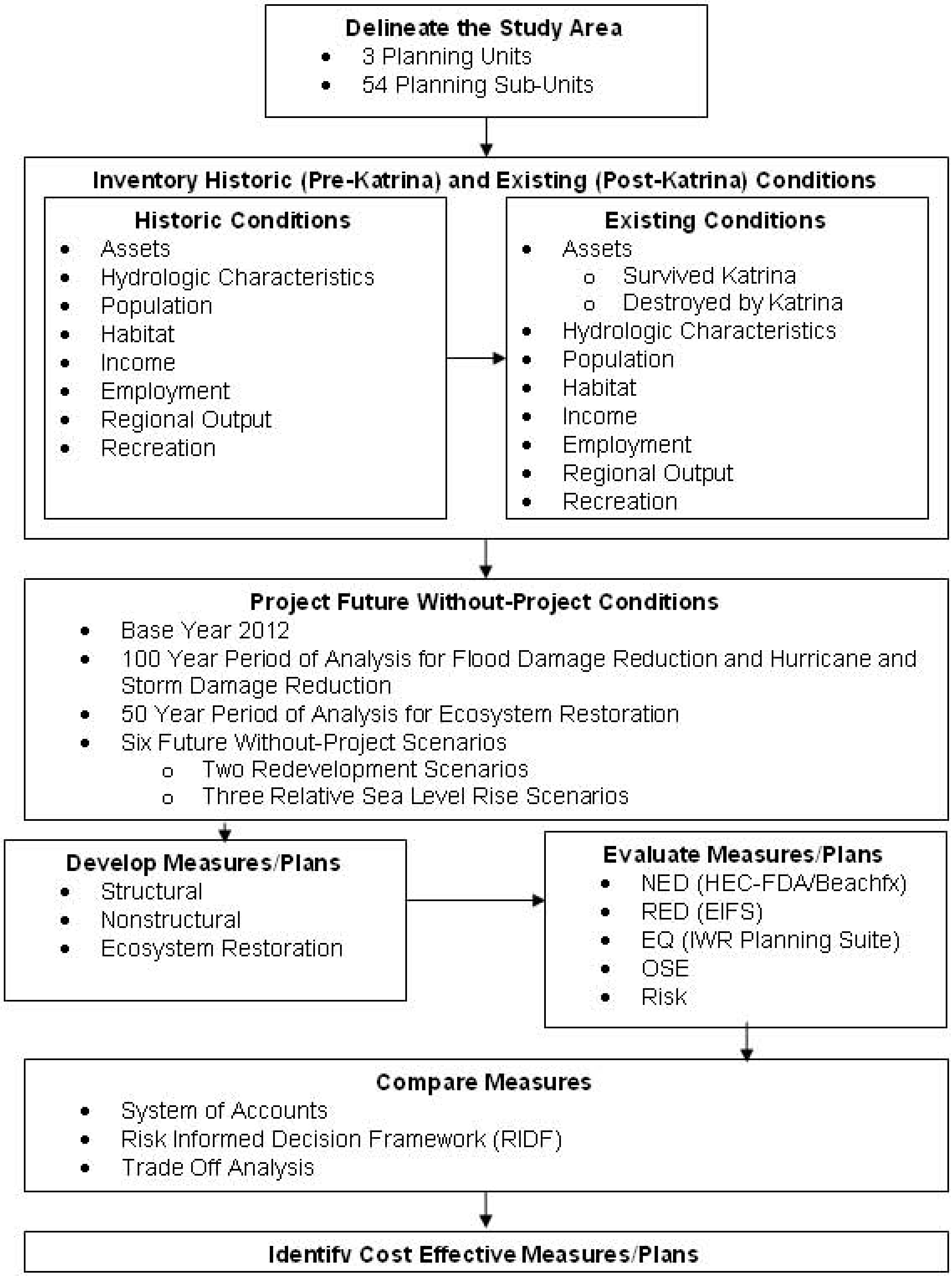


Figure 8. Overview of Economic Methodology

The first step in the process was to delineate the study area. The overarching study area, as defined by Congress, is the three coastal counties in Mississippi; Hancock, Harrison and Jackson from west to east respectively. For purposes of system wide evaluation and aggregating benefits, the study area was divided into four planning zones, three planning units, and fifty-four sub-planning units. These are described in more detail in the following section.

Once the planning zones, planning units, and planning sub-units were identified, the next step was inventorying the economic, social, and environmental characteristics of the area. Data from Local, State, and Federal government agencies was utilized to determine the Historic (Pre-Hurricane Katrina) Condition, including data from the U.S. Census Bureau, the Federal Emergency Management Agency (FEMA), U.S. Fish and Wildlife, the Mississippi Emergency Management Agency (MEMA), the Mississippi Governor's Recovery Office, County Tax Assessors, previously conducted Corps of Engineers studies conducted in the area, and other valuable data sources. Historic data included economic structures (structures, content, and critical infrastructure), social and regional indicators (population, income, and employment), topographic and hydrologic characteristics, acreage of habitat, and etc.

With the historic data serving as a foundation, the next step was to determine the impacts of surge inundation from Hurricane Katrina. The team developed an inventorying methodology that was a combination of sampling and field verification. PDT members drove every street within the fifty-four planning sub-units over the course of four months from June to October, 2006, for purposes of determining the existing (Post-Hurricane Katrina) conditions and characteristics of structures. The findings of this work were put into a structure database that included over 200,000 tax parcels, 138,000 of which contained structures. Hydrologic programming was used to evaluate the surge inundation of each planning sub-unit and a combination of ESRI's ArcMap 9.1 Geographical Information System (GIS) data and ground truthing was used for habitat evaluation.

Six future with-out project scenarios were developed, based on the existing condition characteristics, for the evaluation of future without-project conditions. The six scenarios were evaluated over a 100-year period of analysis from the base year 2012 (2012-2111) and using the FY07 federal discount rate of four-and-seven-eighths (4.875) percent. The six future scenarios include two redevelopment scenarios (residential and mixed-residential and commercial) and three relative sea level rise scenarios (existing sea level, moderate relative sea level rise, and high relative sea level rise) for a total of six different future scenarios. Scenario one is a residential redevelopment with no relative sea level rise over the period of analysis, scenario two is a mixed residential and commercial redevelopment with no relative sea level rise, scenario three is a residential redevelopment with a maximum relative sea level rise depending on location of 2.0-feet over the period of analysis, scenario four is a mixed residential and commercial redevelopment and a maximum relative sea level rise of a 2.0-foot, scenario five is a residential redevelopment with a relative sea level rise depending on location of 3.4-feet, and scenario six is a mixed residential and commercial redevelopment with a maximum relative sea level rise depending on location of 3.4-feet. The detailed evaluation of these scenarios is outlined in the Economics Appendix, and a technical description of the calculation of relative sea level can be found in the Engineering Appendix.

The next step, identified as step three in the planning process, was to develop measures that relate to the planning objectives for this study. A measure is something that can be implemented to directly address a problem within the study area. Some examples of measures include levees and acquisitions for flood damage reduction, beach and dune construction for flood damage reduction and ecosystem restoration, excavation and planting of native species for ecosystem restoration. These measures can be stand alone or may be able to be combined like a system.

For the Mississippi Coastal Improvements Program (MsCIP) Comprehensive Plan Report, multiple measures were developed under structural, nonstructural, and ecosystem restoration categories. The project delivery team applied a screening process based on engineering, environmental, and economic feasibility to narrow the list of viable measures.

The result of the screening was a list of measures that were fully evaluated as compared to the future without-project conditions. These measures were evaluated using the four systems of accounts, outlined in ER 1105-2-100, which include National Economic Development (NED) benefits, Regional Economic Development (RED) benefits, Environmental Quality benefits, and Other Social Effects (OSE). Evaluations of the various metrics that make up these four accounts were conducted using multiple economic programs, expert opinion, and other sources where available. The main economic programs used for the evaluation of measures include the Corps of Engineers Flood Inventory Tool (CEFIT), the Hydrologic Engineering Center-Flood Damage Analysis (HEC-FDA) program, the Beach-fx program, the Institute for Water Resources (IWR) Planning Suite, and the Economic Impact Forecasting System (EIFS). Outputs from these programs were carried forward for the comparison of the measures.

The final two steps of the process include a comparison of measures/plans and the identification of cost effective plans. A comparison of the evaluated measures was conducted using the System of Accounts (SOA) table and the RIDF process developed specifically for the MsCIP and LaCPR studies.

3.6 Geographic Information Systems (GIS) Approach and Analyses

During the MsCIP Comprehensive Study, several Geographic Information System (GIS) software components were used. The GIS software used was created by ESRI and includes: ArcGIS, ArcIMS, ArcReader, ArcGlobe, and ArcSDE. ArcGIS is used for analysis of geospatial data; this software allows the user to overlay data and perform analysis on the data. ArcIMS is used in displaying GIS data on the internet; this software allows users to view and query data without having to purchase software or need training to run the software. ArcReader is a GIS component that allows users to look at data on their local computers without having to purchase software and requires very little training. ArcGlobe is the GIS component that allows users to view data in 3D and is great to use when dealing with depths and heights. ArcSDE is the GIS component that is used to store and organize geospatial data.

3.7 Real Estate Analyses

Real estate costs are an important part of evaluating and comparing different measures to solve a problem. The real estate analysis includes descriptions of the minimum real estate requirements for different measures, estates to be acquired for the alternatives, Land costs to include Easements, Rights-of-way, Relocations and Disposal or borrow areas (LERRD's), and schedules for real estate activities. The real estate analysis was conducted in accordance with Corps' Guidance from Engineer Regulations 405-1-12, and from the Code of Federal Regulations, Title 49, Part 24. Other supporting guidance can be found in the attached Real Estate Appendix.

The real estate analysis for this study required a search of the local public records at local tax and county clerk's offices, to obtain data about owners and the types of properties that would be impacted by potential measures. The analysis includes the proposed acquisition of any land rights in privately owned lands that would be required for the building of a structure like a levee, and any other real estate requirements appropriate for the project construction. The acquisition of land rights may be either a partial or complete purchase of a parcel or tract of land, and in an easement or fee simple interest. Relocation assistance for landowners or tenants when structures are impacted is also included in the analysis. For the nonstructural buyout measures, fee simple purchase of lands and structures along with relocation assistance to displaced persons is recommended. Any such acquisitions of real estate interests and/or relocation assistance for displaced persons are governed by Public Law 91-646.

An assessment was also made of which public facilities would need to be relocated for each measure, including roads, pipelines, utilities, and bridges. The Real Estate Appendix includes information as to the costs and land requirements whether the Government or the local Sponsor would be responsible for the relocation. More detailed investigations of items such as land for borrow areas, pipeline routes, staging areas, etc. will be conducted in a future feasibility study, or studies, if authorized by Congress.

Structural measures, as well as potential Nonstructural buy-out and Ecosystem Restoration sites, all have real estate requirements. Although some measures overlap, each could be constructed as a stand-alone project, and requires a separate real estate cost estimate. The total estimated cost includes land and any associated improvements, relocation payments, and administrative costs to acquire lands and provide relocation assistance services.

The Project Delivery Team (PDT) obtained tax databases for 2005 from the tax assessors' offices in Jackson, Harrison, and Hancock Counties. The team linked this information with GIS “footprints” of the measures to aid in sorting and querying of large amounts of data. These queries were imported into spreadsheets for use by economics, cost engineering, and environmental team members.

Due to the magnitude of the study involving evaluation of approximately 75,000 parcels, a number of assumptions were made in compiling the Real Estate costs. The average number of potentially impacted parcels for the individual interior barrier measures varied anywhere from 320 to over 1,700 parcels. The process originally began by looking at what percentage of each individual parcel might be impacted by the construction of a measure. As changes occurred and more measures were added, it became necessary to discontinue the parcel by parcel analysis and instead make determinations to estimate subsequent real estate requirements based on a percentage factor. Assumptions were also made for when an entire parcel needed to be acquired, and what percentage of structures on a parcel would potentially be impacted by a given measure.

While costs are based on assessed values from the 2005 tax year, an appraiser completed a market study using approximately 135 comparable sales from the three coastal counties. All of the sales used occurred in the first quarter of 2007. From these sales an "adjustment factor" for each county was established. It was found that post Katrina real estate values were approximately double the pre-Katrina values, and the adjustment factors for each county ranged from 1.75 - 2.50 percent. For planning purposes, this adjustment factor was used to bring the assessed values more in line with 2007 "market values".

A Real Estate Supplement (RES) will be prepared for each authorized component once the real estate requirements have been sufficiently identified during a Pre-construction, Engineering, and Design phase (PED). The RES will provide updated information as to final real estate requirements for a particular component and will include updated real estate values and costs. A Real Estate Relocation Plan for displaced individuals and businesses would also be prepared during PED. The Relocation Plan will investigate the availability of replacement housing within a specified radius and any unique or unusual problems that should be considered.

3.8 Costs Estimating Analysis

Rough order magnitude cost estimates have been developed for each of the recommended plan components and comparative alternatives. All cost estimates for a specific plan component/alternative concept have been developed to the same level of detail and include the same level of uncertainty with regard to the precision of the estimate. As discussed below some estimates are considered to be more advanced in that a selected design may have been available to use in developing the estimate.

In general the cost estimates for structural options are based on conceptual designs. To proceed with initial cost estimates, the structural options were conceptually designed to the selected elevations (i.e. 20 feet, 30 feet, or 40 feet) as described in previous paragraphs. These initial elevations selected for each component of the lines of defense are assumed to bracket a wide range of potential storms with corresponding surge elevations. Using these preliminary designs, rough order of magnitude cost estimates were completed for each of the structural options. These cost estimates can used to develop cost curves for future use to estimate costs after final design elevations are selected. Also, these cost curves, can be used in future studies to select varied levels of risk reduction based on risk assessments as well as taking into account future estimates of sea level rise. Cost estimates include not only the construction costs, but also any real estate and/or environmental costs as appropriate. In some cases the costs of environmental mitigation have been assumed to equal the cost of purchase of lands in mitigation banks. Additional detail is necessary before fully developed costs estimates can be developed. As discussed below, the team has included in the estimate a factor for uncertainty with regards to a number of factors (contingency percentages). Costs for plans and specifications have been included where applicable.

Costs for all the environmental restoration options are also estimated at the same rough order of magnitude type estimate, however unlike the structural options, each option had a selected design and no cost curves are developed. Costs for environmental restoration features are based to the maximum extent on prior efforts by the Mobile District in the Mississippi area (i.e. dredging costs for sand placement on barrier islands; costs for acquiring and installing specific vegetation species). Costs for plans and specifications, monitoring and any additional studies have been included where applicable.

Non-structural costs were generated from spreadsheet summaries of the tens of thousands of real estate parcels assigned to the 54 economic reaches based on available data from county tax data bases. All non-real estate contract costs (demolition or flood proofing) for inclusion into these spreadsheets were completed by cost estimators familiar with these activities and acquisition costs were provided by real estate specialists.

A specific analysis of the uncertainties of the cost estimates is being performed to best define the risks associated with the level of cost estimating used for this effort.

3.8.1 Uncertainty as Related to Construction Costs

Even though a Cost Risk Analysis was not developed for the total project cost estimate, some uncertainties were identified and addressed in developing the Construction Contingency. Such uncertainties identified included (a) lack of geotechnical information, (b) physical size and complexity of project, (c) a number of features of the project not being of conventional design, (d) contract requirements, (e) economy shifts, market forecast, (f) quantities not available; assumptions made based on historical information, (g) exclusion of hazardous, toxic, and radiological waste assessments and escalation cost, and (h) no detailed project scheduling.

Contingency in the construction cost estimates represents an allowance for elements within the project scope that are not included in the detailed estimate. This contingency allowance provides a level of confidence that the cost estimate will not overrun due to unpredicted events. Contingency is not intended to cover such factors as estimating allowances, change in scope, inaccurate projections of inflations, unanticipated regulatory standards, and other external factors (bad weather, strikes, labor disputes).

Based on review of identified uncertainties and the project delivery team's (PDT) judgment, the assumed **risk level** is considered higher than normal. Therefore, a Contingency of 25% was used throughout the cost estimate. Even though ER 110-2-1302 identifies Contingencies at 20% for projects greater than $10,000,000 for recon/feasibility phase, it was determined and agreed upon by the PDT that a higher rate should be used primarily due to higher risk than normal, degree of confidence lower than normal, and many features of the project not being of conventional design.

3.8.2 Uncertainty Relating to the Delineation of the High-hazard Areas for Real Estate Acquisitions

Numerous factors contribute to the uncertainty in Real Estate cost estimates. Estimates were made based on proposed project footprints for which plans and specifications are not finalized. Consequently there may be some variance, either higher or lower, in the total number of parcels impacted for a particular option. It is likely that a parcel which may be considered to be partially impacted by project construction could in fact be avoided when plans and specifications are completed. In addition, the real estate land cost is based on tax values with an adjustment factor for 2007 applied to bring the valuations of parcels in line with market values. Additional adjustments may be required to remain current with market conditions and values as project construction is scheduled.

There may also be a variance in the number of structures projected as being impacted since the footprint of actual structures was not available during the data analysis. Assumptions were made based on the "percentage of impact" to the parcel where a structure was shown in the tax data base. The county data bases, appeared to have a mix of pre-storm and post-storm data which mostly affected structure values. If the tax data included a structure value, an assumption was made that a structure is in existence. However, a site inspection is necessary to confirm the actual existence of a structure. Similarly, a parcel assumed to be vacant as per tax information could have a structure at the actual time of acquisition.

The number of relocations under P.L. 91-646 that are projected relates directly to the number impacted structures, and will increase or decrease proportionately with any increase or reduction in the number of structures impacted. An average cost was used across the project for a "relocation" payment with no distinction being made between relocation of an individual or business. Before implementation of acquisition, a relocation plan will need to be completed to gather more specific information and to prepare a more refined cost estimate.

Administrative costs used in the estimate are based on historical costs per tract for other projects. Although none have been as large as the MsCIP, they are thought to be a sound basis for this project. A contingency of 25% was used throughout for each cost estimate prepared.

3.8.3 Uncertainty as Related to Non-structural Costs

The uncertainties related to the delineation of the high-hazard zones would affect the number of tax parcels selected for permanent acquisition versus floodproofing by elevation. In all cases, parcels lying along that line of demarcation between the two measures would be either permanent acquisition or floodproofing by elevation; therefore any differences in cost could be expressed as the average cost difference between the two measures. In the formulation of the accelerated High Hazard Area Risk Reduction Plan the average homeowner payment for acquisition was calculated to be $143,000. The average cost estimate to raise an existing structure up to 6 feet was $140,000 – a difference of $3,000 between the two measures for any structure along the demarcation line.

The differences in the number of parcels allocated to one or the other of the two measures would affect the relative amounts of cost allocated between the project accounts. Since the lines delineating the various zones may have not exactly matched the parcel boundaries, there is some inherent inaccuracy in the accumulation of the affected parcels by the GIS database in one or the other of the two categories of measures included in the plan.

The uncertainty surrounding the delineation of the high-hazard areas along the Mississippi coast is based upon three primary components: 1) the accuracy of the FEMA geographic information system (GIS) layer that delineated the VE Zone (Velocity Elevation Zone) on the Flood Insurance Rate Maps for the three counties and municipal areas along the coast, 2) the accuracy of the GIS layer delineated by FEMA in their post-Katrina report regarding the catastrophic damage zone where damages to insured structures exceeded 50%, and 3) the accuracy of a GIS-generated polygon depicting a 800-foot wide buffer zone in Jackson County that mimicked the damage areas observed in Hancock and Harrison counties.

The GIS layers used in the Nonstructural Appendix to delineate the VE and catastrophic zones were taken from FEMA published data. Considering the scales used on FEMA National Flood Insurance Program mapping and the dates of the flood insurance rate maps from which the GIS layers are taken (1970's) it's likely that there are inherent inaccuracies in the GIS layers. Any inaccuracies that may have been inherent in that data have been carried into the Corps document. The construction of the 800-foot wide buffer area was generated and whatever inaccuracies are imbedded in that layer are also within the report database.

3.9 Communication and Collaboration

Collaborative planning requires that the Corps move beyond the Corps interest and embrace solutions that reflect the full range of the national Federal interest. In an effort to fully embrace this, concept steps have been taken to involve all applicable state and Federal agencies in the development of the various measures being considered. The USFWS and NPS have assigned specific individuals to be on staff at the District as they participate on the PDT. Other agencies have identified specific individuals to represent their agencies on all team efforts. Further, the environmental PDT has been communicating on-going effort to the resource agencies. Measures that have been developed relate to activities that cross all boundaries of the Federal government. In particular, plans for the systematic restoration of the Mississippi barrier islands have been developed jointly by the NPS, USGS, NOAA, EPA and the Corps. Collaboration with the State of Mississippi is a critical building block of the MsCIP as we move forward with the long-term restoration of the coast. Elements of this collaboration including sharing personnel and data have resulted in the development of a comprehensive restoration strategy.

Communication among all the stakeholders has been a critical element of the MsCIP. From the inception, the importance of communication is evident with the hiring of a specialty firm to assist in the development of the stakeholder base and the dissemination of information. Group Solutions Inc. has employed a number of innovative techniques to assist in obtaining participation from the largest number of stakeholders possible. The MsCIP communication plan includes the use of public workshops and meetings, meetings with special interest groups including NGOs, web based meetings, and extensive use of the internet to facilitate communication. As a result of the extent of the damage from the hurricanes, a large number of stakeholders have been displaced and every effort has been undertaken to reach these individuals as well as those currently residing along the coast. Although a large amount of effort has been taken to reach the stakeholders (over 30 meetings since April 2006), we are still not satisfied with the participation and will continue to take additional steps as the comprehensive plan develops.

3.9.1 Regional Sediment Management (RSM)

Regional Sediment Management uses the understanding of sediment dynamics (inputs, outputs, movement) to manage sediment resources towards implementing environmental restoration, conservation, and preservation while reducing coastal erosion, storm damages, and associated costs of sediment management. The MsCIP study team is building on RSM relationships, technology, data, and tools; likewise, the RSM program is benefiting from the extension of these relationships, technology, data and tools as well as lessons learned through MSCIP. Prior to the MsCIP project, data and information were lacking along coastal Mississippi. The MsCIP project is providing valuable information and data, and is improving our understanding of the coastal processes, which occur along the Mississippi mainland shoreline as well as the barrier islands. Additionally, MsCIP project's coordination and relationships developed with other Federal agencies, sponsors, and stakeholders will enhance the RSM programs ability to coordinate and implement future RSM strategies in coastal Mississippi.

Formulation of measures and alternatives fully considered the opportunities of applying RSM. Measures formulated consistently considered the beneficial uses of sediment in the larger ecosystem, as well as ways by which sediment delivery or re-allocation could be enhanced to areas of greatest need. This objective was carried through the formulation, evaluation, screening, and selection process.

The State of Mississippi as part of Gulf of Mexico Alliance has acknowledged that sediment resources are integral to accomplishing many restoration initiatives. It is also recognized that there is a need for a better understanding of regional sediment systems and processes to inform decisions about projects and actions that use or affect sediment resources. Mississippi is actively involved in the development of a Gulf Regional Sediment Management Master Plan as an implementation action for the Gulf Alliance Conservation and Restoration Workgroup. The regional sediment management plan will also help link sources of sediment with sediment needs, provide a basis for assessing competing needs for sediment, and foster more cost effective sediment management.

3.9.2 Public and Agency Involvement in the Planning Process

The Corps' 6-step planning process is a structured approach to problem solving that provides a rational framework for sound decision making. The 6 steps consists of: identifying problems and opportunities; inventorying and forecasting conditions; formulating alternative plans; evaluating alternative plans; comparing alternative plans; and selecting a plan. The MsCIP team has made every effort to involve the public and agencies throughout the entire Interim and Comprehensive Plan development. Immediately following Hurricane Katrina, members of the MsCIP team were openly communicating with state, federal, and local agencies regarding their concerns, obstacles, hurricane-related problems, needs, and opportunities. Agencies, educational institutions, and interested individuals have been contacted via phone, e-mail, or public notice, to solicit input, ideas, and constraints to the plan formulation process. A website was developed and maintained as a way of disseminating information and receiving public comments regarding potential issues and their concerns. Over 60 Federal, State and local government agency representatives and other community leaders from business and industry gathered in Biloxi on April 7, 2006 to identify early needs, opportunities and recommendations for the MsCIP process. Many other public and agency meetings have been held in Harrison, Jackson and Hancock Counties to examine a broad range of potential coastal protection options and solicit input on designing comprehensive improvements. Comments received from these meetings have led the team to revise some of the initial proposed measures. Existing and future conditions were identified and projected in coastal Mississippi by Corps, MDMR, USFWS, and the NPS members. On May 7, 2007, the MsCIP team held a public workshop to present additional environmental, structural and non-structural measures. Input provided from these meetings was used during further formulation of the comprehensive plan.

3.9.2.1 Initial Coordination by Mobile District Team

The hurricanes of 2005 caused numerous deaths and untold injuries to local residents and visitors to the area, extensive damage to environmental resources, homes, businesses and industries. Soon after Hurricane Katrina struck coastal Mississippi, the Mobile District made and received contact with local government officials, agencies, and the public regarding the impacts of the storm and conditions on the coast. This interaction was encouraged by the existing working relationships established during the normal water resource activities conducted by the Mobile District and the state and local governments. After the MsCIP authorization, Mobile District multi-disciplined project teams went to each coastal Mississippi county and municipal area to assess damages and needs first hand identifying needs and formulating ideas and opportunities.

3.9.3 Public and Agency Involvement Process

The MsCIP team places a high value on public and agency involvement during development of the Interim and Comprehensive Plans. Participation from Federal and state agencies, local governments, and stakeholders was obtained through an on-going and engaging series of public scoping meetings, public input meetings, agency and stakeholder meetings, web-casts, on-line auditoriums, Federal principals group, vertical teams, regional coordination meetings, in-house USFWS and NPS personnel, MDMR personnel, non-structural road shows, on-site meetings and multi-participant plan formulation.

3.9.4 Public Input and Review of Planning Options: Round One

Planning solutions to water resource problems is not an activity just for engineers and scientists. It also involves homeowners, businesses, environmental advocates, interest groups, and other members of the public as well as people from Federal, State, regional and local agencies. Citizens have the right to participate meaningfully in public decision making processes, and to be informed about the bases for those decisions. In addition, public participation will undoubtedly lead to better decisions. The wisdom needed to solve complex problems is not limited to the technical experts in public agencies. Early and continuing participation by a diversity of interests, including project sponsors, customers, partners and other stakeholders, can provide essential information and insights. Public participation also increases confidence in the planning process and acceptance of its resulting decisions. The following sections show how the public was involved early and often during the MsCIP planning process.

3.9.4.1 Regional Coordination Workshop

A highly interactive Regional Coordination Workshop was held in Biloxi, MS, on April 7, 2006 for a group of state, municipal, county, NGOs, and agency officials. Approximately 200 participants were invited to attend the workshop through letters, e-mails and phone contacts. Approximately 75 individuals participated representing a spectrum of participant groups invited. Participants were asked to provide the Corps guiding principles for MsCIP direction and specific projects that should be included within the two plans (i.e. Interim and Comprehensive) for Congress. Over a hundred ideas were generated at the workshop. The ideas ranged from small local projects to coastal-wide submissions. The MsCIP Team reviewed these ideas or potential projects for consideration as near-term projects in the Interim Report or actions to be considered in the Final Report.

3.9.4.2 Public Workshops

Following the Regional Coordination Workshop, the Corps held 3 Public Workshops; April 10, 12, and 13, 2006. One workshop was held in each of the 3 coastal Mississippi counties, Jackson, Harrison, and Hancock. Invitations to participate in Public Workshops were made through a Mobile District Public Notice sent to standard environmental coordination mailing list, Mobile District press releases sent to the media, and by Mobile staff contacts. We asked state, county and local officials to help get word of the workshops out to the public.

The purpose of the workshops was to review the ideas already gathered from previous involvement activities and gather additional ideas for inclusion in the MsCIP reports and plans. The workshops

were interactive and non-confrontational. Public participants were polled on project direction and the important principles of recovery that should be used in the plans. The public was invited to review the ideas already submitted and to add additional ideas or creative combinations of existing ideas to the list. Input could be provided via a network of PCs and structured questions. Alternative input opportunities for those uncomfortable or unable to respond via PC were also provided. Comment cards, post-it notes for maps, and a court reporter were available to capture ideas. From the Public Workshops, the list of MsCIP ideas grew to over 180. Again the MsCIP Team reviewed these ideas or potential projects for consideration as near-term projects in the Interim Report or actions to be considered in the Final Comprehensive Report. It should be noted that the residents of coastal Mississippi have been through a terrific ordeal. In some cases, their lives have returned to normal while in others the recovery process is just beginning. These conditions made acquiring public input difficult. Frequent comments were made that people were generally "tired of the storm and tired of meetings about the storm." In spite of that, needs and opportunities for specific areas were gathered from the public.

3.9.4.3 Website and Webcast

As discussed previously, the website (www.MSCIP.usace.army.mil) was established and maintained as a repository of MsCIP information and a different vehicle to allow interested public and agencies to provide comments and ideas including those who were displaced from there homes or could not attend the workshop opportunities. A webcast was created and provided on April 18, 2006 to allow those that could not attend the public workshops and online alternative for participating in the project. The webcast had conference call participation for all callers, a video and PowerPoint presentation delivered through a special webcast, polling, and a question and answer portion with Mobile District staff fielding questions.

3.9.5 Coordination with LaCPR

The MsCIP team took a systematic and regional integration approach with the Louisiana Coastal Protection and Restoration (LaCPR) study team. For a detailed account of this approach, please see the Main Report.

3.9.6 Public Input and Review of Planning Options: Round Two

3.9.6.1 Regional Coordination Workshop

The Round Two, Regional Coordination Workshop was held in Biloxi on April 26, 2006 with similar participants as Round One. The purpose of the Round Two Regional Coordination Workshop was to review the planning options that emerged from the Round One workshops. Prior to the workshop, participants were provided via the MsCIP website a list of ideas that emerged Round One and the screening criteria to be used to recommend near-term projects for inclusion in the Interim Report or retain them for evaluation in the Final Report. There was general understanding of the concept of near-term projects that can be implemented quickly to help in the immediate recovery of coastal Mississippi while the Comprehensive Plan is being developed. The screening criteria and their application to the potential projects were discussed. The Mobile District presented a preliminary, by-county, list of projects to be potentially recommended in the Interim Report. The potential near-term projects were discussed and none recommended for Interim Report received objection. However, participants requested review of a limited number of additional projects for inclusion in the Interim Report. As a result of this discussion, additional projects were considered and at least one additional potential near-term project (Jackson Marsh Restoration) was recommended for the Interim Report. No potential projects were deleted from consideration in the MSCIP, simply deferred to consideration in the Comprehensive Analysis and Final Report. Using these recommendations, the MsCIP team then began developing the structural lines of defense concepts. The MsCIP environmental and non-structural team analyzed environmental benefits anticipated from restoration while the other team assessed flood-proofing techniques.

3.9.6.2 Public Workshops

The Round Two, Public Workshops were held May 1, 2, and 4, 2006. The purpose of the Round Two Public Workshops was to review the planning options that emerged from the Round One workshops and discuss recommendations for near-term projects to be recommended in the Interim Report. The Mobile District presented a by-county list of projects to be potentially recommended in the Interim Report and the screening criteria for selecting those projects. None of the projects recommended for Interim Report received objection. However, participants requested and received clarification regarding why specific potential projects were not recommended as near-term projects. No potential projects were deleted from consideration in the MSCIP, simply deferred to consideration in the Comprehensive Analysis and Final Report. The MsCIP team had another public workshop on December 19, 2006 to present general ongoing efforts and to discuss conceptual solutions for coastal Mississippi. On April 5, 2007, the MsCIP team then presented detailed plans for environmental, non-structural, and structural plans to protect coastal Mississippi from future storms.

3.9.6.3 Web-site and Webcast

A Round Two webcast was created and provided on May 3, 18 to allow those that could not attend the public workshops and online alternative for participating in the project.

3.9.7 Public Scoping

Public and agency involvement has been a critical, early, and continuing part of the MsCIP project. Public and agency involvement accomplished to date has been a multi-step and multi-component process. Persons and organizations having a potential interest in the proposed action, including minority, low-income, disadvantaged, and Native American groups, have been urged to participate in the environmental impact analysis process.

Scoping can lay a firm foundation for the rest of the decision-making process. Scoping is often the first contact between project planners and the public. The MsCIP team held many meetings prior to the actual formal Public Scoping meeting on 19 December 2006. These initial meetings were held due to the accelerated timeframe involved in preparing the 6-Month MsCIP Interim Report. At the December Public Scoping meeting, individuals presented their concerns to the MsCIP team and also to each other. The issues brought forth included concerns regarding construction of levees, preservation of the natural environment, impacts to natural resources especially wetlands regulatory permits for wetland fill, future growth, potential future storms, and etc. Possibilities and clarifications on initial thoughts were discussed during the Public Scoping meeting. This scoping process led the MsCIP team to think about the proposal early on, in order to explain it to the public and affected agencies. The participants were able to respond with their own concerns about significant issues. Incorporation of public and resource agency input will likely reduce the need for changes after the draft documentation is finished, because it reduces the chances of overlooking a significant issue or reasonable alternative.

4 PLANNING CONSTRAINTS

There are a number of issues that constrain the development of certain potential measures that might be used to address the identified problem set. Planning constraints are limited to laws and regulations that constrain the planning process. Among these include:

- Measures developed must not negatively impact the resources within the NPS's Gulf Islands National Seashore, particularly with respects from those constraints created by inclusion of Horn and Petit Bois Islands as Wilderness Areas;
- Measures developed must avoid, minimize, or mitigate any negative impacts to T&E species identified as residing within areas potentially impacted by study recommendations;
- Measures developed must be consistent with State of Mississippi Coastal Management Plan;
- Measures developed must meet the guidelines directed at maintenance of State Water Quality standards;
- Measures must be consistent with provisions of CWA;
- Measures must be consistent with provisions of NHPA;
- Measures must be consistent with Clean Air Act (CAA);
- Measures must be consistent with the ESA and the Fish and Wildlife Coordination Act (FWCA);
- Measures must be consistent with CBRA;
- Measures must be consistent with EO – Environmental Justice and Protection of Children; and
- Measures must be consistent with the Magnuson-Stevens Fishery Conservation and Management Act as amended by the Sustainable Fisheries Act of 1996.

5 INVENTORY AND FORECAST OF FUTURE CONDITIONS/RESOURCES

As mentioned earlier, six future "no-action" scenarios were developed to evaluate the impacts of plan components over time. The six scenarios were evaluated over a 100-year period of analysis and include two redevelopment, and four sea-level rise scenarios. The first redevelopment scenario assumes the residential and commercial rebuilding that existed before Katrina will be built back as the same type (residential or commercial). The second rebuilding scenario assumes that a majority of the waterfront properties destroyed will be built back as commercial (i.e. high-rise condominiums). The three relative sea level rise scenarios are comprised of existing sea level, a moderate relative sea level rise, and high relative sea level rise. Scenario one is a residential redevelopment with no relative sea level rise over the 100-year period of analysis. Scenario two is a mixed residential and commercial redevelopment with no relative sea level rise, scenario three is a residential redevelopment with a maximum relative sea level rise depending on location of 2.0-feet over the period of analysis, scenario four is a mixed residential and commercial redevelopment and a maximum relative sea level rise of a 2.0-foot, scenario five is a residential redevelopment with a relative sea level rise depending on location of 3.4-feet, and scenario six is a mixed residential and commercial redevelopment with a maximum relative sea level rise depending on location of 3.4-feet. The detailed evaluation of these scenarios is outlined below, and a technical description of the calculation of relative sea level can be found in the Engineering Appendix.

The first round of inventory and forecast indicated that several future conditions scenarios should be revised. Key among these was the uncertainty of forecasts of future re-development and relative sea level rise. Future relative sea level rise is an especially important factor in defining conditions of the barrier islands, estuarine circulations, water quality, etc. A detailed discussion of relative sea level rise has been provided earlier in this report. As discussed earlier, this was accommodated by the inclusion of sensitivity analysis for both factors, to determine what effect alternative future scenarios might have on benefits, costs, and other considerations, under each scenario.

5.1 Forecasting of Future Re-development: Scenarios

The Mississippi Coast is rebuilding from the aftermath of the storms of 2005. Due to numerous factors (i.e. insurance payments, business opportunities, etc.), the exact rate at which re-development will continue to occur is not known. For this study an approximation was made based on the following assumptions:

- The structures destroyed as a result of Hurricane Katrina will be rebuilt and the population will return to at least pre-Katrina levels.
- Full redevelopment of structures will occur by 2012. Redevelopment is defined as the building back structures that existed before Hurricane Katrina, not development that occurs on land that was undeveloped.
- Redevelopment of the study area could take the form of residential redevelopment (exactly the way it was pre-Hurricane Katrina) or a mixture of commercial/condominium and residential redevelopment.
- FEMA guidelines require minimum heights that the first floor elevation must be built to in order to be included in the National Flood Insurance Program (NFIP). For the purposes of the redevelopment projected in this report, houses that will be rebuilt before the start of 2009 are assumed to be rebuilt to the Pre-Hurricane Katrina Base Flood Elevation (BFE) and those that are rebuilt between 2009 and 2011 will be rebuilt to the Advisory Base Flood Elevation (ABFE) as existed May 2007.
- The surge damage characteristics (by depth) of structures vary by the type of construction and are assumed to be similar to those in the New Orleans area (where this type of data is available). It is also assumed that the duration of surge inundation is approximately 24 hours, which is considered a short-term duration. The depth-to-damage relationships are explained in more detail in the Economic Appendix.

- A depreciated replacement cost of structures was used unless a structure was destroyed fifty percent or more due to surge from Hurricane Katrina. For those structures damaged fifty-percent or more and must be rebuilt, the full replacement cost was used to denote the value in the structure inventory.

Redevelopment is anticipated to occur as follows:

Table 18.

Redevelopment Assumptions

Assumptions of Structure Redevelopment by Year		
Year	**Percent Redeveloped**	**Height of Redevelopment**
2005	N/A	Hurricane Katrina Landfall (August 29th)
2006	10%	Pre-Hurricane Katrina Base Flood Elevations
2007	25%	Pre-Hurricane Katrina Base Flood Elevations
2008	40%	Pre-Hurricane Katrina Base Flood Elevations
2009	60%	Advisory Base Flood Elevations
2010	80%	Advisory Base Flood Elevations
2011	100%	Advisory Base Flood Elevations
2012	Full Redevelopment	Base Year

5.2 Forecasting of Relative Sea Level Rise: Scenarios

In addition to redevelopment, relative sea level rise could also impact solutions (and decisions) to the water resource problems being evaluated along the Mississippi coast. The following scenarios were evaluated to account for relative sea level rise:

- Baseline. This is the current condition (or existing sea level) from where all other scenarios would be measured. This condition, although unlikely, must assume no further sea level rise (or land subsidence)
- Medium. This scenario assumes a relative sea level rise of about 2.4 feet over the 100-year period of analysis and is consistent with current Corps policy.
- Increased. This scenario assumes a relative sea level rise of about 3.4 feet over the 100-year period of analysis. This represents a reasonable upper bound of what could happen over the life of the project.

Because the scenarios are so wide-ranging geographically, and so dramatic in some reaches and not in others, one may need to examine the detailed results of the potential damage functions contained in the Economic Appendix to see what effect adding two feet, for instance, has on the number of structures that would be inundated in a given area, for a given event, and of a given frequency in 2012, versus those that would be inundated in Reach X for an event of a given frequency in 2111 (i.e., illustrating the differences over the 100-year planning horizon). There are few general statements, or statements that apply to the entire coast that can be made for relative sea level rise. The single statement that applies is that sea level rise over the period of analysis, be it 50-year (used for evaluation of ecosystem restoration measures) or 100-year (used for storm damage reduction measures), would cause more damage over time, for an event of a given frequency. This is illustrated in Figure 9, below, which shows the increase in average annual damages for Hancock County, using 3 relative sea level rise scenarios.

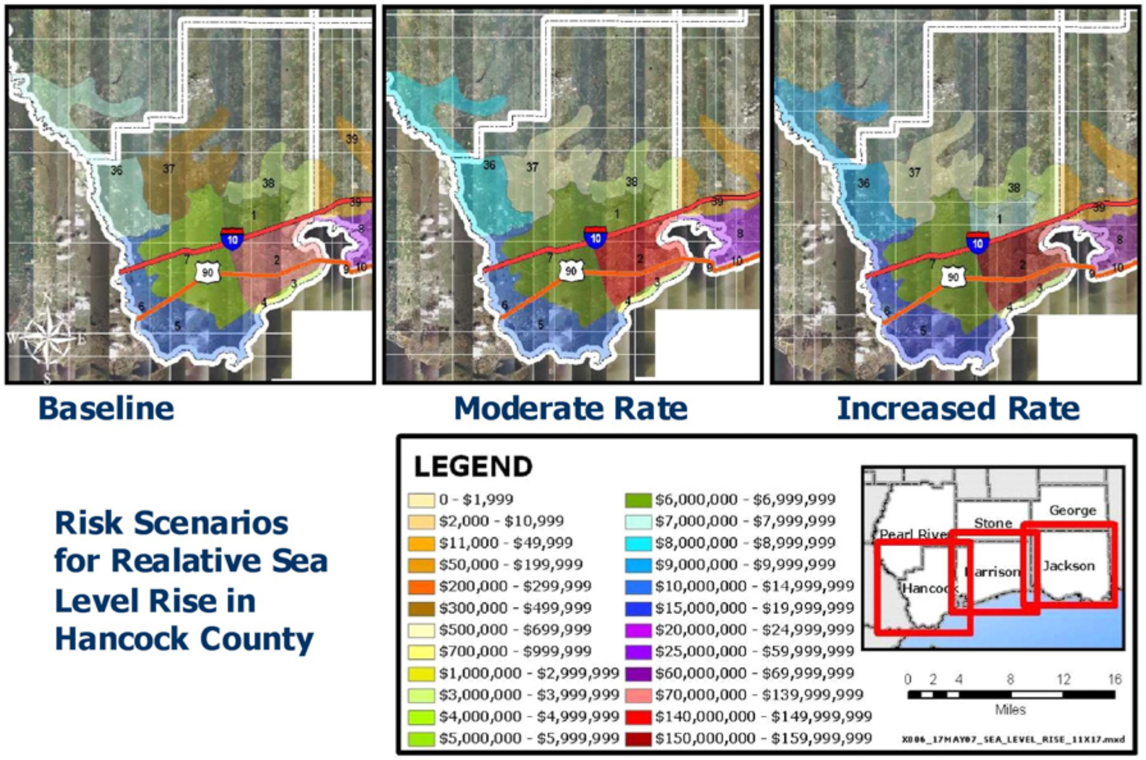


Figure 9 – Hancock County Annual Average Surge Damages by Sea Level Rise Scenario

It should be noted that the global debate over sea level rise is ongoing and the Corps will continue to design using the most up to date data available.

5.3 Preliminary Screening of Problem Areas

Following the initial identification of sites and problem areas, a preliminary screening analysis was conducted. Key to the success of this effort was the need to screen problem areas or sites that did not satisfy a link to:

- The problem being caused or exacerbated by the hurricanes of 2005;
- Based on the professional judgment of the study team that the problem area could not recover on its own;
- Congress' provided areas of investigation (storm damage reduction, erosion, fish and wildlife preservation [ecosystem restoration], saltwater intrusion, or related water resource issues;
- Ecosystem significance (scarcity of resource), from a national or regional perspective; and
- Being technically or environmentally feasible.
- Already being addressed by others.

The list of problem areas and sites screened as part of this process are shown in Table 19 below.

Table 19

Preliminary Screened List of Problem Areas

#	Name	Problem Resolution/Status
1	Coastal Mississippi Hurricane Evacuation Plan	1. FEMA "Integrated Public Alert and Warning System" update 2. State of MS. "Comprehensive Emergency Management Plan" update
2	Coastal Mississippi Artificial Reef Project for Remediation of 2005 Hurricane Damage	Mississippi Department of Marine Resources
5	USE selected levels of rip-rap instead of bulkheads for erosion control	Local Governmental Entities
7	Provide 100 acres of oyster reef restoration	MsCIP Interim & Comprehensive - Partnership with MDMR
8	Work with State to authorize transfer of development rights in state statutes	State of MS
9	Include repair standards in building codes	Local Governmental Entities
10	Dredge access channels to existing public marine industry and recreational boating	1. USCG clearing dredging tidal channels 2. FEMA evaluating remaining channels for debris and sediment removal
13	Form a monitoring network that will survive and function throughout a major storm to provide data that is critical to emergency managers	FEMA "Integrated Public Alert and Warning System" update
14	Provide an incentive for replacing failing septic systems in rural areas to improve water quality along bayous and bays.	1. Section 592 Program 2. State Regional Water and Wastewater Authority
17	Complete snagging/clearing, etc. to restore the capacity of existing drainage.	1. MsCIP, four Interim projects and recommendation for Forrest Heights 2. Jackson County Permitted for six drainage ways 3. FEMA evaluating remaining channels for debris and sediment removal
18	Repair existing bulkheads or other structural drainage components that were damaged during the storm to reduce future failures during similar events.	1. MsCIP, two Interim projects- Jackson Marsh, Courthouse Road 2. FCCE, Harrison County Beach project 3. City of Pascagoula has repaired
19	Maximize Beneficial Use of Dredge Materials	1. MsCIP Barrier Island recommendation 2. FCCE, Harrison County Beach project
20	Consider brown water system to minimize demand on ground and surface waters and limit saltwater intrusion.	USEPA
21	Re-establish Benchmark Information Coastal-wide	FEMA
22	Relocate wastewater treatment facilities out of the surge-prone areas	State Regional Water and Wastewater Authority
23	Inspect and Rehabilitate Wastewater and Piping Systems	State Regional Water and Wastewater Authority
28	Barrier Islands - Remove hazardous materials	Other
30	Barrier Islands - Protect From Spills	Other
31	Barrier Islands - Evaluate Sediment Transport - Ensure sand mining does not Impact Islands	1. MsCIP Barrier Island recommendation 2. MsCIP/ERDC Sediment Budget evaluation

#	Name	Problem Resolution/Status
34	Partnership Efforts with Louisiana to Marsh Island Areas	LaCPR Comprehensive
37	Provide protection for public facility (i.e., WW treatment plants).	1. State of MS Regional Water & Wastewater Authority via FDA funds. 2. MsCIP LOD-4 recommendation
38	Bay St. Louis Downtown HSDR	MsCIP Interim Project
39	Cowand Point Seawall Erosion Control	MsCIP Interim Project
40	Hancock County Beach Ecosystem Restoration and HSDR	MsCIP Interim Project
41	Clermont Harbor Seawall HSDR and Erosion Control	MsCIP Interim Project
42	Hancock County Comprehensive HSD - Ecosystem Restoration	MsCIP Interim & Comprehensive Ecosystem Restoration Recommendation
43	Jackson Wetland Restoration	MsCIP Interim Project
44	Bayou Caddy Shore Protection and Ecosystem Restoration	MsCIP Interim Project
46	Lakeshore Beach Ecosystem Restoration	State of MS - Environmental Concerns - Potential SAVs
48	Hancock County Communities Flood Damage Reduction	MsCIP Interim Project
49	White’s Road Evacuation Route Protection	State of MS. "Comprehensive Emergency Management Plan" update
55	Restore more natural freshwater flows by closing the MRGO	USACE-MVN is funded to close MRGO
56	Remove storm debris (i.e., demolition debris carried in by surge retreat) from aquatic environments. Restore traditional shrimping and fishing areas rendered un-trawlable by storm debris.	1. City of Pascagoula funded to construct Boardwalk 2. MsCIP to construct Beach along entire sound-front from city park westward 3. MsCIP Environmental Restoration recommendation
57	Ferries to Temporarily Replace Bridges.	State of Mississippi, Bridges Repaired
59	Restore Hancock County Beaches to Pre-Katrina conditions	1. MsCIP Interim Project Dunes Only
60	Widen Hancock County Beaches, jump-start dunes	1. MsCIP Interim Project Dunes Only
61	Preserve Bayou Caddy Area	MsCIP Interim Project
62	Protect Hancock County wetlands from filling for development	1. MsCIP Environmental restoration recommendation 2. MsCIP Regulatory Collaboration
63	Construct a N/S rail link connecting Port Bienville Industrial Park to the Norfolk and Southern Railroad through Stennis Buffer. Hurricanes cause CSXT rail outages which cost > $20,000/day	State of Mississippi and Congressional Representatives
64	Open the east Pearl River channel so it can be used by commercial marine traffic from Port Bienville	USCG

#	Name	Problem Resolution/Status
66	Mississippi Coastal Pump Station Inundation Protection	1. State of MS Regional Water & Wastewater Authority via FDA funds. 2. MsCIP LOD-4 recommendation
68	Mississippi Coastal Barrier Island Restoration	MsCIP & NPS Barrier Island restoration recommendation
69	Mississippi Coastal Improvement and Hurricane Storm Damage Reduction Program	Mississippi Department of Marine Resources
70	White's Road Evacuation Route Protection	FEMA evaluating remaining channels for debris and sediment removal
71	White's Road Evacuation Route Protection	FEMA evaluating remaining channels for debris and sediment removal
72	Harrison County Beach Ecosystem Restoration and Erosion Control	MsCIP Interim Project
73	Long Beach Harbor HSDR	Harrison County Beach Authority
74	Highway 90 - Rodeburg to St. Charles St. HSDR and Flood Control	State of Mississippi DOT
75	Pass Christian Harbor HSDR	Harrison County Beach Authority
78	Gulfport Commercial Harbor	State of Mississippi Port Authority
80	Turkey Creek Flood Damage Reduction	1. MsCIP Forrest Heights Levee Recommendation 2. MsCIP Regulatory Collaboration 3. MsCIP Interim Project at Long Beach
81	North Gulfport Interior Drainage	1. FEMA evaluating remaining channels for debris and sediment removal 2. MsCIP Interim Project at Long Beach
82	Long Beach Interior Drainage HSDR (includes Canals 2 - 3)	MsCIP Interim Project
83	Harrison County Industrial Seaway Harbor of Refuge	State of Mississippi
85	Courthouse Road Wetlands Ecosystem Restoration and Preservation	MsCIP Interim Project
91	Extend South Side of Deer Island. Extend 200 yards to repair breach in island and restore original footprint of island.	SAM FCCE Project
92	Deer Island enhancements. Cap shell middens on western side of the island and restore top soil in maritime live oak forest	Section 528 Construction General & FCCE Funds
93	New Sewage Treatment Plant in Woolmarket Lagoon Area - Move the Woolmarket Lagoon to north of I10 north of the area. would protect the citizens by moving the sewage from the flood prone areas:	State Regional Water and Wastewater Authority
94	Flood-Proof Existing Infrastructure	State Regional Water and Wastewater Authority
95	Enhance Lee and Bayview Docks for commercial shrimpers.	Other Local and State Entities
96	Enhance Maine Street Docks for commercial shrimpers.	Other Local and State Entities
98	Develop Concrete Staging Center in Industrial Canal. Develop Harrison county industrial canal artificial reef staging area to stockpile concrete debris for oyster reef and other useful projects.	MDMR and MsCIP Comprehensive - Partnership with State

#	Name	Problem Resolution/Status
99	Restore or enhance Mississippi oyster reefs.	Mississippi Department of Marine Resources
100	Open hw 90 Bridges quickly	State of Mississippi DOT - Bridges are Open
101	Utilize HW 90 bridge as artificial reef material	State of Mississippi DOT
103	Economic Development of Downtowns. Orderly expansion of municipal harbors along with revitalization of downtowns would provide green space; non-water dependent retail, and a manageable beach blvd. (NOT HW 90).	State of Mississippi, Governors Renewal Initiative State of Mississippi Port Authority State of Mississippi DOT Alternate Hwy 90 proposal
105	Complete the purchase of "optional" Cat Island for inclusion into Gulf Islands Nationals Seashore	National Park Service
106	Rebuild the Harrison County boardwalk with concrete to accommodate pedestrians, bicycles, and possibly street vendors.	Harrison County Beach Authority
107	Provide inland marine vessel storm shelter location with adequate moorings.	State and Local Entities
113	Reconsider dioxin cleanup on navy base post Katrina.	USEPA
114	Long Beach Interior Drainage HSDR (includes Canals 2 - 3)	MsCIP Interim Project
115	Reduce toxic exposure which exacerbates storm damage – Dioxin, Creosote, Titanium Dioxide, and Gypsum.	FEMA evaluating area regarding hazardous materials
116	Turkey Creek watershed Greenway	MsCIP Comprehensive Future Studies and Gulf Coast Trails
117	Forrest Height Levee :- Restore; Vegetate with native species; Footbridges; Nature trail atop	1. MsCIP Forrest Heights Levee Recommendation 2. Rivers, Trails and Conservation Assistance Program
118	Dredge shoaled channels hindering storm evacuation	FEMA evaluating remaining channels for debris and sediment removal
119	Dredge shoaled marinas	US Coast Guard
120	Deer Island re-nourishment of south side.	SAM Project Section 528
122	Possibly add height to the existing beach elevation and redevelop lost dune vegetation.	1. MsCIP Interim Project 2. SAM FCCE Harrison County Beach Restoration Project 3. MsCIP Comprehensive, LOD 2
123	Flood-proof low-lying sewer treatment plants. Lift stations and wells and their electrical and electronic controls.	State of Mississippi Regional Water and Wastewater Authority
128	Shearwater Bridge Erosion Control	MsCIP Interim Project
131	Pascagoula Beach Blvd. Restoration	MsCIP Interim Project
133	Beach Boulevard Erosion Control	MsCIP interim Beach Project
135	Chicot Road Flood Damage Reduction	City of Pascagoula
138	Upper Bayou Cassotte Flood Damage Reduction	MsCIP Interim Project
142	Greenwood Island Ecosystem Restoration	State of Mississippi
146	Old Spanish Trail Comprehensive Flood Damage Reduction/Drainage	1. MsCIP Comprehensive - Non-Structural/SDSS for further evaluation

#	Name	Problem Resolution/Status
		2. FEMA evaluating remaining channels for debris and sediment removal
147	Old Spanish Trail Comprehensive Flood Damage Reduction	FEMA evaluating remaining channels for debris and sediment removal
148	Old Spanish Trail Comprehensive Flood Damage Reduction	1. MsCIP Interim Project 2. NRCS Recovery Project
150	Franklin Creek Floodplain Restoration/Franklin Creek and Pecan Hydrology Project	MsCIP Interim Project
152	Gautier Hurricane Storm Damage Reduction and Ecosystem Restoration/Ladnir Rd	1. MsCIP Interim Project 2. Coast Guard Dredging Project 3. FEMA evaluating remaining channels for debris and sediment removal
153	Bayou Chico Beach HSDR/Bayou Chico Bulkhead Rehabilitation	Local Governmental Entities
154	Round Island Ecosystem Restoration/Round Island Lighthouse Relocation	State of MS
155	Upper Old Fort Bayou Comprehensive Flood Damage Reduction/ C. Byrd Road Drainage	1. MsCIP Comprehensive - Non-Structural/SDSS for further evaluation 2. FEMA evaluating remaining channels for debris and sediment removal
156	Upper Old Fort Bayou Comprehensive Flood Damage Reduction/ C. Byrd Road Drainage	1. MsCIP Comprehensive - Nonstructural/SDSS 2. FEMA evaluating remaining channels for debris and sediment removal
157	Pascagoula beaches, offshore breakwater/dunes/reefs/marshes to dissipate wave energy	MsCIP Interim Project
158	Restore natural drainage ways upper Bayou Casotte (vic Fishhawk Rd, Meadow Dale Dr., Longwood Dr, and Bayou Casotte Dr)	1. MsCIP Comprehensive - Nonstructural/SDSS 2. FEMA evaluating remaining channels for debris and sediment removal
159	Restore natural drainage ways upper Sioux Bayou (vic Laville Subdivision and Westgate Subdivision)	FEMA evaluating remaining channels for debris and sediment removal
160	Restore natural drainage ways upper Mary Walker Bayou (vic Northwood Hills, Rolling Meadows, and Bayou Oaks subdivisions)	FEMA evaluating remaining channels for debris and sediment removal
165	Pascagoula Beach Restoration. Dunes, grasses, trees, with intermittent pockets of sand beach	MsCIP Interim Project
166	W Land Lake Pascagoula. Dredge to recover retention qualities and install new drainage pipes to north.	FEMA evaluating remaining channels for debris and sediment removal
168	Study same as 58	FEMA evaluating remaining channels for debris and sediment removal
169	11th St Bridge and Drainage Canal. Bridge is failing and canal walls are caving in.	Jackson County Road Repair
170	Drainage improvements - same as 65	FEMA evaluating remaining channels for debris and sediment removal
171	Old Mobile Hwy Bridge Failing	Jackson County Road Repair

#	Name	Problem Resolution/Status
172	Bridge at Old Mobile Highway and Hospital Road is Damaged	Jackson County Road Repair
173	Restore Bates St Drainage to Open Water	FEMA evaluating remaining channels for debris and sediment removal
174	Inspection & Rehabilitation of Sewer and Storm Piping for Pascagoula	MVK Section 592 Program
175	Relocate Pascagoula WWTP out of surge area	State of Mississippi Regional Water and Wastewater Authority
176	Re-establish benchmarks Pascagoula city-wide	FEMA
177	Pascagoula brown water system study	State of Mississippi Regional Water and Wastewater Authority
178	Pascagoula Beach Blvd. Restoration (Boardwalk, beach, and marsh addition along Pascagoula front beach)	1. MsCIP Interim Project 2. City of Pascagoula Renewal Project
179	11th St Bulkhead Rehab	City of Pascagoula
180	Pascagoula main drainage system restoration including additional wetland side storage. City-wide retention/detention system. Drain barrier valve system.	1. MVK Section 592 Program 2. State of Mississippi Regional Water and Wastewater Authority 3. MsCIP Comprehensive - Nonstructural/SDSS for wetland Evaluation
181	C. Byrd Road Drainage	1. MsCIP Comprehensive - Non-Structural/SDSS for further evaluation 2. FEMA evaluating remaining channels for debris and sediment removal
183	Use jetties to prevent sediment flow clogging channels	Local Governmental Entities
186	Dredge/clear area in front of beachfront outfalls.	1. MsCIP Interim at Pascagoula 2. MsCIP Comprehensive, LOD 2 at Ocean Springs
188	Improve the Jackson-county seawall. Provide additional county-wide seawall construction, boardwalks, beach construction, marsh construction, or a combination of these elements	1. Mississippi Rebuild Renew Initiative 2. MsCIP Interim Projects
189	Gautier improvements to drainage. Same as 158.	1. MsCIP Comprehensive - Nonstructural/SDSS 2. FEMA evaluating remaining channels for debris and sediment removal
190	Gautier, drainage improvements. Same as 159	1. MsCIP Comprehensive - Nonstructural/SDSS 2. FEMA evaluating remaining channels for debris and sediment removal
191	Bayou Outlets on the Mississippi Sound that require actions to remove deposited siltation	1. MsCIP Interim Project 2. Coast Guard Dredging Project 3. FEMA evaluating remaining channels for debris and sediment removal
192	Gautier improvements to drainage. Same as D.	FEMA evaluating remaining channels for debris and sediment removal
193	Dredge Davis & Simmons Bayous to include all connecting bayous to help prevent flooding.	FEMA evaluating remaining channels for debris and sediment removal
194	Rebuild and enlarge Marsh Island	State of Mississippi

6 FORMULATION ROUND ONE

After narrowing the list of problem areas, the MsCIP study team developed potential problem-solving measures. The initial measures were developed independently within the structural, environmental, and nonstructural sub-teams and then later evaluated by the entire group. These potential measures were also solicited at each of the Regional Coordination, agency, and public workshops, and through detailed discussion with the entire study team. In order to not short-cut the planning process, and to ensure that good ideas were allowed to proceed through the process, a simple definition of a potential *measure* was provided to the team members, as "a feature or activity at a particular site". This definition was reiterated over and over to the formulators of measures, as the team progressed through this phase and following phases of formulation.

Formulation of measures to reduce storm damage, reduce coastal erosion, restore damaged ecosystems, or deal with saltwater intrusion, generally fell under the category of *Engineering solutions* in the case of the first two issues, or under the category of *Environmental solutions*, in the case of the last two issues.

6.1 Development of the No Action Plan

NEPA regulations (40 CFR 1502.14(d)) require that no action always be considered a viable alternative in any final array of plans. The no-action plan is the default choice. The planning process is built on the default assumption that the Corps should do nothing to address the problems and opportunities. The Corps should become involved in a project only if it is better for society than doing nothing. Hence, the planning process must convincingly demonstrate that involvement in some project is preferred over no action by the agency. In other words, one should not overlook the importance of the first decision to be made at this step, should something be done? The "no action" alternative is the same as the 'without project' condition described in more detail in the Main Report.

The most notable adverse changes that would occur as a result of no actions being taken are within the areas of flood damages and fish and wildlife. It is anticipated there would be little or no change within the existing soils, sediments, climate, air quality, water supply, and geology of coastal Mississippi. Due to the current rebuilding throughout the coast, slight increases in noise could occur during rebuilding construction activities. It is anticipated that these disturbances would be temporary and have only minor impacts to the community.

The wetland community will likely suffer the most significant impacts under the no action alternative. A large amount of exotic specie vegetation has been colonizing parts of coastal Mississippi following the storms of 2005. Hurricane Katrina left extensive debris fields and sedimentation in the area destroying many native trees and vegetation. Due to the loss of the native species, this area has experienced a severe infestation of the invasive Chinese Tallow tree, which is invading the marshes and adjacent flatwoods. The native species of wetland vegetation act as filters removing pollution from runoff, and allow these areas to act as natural buffers improving water quality, storing floodwaters, and reducing erosion. Exotic species, however, out-competes the native vegetation so that it negatively alters the hydrology of the wetlands, reduces the available food source for fish and wildlife, and degrades the entire wetland community by impeding the natural biogeochemical process. Exotic vegetation would continue to persist under the no action alternative, and eventually worsen.

It is anticipated there would be a slight recovery of the vegetation within various habitats such as dune plants, emergent marshes, and pine savannah wetlands under the no action alternative, but these areas would also generally degrade over time. Further fragmentation of once contiguous wildlife corridors in the northern reaches of the study area will also continue to occur as new development continues to move further away from the coast.

Tidal habitat for fish and wildlife (i.e. barrier islands, marsh habitat, wet pine savannah, etc.) may also be adversely impacted under the no action alternative. Many marine species depend on sea grass beds that were destroyed during Hurricane Katrina for foraging opportunities and cover. An increase in saltwater intrusion will continue to degrade the estuarine environment of the Mississippi Sound. Examples of the species that are dependent on this type of habitat are oysters, shrimp, crabs, finfish, coastal shore birds, and sea birds.

Many threatened and endangered species (i.e. Sandhill Crane, piping plover, etc.) could also be adversely impacted under the no action plan. Their continuing loss of habitat could occur as development and further degradation occurs.

With no Federal action, the city's municipal services would not likely be relocated and the badly damaged or uninhabitable structures would have to be reconstructed in the same area as funding becomes available. It would also likely result in changes to existing land uses. The city of Biloxi in Harrison County is experiencing record number building permit requests for waterfront development, such as condominiums and commercial businesses. In fact, the number of building permit requests has increased to about six times more than prior to Hurricane Katrina. While over time the building rate should level off, building is still likely to continue under the no action plan, even into areas that are not suitable to support development.

Significant impacts to the cultural resources would likely occur under the no action alternative. Archaeological and architectural studies along the Mississippi Gulf Coast have documented the destruction caused by natural forces, most notably hurricanes. Standing structures are often the most dramatic and visible witnesses to this destruction. However, prehistoric and historic archaeological sites are also extremely vulnerable. Shell middens, found along the immediate shoreline and within coastal marshes and estuaries, often are flipped and re-deposited by the storm surge and wave action of hurricanes. This effectively destroys much of the value of the sites. Historic Indian villages and historic town sites, such as those along the bluff on Bay St. Louis, could be destroyed by continued exposure to wave action. In addition, post storm activities offer many more mechanisms for site destruction. These include clearing of timber by use of skidders and other heavy equipment, debris removal, and reconstruction. The destructiveness of these activities is well documented from the years following hurricane Camille which struck the area in 1969. Hurricane Katrina has been documented to have destroyed a vast majority of the standing historic properties within Hancock County, and a large number of those within Harrison and Jackson Counties. Future storms will likely continue this trend under the no action alternative. For a more detailed discussion on storm surge damages, please see the Economic Appendix.

6.2 Development of Storm Damage Reduction and Erosion Reduction Measures

Examples of preliminary measures for storm damage reduction, supplied by the study team, agencies, and public, included:

- Levees, seawalls, or embankments (barriers to surge);
- Gates, berms, and breakwaters (barriers to surge);
- Elevating structures (elevation above inundated area);
- Acquisition and removal from high-risk areas (removal from high-risk inundation zones);

- Zoning and Building Code modification (removal of the most damageable or critical infrastructure or services from highest risk areas);
- Floodplain Management (removal of the most damageable or critical infrastructure or services from highest risk areas);
- Moving back from the shoreline (removal of the most at-risk development, most damageable or critical infrastructure, or services from highest risk areas);

Examples of preliminary measures for erosion reduction, supplied by the study team and public, included:

- Placement of additional sand;
- Placement of harder erosion-control features, such as shell materials, construction debris, rubble, stone, geo-textiles;
- Supply of additional sand to littoral zone;
- Reduction of sand-robbing activities in the near-shore or barrier island zones.

Additional measures were added later, as more factual information became available, and as more input was provided and more technical results became available.

6.3 Development of Ecosystem Restoration, Preservation of Fish and Wildlife and Saltwater Intrusion Reduction Measures

Examples of preliminary measures for ecosystem restoration and fish and wildlife preservation, supplied by the study team and public, included:

- Removal of sediment and/or debris, choking streams and estuaries;
- Re-grading to historic conditions and topography;
- Removal of invasive species;
- Removal of dead vegetation, deadfalls, and other vegetation that interferes with natural functions;
- Planting of native species in areas in which those species were killed by the hurricanes; and
- Filling of drainage channels that interfere with natural functions.

Examples of preliminary measures for saltwater intrusion (actually encroachment into a freshwater body) reduction, supplied by the study team and public, included:

- Reallocation of freshwater supply by re-regulation of reservoirs and
- Diversion of freshwater sources to direct more freshwater into areas of critical need.

The list of potential measures that applies to each site was crafted to that specific site based on its characteristics. More detail is provided on the list of potential measures within its appropriate appendix.

Formulation of these preliminary measures was also based on consideration of both what resources it would reduce damages to (i.e. - targeted developed areas of the coast or targeted ecosystem features), as well as the potential negative outcomes it might cause (i.e. - induced flooding). All of the structural measures were also formulated in such a way that they could be laid out as either stand-alone concepts, or as components of a multi-featured plan for a given area (i.e. – structural, nonstructural, or ecosystem restoration plan).

6.4 Evaluation of Measures: General Discussion

Each problem area or site was then evaluated to determine the level of effort required for more detailed development of solutions, the need for more rigorous technical analyses (such as detailed modeling), the need for more detailed environmental analysis related to its implementation and long-term effects, such as the potential for impacts to sensitive, threatened or endangered species or habitats, and a host of other factors. Evaluation at this phase of study was based on discussion between study team members and technical experts, on the results of preliminary modeling of potential storm surge, for instance, or, in the case of ecosystem restoration, calculation of potential improvement output, to determine the relative potential damage reduction or environmental output improvement achievable, and problems encountered or solved.

6.5 Evaluation of Storm Damage Reduction and Erosion Reduction Measures

Early evaluation indicated many areas of the coast that are not highly developed, and other areas that contain significant obstacles to formulation of structural measures. Many areas were found to be extremely difficult to reduce damages when using structural measures, compared to areas such as those in certain areas of Harrison County, where the entire coastline is densely developed, but have lesser degrees of environmental resource concentration. Many outlying areas were found to require individual means to achieve storm damage reduction.

Almost any problem area or site along the Mississippi coastline was found to have environmental considerations that required adjustment or modification of formulated structural measures to address those concerns. However, in Jackson County, the Pascagoula River system separates the city of Pascagoula from most of the coast to the west. This river system with its vast marshes areas is one of the last major free-flowing rivers in the southeast, and has numerous environmental resource concerns. In the western portion of the state, extensive mashes create other concerns along with the Pearl River that separates Mississippi from Louisiana. Other technical issues also made structural damage reduction in these areas problematic.

Review of the coastline in Mississippi using aerial photographs, topographic maps, LIDAR surveys, and storm inundation data revealed that natural topography could play a major role in forming storm barriers. Other features such as the offshore barrier islands, extensive beaches in many areas, and existing beach-front roadways were also determined to have a substantial role in potential damage reduction. The modeling also indicated that the high ground followed by the CSX Railway crossing the entire state near the coast, functioned as a barrier to surge during Katrina, and thus, should be considered as a potential inland barrier during future events.

Review of the inundation maps generated during the surge modeling of Katrina and other events also indicated that the extensive low-lying areas associated with two bays that extend inland from the coast would require more refined methods than a simple barrier, to solve the surge inundation issue. It was apparent that any continuous storm protection systems would have to consider these as breaks in the line. Closing off rivers and bays with surge gates have been used in Europe to protect inland areas and different designs of gate structure had to be evaluated and considered in the development of comprehensive plans for coastal Mississippi.

6.6 Evaluation of Ecosystem Restoration and Saltwater Intrusion Reduction Measures

The following four models were utilized by the MsCIP environmental PDT to evaluate the performance of potential ecosystem restoration measures:

- Mississippi and Alabama Gulf Coast Tidal Fringe HGM;
- Wet Pine Savannah HGM;
- FHI Model for Evaluation of Coastal Maritime Forest/Beach-Dune Habitat; and
- GIS-tool Wetland Restoration SDSS Model.

The HGM and FHI models are discussed in more detail in the Environmental Appendix.

In addition to HGM and FHI, a SDSS model, which related areas of hydric soils and other factors related to long-term survivability of a wetlands resource, was also used as a formulation, evaluation, and ultimately, screening tool. The SDSS model scales and combines multiple GIS layers for the purpose of identifying and evaluating potential wetland restoration sites within the three coastal counties. The results of the model were used in conjunction with local expertise to evaluate potential wetland restoration areas.

The results of the HGM modeling were used for functional assessment of existing and future “without-project”, and also preliminary “with-project” measure assessment, of both tidal fringe wetlands and wet pine savannahs habitats. The tidal fringe HGM model was also used to evaluate impacts to tidal fringe wetlands that would result from levee alignments including various ring levee alignments. The functional assessments helped to determine mitigation requirements for unavoidable wetland impacts by structural components of the comprehensive plan. The wet pine savannah HGM allowed the team to assess impacts to wet pine savannah habitats at several of the recommended environmental sites.

The results of the FHI modeling was used for functional assessment of existing and future “without-project”, and also preliminary “with-project” measure assessment, of all potential coastal maritime forests/beach-dune habitat restoration measures.

Future with-project condition scores, established by the study team’s modeling analysis of the specific functions that would be modified, either positively or negatively, at each site, plus “No-Action”, existing and future “without-project” score, are shown in the Environmental Appendix, by site or problem area.

Evaluation of saltwater intrusion reduction methods involved the investigation of freshwater diversion measures at several locations. These would divert freshwater from the Mississippi River or other sources as a mechanism to promote a reverse of the recent increases in salinity in the Mississippi Sound/Biloxi marshes areas. This would support fresher marshes and oyster reef health and productivity, thus enhancing both their economic value and the ecological services they provide.

In an effort to initiate the proper evaluation of freshwater diversions, a water quality model (WQM), which is based on the CE-QUAL-ICM water quality model code, is coupled to output from a three-dimensional hydrodynamic model of the region, which is based on the CH3D hydrodynamic model. The version of CH3D with sigma coordinate in the vertical dimension is being used. The model grid extends seaward beyond the Chandeleur Islands and includes Mobile Bay, Lake Borgne, Lake Pontchartrain, the Inner Harbor Navigation Channel of New Orleans and the Mississippi River Gulf Outlet Channel. Predicted water quality constituents, including nutrients, phytoplankton, dissolved oxygen, temperature, salinity, and underwater light intensity were evaluated for several scenarios and compared to modeled existing baseline conditions to assess relative changes.

The WQM was applied at three locations: (1) a diversion of freshwater flow from the Mississippi River at Bonnet Carre' spillway, (2) a diversion of freshwater flow from the Mississippi River at Violet Marsh, and (3) a diversion of all of the Escatawpa River flow into Grand Bay. The modeled release of water at the Bonnet Carre' diversion was varied by month, and the Violet Marsh model was designed to have a constant flow. The Escatawpa diversion was modeled after the flow that occurred in the Escatawpa River during 1998. The WQM was applied for the period April through September 1998. The hydrology model was run with the same conditions as used for the base conditions used in the WQM calibrations for 1998 except that the additional freshwater flows were introduced.

6.7 Comparing Measures: Formulation Round One

Each preliminary measure (potential solution, activity, or feature) for each problem area or site was then compared to other measures developed for that site or problem area. Again, comparison at this phase of study was based on discussion between study team members and technical experts, to determine the *relative* potential damage reduction or environmental output achievable, and problems encountered or solved, particularly in comparison with the "No-Action" Plan, or the condition in which no action is taken to solve as problem or provide the means for improvement of a given degraded condition or set of circumstances.

Comparison of structural and non-structural damage reduction measures, and erosion control measures, was done by comparison of their relative ability to reduce damages, with consideration given as to their potential environmental mitigation requirements or negative impacts, potential costs, and other potential issues. Comparison of ecosystem restoration measures, and saltwater intrusion measures, by the means discussed in the immediately preceding sections, was done by comparison of their relative ability to achieve the previously-discussed criteria, as well as their potential costs, and potential environmental outputs as compared to the "No-Action" Plan.

6.8 Screening Measures: Formulation Round One

6.8.1 Initial Screening Criteria

After the preliminary screening of problem areas and sites, and development and evaluation of measures was developed for each problem area, the list of problem areas and sites was then screened based on the input of the inter-disciplinary study team's understanding of each site's potential to meet a variety of criteria.

For storm damage reduction or erosion reduction, the site or problem area had to have:

- **Technical feasibility** (i.e., will a given measure provide a sound technical solution to the identified problem(s)?), and thus, at least one technically-feasible solution from the above list;
- **Environmental feasibility** (i.e., will a given measure provide a sound solution to the identified problem(s), without creating environmental resource problem of its own?), and;
- There were identified some potentially **cost-effective** solutions to the identified problem suite.

For ecosystem restoration or saltwater intrusion reduction, the site or problem area had to be identified as having:

- no ability to either heal on its own, unaided by human intervention, or;
- national and/or regional significance in regards to the type of ecosystem it represents;
- the need for assistance to restore vital hydrologic links;
- the potential need to manually remove blockages created by hurricane-deposited debris that was impacting function;
- the potential need to remove excess sediment deposited by the hurricanes that had changed the nature of the land's surface and resulted in degraded function and value;
- the potential need to remove invasive species that had entered the area since the hurricanes and caused displacement of native plant species (and potentially wildlife depending on native species), degrading function of the ecosystem;
- or the potential need for planting of native species vital to restoration of a significant ecosystem and restoration of its functions and values.

6.8.2 Screening of Preliminary Measures

The MsCIP planning process required this screening process to "weed out" unproductive measures, or those that did not meet the planning objectives. Application of the screening criteria above resulted in the screening of a large number of less significant areas, as well as many that the study team determined was capable of recovery on their own.

Additionally, as more technical and environmental data became available, more judgment is able to be applied as to the relative value of any given measure, when compared to others applied to that same site or problem area. Preliminary analysis again indicated that there were many solutions or measures that were *obviously* cost-prohibitive, unequivocally environmentally damaging, or simply technically infeasible, when compared to other measures, when each problem area or site was evaluated individually.

Due to the large number of measures involved, and the fact that initial evaluation and screening was done on a case-by-case basis by the study team in the field or in discussion held for each site, no detailed discussion of each of them is contained here, although numerous preliminary measures and their evaluation, comparison, and screening are referenced in the Engineering and Environmental appendices.

The screened list of remaining ecosystem problem areas and sites was narrowed to the following:

- Restoration of barrier islands. Includes entire restoration of the MS barrier islands including littoral placement, re-vegetation, and restoration of Submerged Aquatic Vegetation.
- Restoration of Dune habitat. Using dune barriers along the MS coast as either an ecosystem restoration measure, or in combination with dune use as a storm damage reduction barrier.
- Reduction of saltwater intrusion by restoring fresh water flows from the Escatawpa, Pearl, and Mississippi Rivers.
- Restoration of coastal Mississippi wetlands and forests by evaluating historical wetland areas frequently flooded populated areas, and current wetland and forest areas degraded by the storms of 2005.

For damage reduction concepts, a structural "Lines of Defense" concept (see Figure 11) was developed that started with the offshore barrier islands and progressed inland to what could be considered the surge extent of the worst possible theoretical storm. This storm, labeled the

Maximum Possible Intensity (MPI) event would be used to define a line, based on ground surface elevation that the storm surge would not exceed. The lines of defense would be designed to provide increasing levels of protection as you transgressed inland. Some lines would not provide protection from large storms, and several areas of the coast could not be included in continuous line of defense. These areas would be either placed in a ring levee system or designated to a non-structural solution during the second round of evaluation.

Many types of structural and nonstructural protection were reviewed. Some examples of the types of measures that were screened out due to a lack of technical feasibility are identified below and depicted in Figure 10.

- Inflatable barriers,
- Concrete sidewalks or roadways that could be hydraulically rotated upwards to form a seawall,
- Sliding panel gates, and
- Offshore breakwaters.
- Contiguous Barrier Island 'Wall'
- Galveston type Seawall

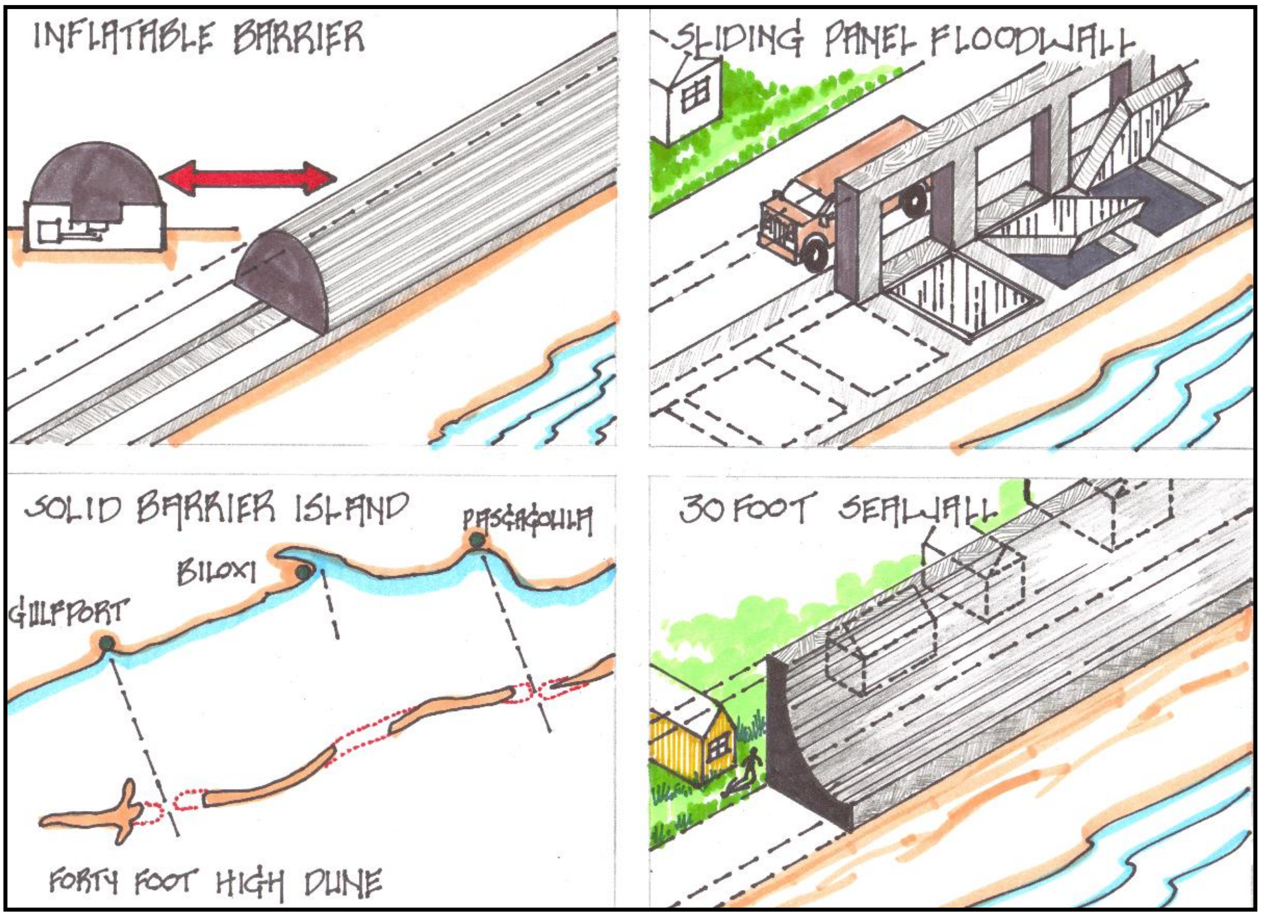


Figure 10 Preliminary Damage Reduction Measures Screened Out

The screened list of damage reduction concepts and/or alignments includes the following for further analyses and depicted in Figure 11:

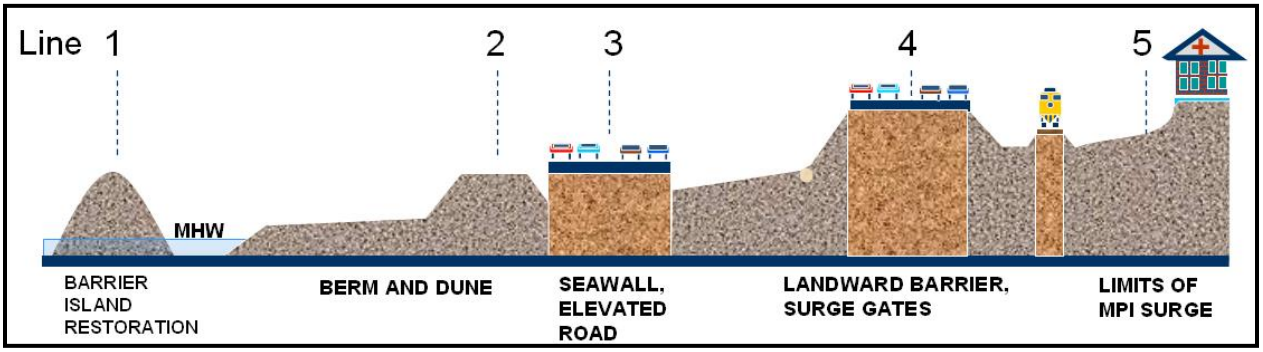


Figure 11 Lines of Defense Concept

First Line of Defense – Barrier Islands. The coastline of mainland Mississippi is bordered on the south by the Mississippi Sound, a shallow body of water that separates the coast from four barrier islands that lie several miles to the south. These barrier islands are located along a littoral drift zone that moves sand westward creating three elongated islands and then to the westward most island where littoral currents are not as well defined. From east to west, the islands are Petit Bois, Horn, Ship, and Cat. Ship Island has been breached by prior hurricanes and now is actually two small islands, West Ship Island and East Ship Island, with a shallow sand bar between the two. Since Hurricane Camille in 1969, this breach has existed with varying amounts of natural rebuilding between later storms. The western ends of both Petit Bois and Ship Islands have migrated to maintained navigation channels and the continuing littoral drift of the sand into the channels is causing an artificial termination of the migration. A new island has emerged on the west side of the channel from Petit Bois Island, created from the dredged sand coming from island that is disposed of on the west side of the channel. Soon after Hurricane Katrina, it was reported that many in Mississippi felt that if the islands had been in the condition that existed prior to Hurricane Camille, there would have been less damage along the coast from Hurricane Katrina. This idea was also included in the Mississippi Governor's Restoration Plan, which called for restoring the islands to a pre-Camille footprint. The idea was also included in the Mississippi Governor's Restoration Plan, which called for restoring the islands to pre-Camille footprint. This measure (identified as LOD-1) was selected to be carried forward for further analysis.

Second Line of Defense – Dunes along Existing Beaches. Essentially all the beaches along coastal Mississippi are man-made. Harrison County has the most beach-front with 26-miles extending from Biloxi Bay to St. Louis Bay. Hancock County has several miles of beach and Jackson County only a short length. In total, the beaches extend along less than half of the Mississippi coastline. Most of the dunes that previously existed along these beaches were destroyed by Katrina and much of the beach was damaged. Reconstruction of the dunes, where beaches exist, will likely provide reduction of damaging wave action from smaller storms.

The beaches, as situated immediately seaward of developed areas, provide a location where elevated dunes could be constructed to provide some protection from smaller hurricanes. This measure (identified as LOD-2) was selected to be carried forward for further analysis. First concepts would look at crest elevations of 10.0 and 15.0 feet above sea level (NAVD-88) as options for the all dunes.

Third Line of Defense – Raised Roadway or Seawall and Ring Levees. All of the beaches described in LOD-2 have a roadway landward (North) of the beach. These roads vary from local or county roads to US Highway 90, a major, four-lane, highway that extends across the entire Harrison County coast. The existing roadways vary in elevation from four to five feet above sea level (NAVD-88) in Jackson and Hancock County and up to about 15 feet above sea level in Harrison County. All of these roads are evacuation routes and all have been damaged in past hurricanes. In a damaged or destroyed condition, these roads make re-entry to the area difficult after a hurricane has passed. Raising and using these roadways as barriers or having an associated seawall defines a portion of the 3rd line of defense (LOD-3) and will be carried forward for further analysis. This line will be the first hard engineered structure and will be initially evaluated at elevations 12.0, 18.0 and 24.0 feet above sea level and will be supplemented by nonstructural solutions such as the elevating or buying out of structures.

Fourth Line of Defense – Inland Barrier. To preserve the shoreline environment as much as possible, a 4th line of defense (LOD-4) for very large storms is envisioned that would be inland from the coast (and LOD-3). This line of defense would be the highest line and could be designed to contain a larger storm surge, such as the "Maximum Possible Intensity" (MPI) hurricane, and will also be supplemented by nonstructural solutions such as the elevating or buying out of structures. This line of defense was selected to be carried forward for further analysis. First efforts would model LOD-4 as an infinitely high barrier against storms varying from a Camille type storm up to the MPI.

Fifth Line of Defense – Maximum Surge Limit. This line of defense will be a line on a map that indicates the extent of surge resulting from the "Maximum Possible Intensity" storm. Structures that are situated or built above (North of) this line should not be inundated from surge by large storm events. This fifth line of defense (LOD-5) was selected to be carried forward for further analysis. Initial efforts would look at nonstructural plans to either build future or relocate existing emergency services such as hospitals, or police and fire stations.

The following figures (12 - 14) indicate the initial alignments of the lines of defense concepts.

Figure 12 Initial Lines of Defense for Hancock County

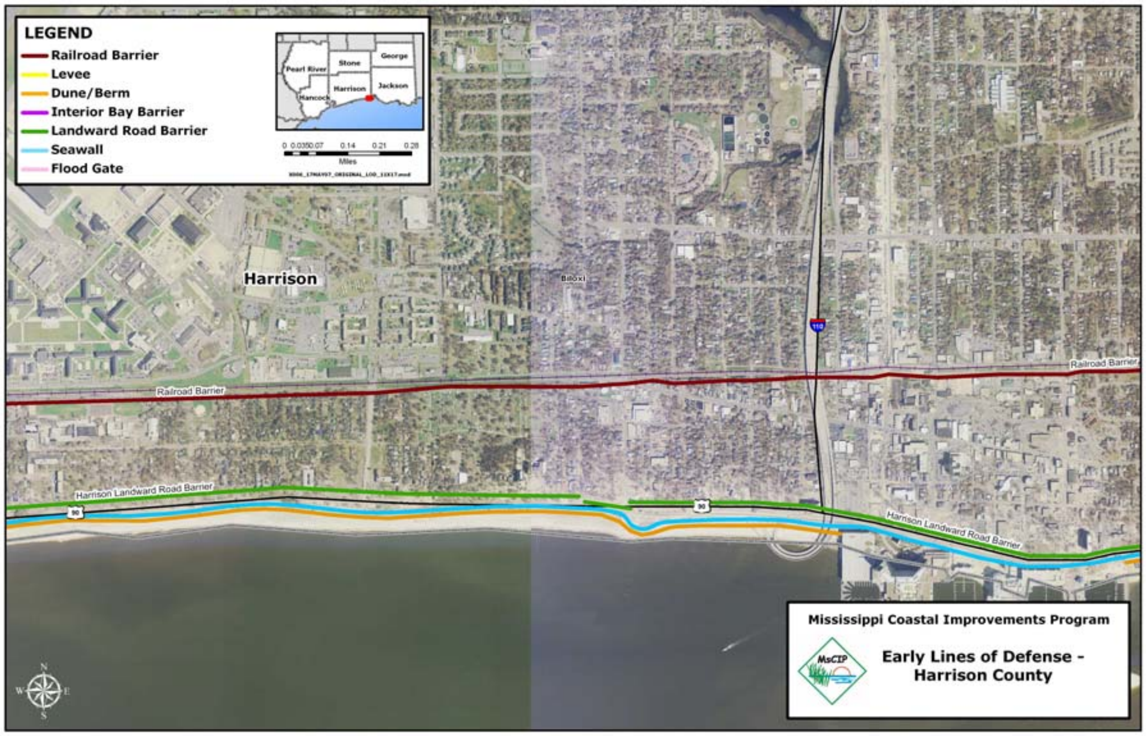


Figure 13 Initial Lines of Defense for Harrison County

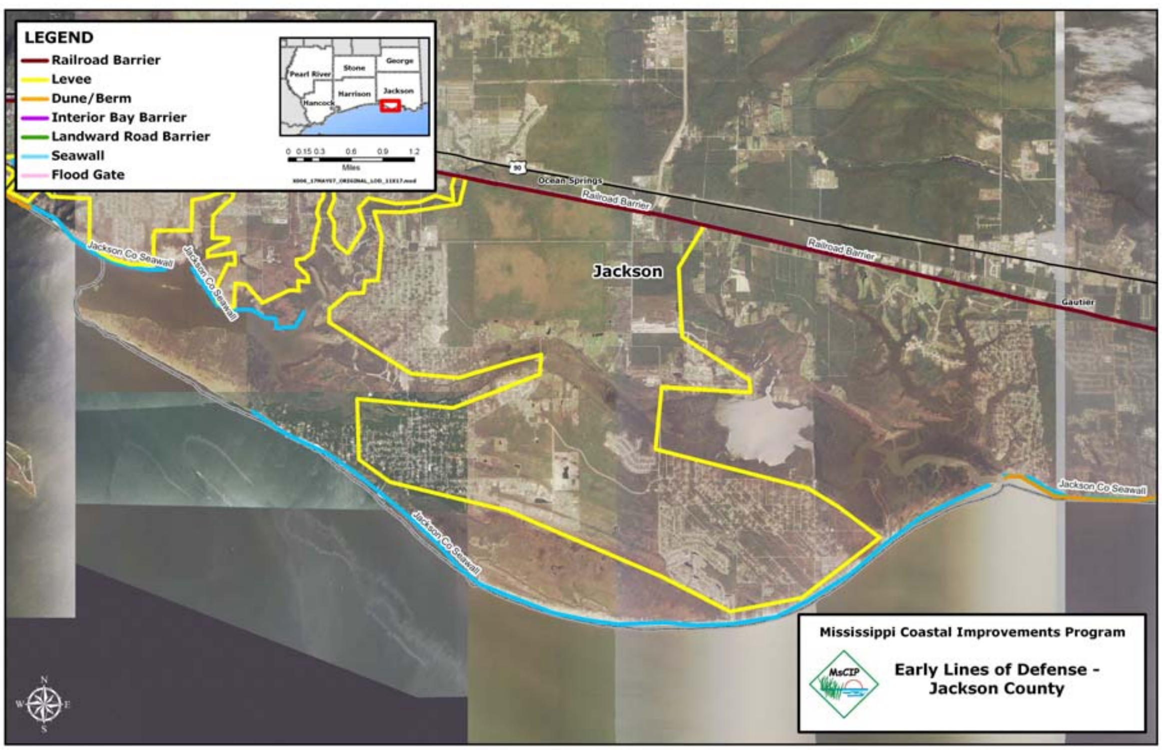


Figure 14 Initial Lines of Defense for Jackson County

Due to the relatively low elevations, type of construction, and the nature of storm surge throughout the coastal area, several preliminary nonstructural measures were also screened from further evaluations. These include:

- Elevating structures on fill material
- Dry floodproofing of residential structures (maximum protection is 3 feet), and
- Wet floodproofing of residential structures (elevating utilities)

Additional information on these measures can be found in the Engineering, Environmental, and Nonstructural Appendices.

7 Risk Assessment and Education in Plan Formulation

7.1 Intro to Risk

The additional process of evaluating and appropriately integrating risk, uncertainty and consequences of potential actions in the plan formulation process used the following criteria of: a) identification, b) quantification, and c) characterization, of these factors. This process is summarized below.

7.1.1 Risk in Identification in Technical Analyses

Risk identification involved the selection of various parameters around which risk might be quantified. The first level of risk identification involved the selection of those parameters, by agreement of the study team, technical experts, and appropriately-trained risk-educated staff brought in to assist in this process, from the Corps Engineering Research and Development Center (ERDC).

Risk was initially identified for certain technical parameters, including stage (the depth to which water could rise during a surge event), frequency, wave height, first floor elevation of structures, structure value, and content value. Uncertainty was also accommodated by the evaluation of multiple storm tracks (paths), magnitudes (strength), and alignments, to ensure that the maximum number of potential conditions was incorporated into the assumptions that went into defining future without-, and with-project conditions.

7.1.2 Risk Identification in the Planning Process

In addition, to risks and uncertainties in technical parameters, numerous other factors were also identified as having the potential for risk, uncertainty, or consequences. These included risks associated with the potential for impacts to culture and historical properties, public service disruption, risk associated with long-term sustainability of measures, risk, uncertainty and potential consequences to individuals and families, and other societal issues.

Identification of factors that required assessment also included the definition of a unit of measure (or "metric") by which the factor would be judged, such as measuring risk of being off on an estimate of inundation depth by how many feet above or below the expected depth the technical expert could consider that value to vary for a given storm; another example could be the amount of money that a damage estimate might vary for a given storm event.

Input on the factors found to be of most importance to the public and decision-makers was sought at public workshops set up to establish *which factors* were of importance, and also get input on which factors they found of *highest* importance. A full discussion on the selection of risk "metrics" and their discussion and selection by the public, is contained in the appendix on the RIDF process.

7.2 The Risk-Informed Decision Framework (RIDF) Process

The first step in the planning process is determining the problems, opportunities, and objectives which guide the study team in developing solutions. The next step involving risk is to structure the objectives using a hierarchical approach. For example, the study team considers many different risks associated with a flood event in an effort to develop and implement measures to minimize damages cause by storm surge. Residual risk is that portion of the total sum of all risks that still exists after a flood damage reduction project is implemented. Therefore, the overall objective guiding the selection of measures could be expressed as minimizing the residual risk from storm surge in terms of the economic, environmental and societal consequences associated with a flood event. This overall objective might be further divided into its component, or sub-objectives (i.e. - economic, environmental, and societal). These sub-objectives are incorporated into the planning process through measurable metrics that are used to compare the performance of each measure in an economic context (e.g., cost effectiveness), an environmental context (e.g., preservation of fish and wildlife habitat for ecological stability), or a social context (e.g., societal displacement). Successful planning requires giving careful attention to clearly describing and structuring the objectives for the study in detail. The next step involves developing metrics to represent the objectives. These metrics will then be used to calculate performance scores and ranks for the measures during the evaluation and comparison steps of the planning process.

7.2.1 Risk "Metric" Development

The MsCIP team developed metrics to be used in evaluating measures to accomplish the study objectives. If a measure did not meet the performance goals, it would either be screened out (dropped from further consideration) or taken back to the "drawing board" for refinement. The metrics themselves would be scored (or weighted) and ranked by various stakeholder groups, which would in turn aid decision makers in identifying a plan or plans to be recommended for implementation.

Evaluating measures by a large set of metrics can be complex and very time consuming. With this in mind, the study team selected an effective set of metrics that, while representing the best available information, would not be so large as to hinder the evaluation process.

The following criteria were used in selecting metrics to insure that they were:

- Scientifically verifiable. Meaning that two independent assessments would yield similar results.
- Cost-effective. The technology required to generate data for the metrics is economically feasible and does not require an intensive deployment of labor.
- Communicable. Are easy to communicate to a wide audience. The public would understand the scale and context, and be able to interpret the metric with little additional explanation.
- Changeable by human intervention. The metric would describe a dependent relationship between the outcome of the measure and those things that are under a decision-maker's control. Metrics that are independent of human action does little to help evaluate a measure.
- Credible. It would be perceived by most stakeholders as accurately measuring what it is intended to measure.

- Scalable. It would be directional in nature, whether qualitative (best, good, worst) or quantitative (dollars, acres, percent damaged), as appropriate.
- Relevant. It would reflect the priorities of the public and other stakeholders and enhance their ability to execute their stewardship responsibilities. There is no point assembling a metric no one cares about.
- Sensitive. The metric must be able to capture the minimum meaningful level of change, make the smallest distinctions that are still significant, and any uncertainty about the metric is easy to communicate.
- Minimally redundant. What the metric measures is not essentially reflected by another metric.
- Transparent. The use and development of the metric is readily apparent.

It is important to acknowledge here that there will be "conflicts" among metrics, resulting in the need to make tradeoffs. For example, a tradeoff exists between achieving any significant benefit from a project and minimizing cost. As a consequence of such "conflicts", a given measure may not take clear precedence over other measures in respect to every "metric" for evaluating performance. This may present a dilemma to decision-makers, who are trying to choose a single measure. It is important to place development of metrics prior to the development of measures because the "hard thinking" that goes into developing the metrics can create an improved set of measures. This permits stakeholders to focus on thinking about the objectives rather than anchoring themselves to their "favorite" measures.

Within a particular scenario, the amount of uncertainty surrounding metric values must be clarified. Metric values depend upon either a mathematical model, empirical data from a study, or expert opinion. All of these sources share varying degrees of uncertainty, presumably more so for expert opinion than for models and studies. Therefore, along with indicating the basic source of the metric values, it is also necessary to describe the assumptions that went into calculating the value. Estimates of the uncertainty for a metric should be quantified (e.g., in terms of the variance or range associated with the estimate). This quantification must be captured and integrated into the decision analysis in order to make risk-informed decisions.

An initial set of metrics were developed by the study team and then shared with several "focus" groups". They in turn helped to shape the final list of metrics, described and grouped by different accounts below.

Environmental Quality (EQ) Metrics

1) Tidal Habitat Restored - This metric measures (in acres) positive changes to the tidally-influenced wetlands that results from the implementation of a measure or plan. These are positive benefits from implementing a restoration plan or a combination of plans. Ecosystem components included in this metric are tidal wetlands (i.e., tidal fringes), associated threatened and endangered (T&E) and other species, associated essential fish and other tidal habitats (i.e. oysters, submerged aquatic vegetation), and related losses that require mitigation due from implementation of structural plans. There are 5 tidal wetland functions measured: wave energy attenuation (wave energy absorbed by wetland through landscape position, marsh width, and vegetation cover), biogeochemical cycling (receive, transform, and export nutrients through a wetland), nekton (swimming organisms) utilization potential (whether wetland contains suitable habitat for nekton), provide habitat for tidal marsh dependent vertebrate wildlife, and maintain a characteristic tidal marsh plant community. Units for this metric are the percentage increase of quality fish and wildlife habitat in functional habitat units (FHI).

2) Tidal Habitat Lost - This metric measures adverse impacts to the tidally-influenced wetlands that results from the implementation of a measure or plan. Ecosystem components included in this

metric are tidal wetlands (i.e., tidal fringes), associated threatened and endangered (T&E) and other species, associated essential fish and other tidal habitats (i.e. oysters, submerged aquatic vegetation), and related losses that require mitigation due from implementation of structural plans. There are 5 tidal wetland functions measured: wave energy attenuation (wave energy absorbed by wetland through landscape position, marsh width, and vegetation cover), biogeochemical cycling (receive, transform, and export nutrients through a wetland), nekton (swimming organisms) utilization potential (whether wetland contains suitable habitat for nekton), provide habitat for tidal marsh dependent vertebrate wildlife, and maintain a characteristic tidal marsh plant community. Units for this metric are also in acres.

3) Non-tidal Habitat Restored - This metric measures (as functional units) positive changes to the non-tidal ecosystems that result from the implementation of a measure or plan. These are positive benefits from implementing a restoration plan or a combination of plans. Ecosystem components included in this metric are maritime forests, beach nourishment, dune restoration and vegetation, and associated threatened, endangered and other species in non-tidal habitats. There are numerous functions provided by upland habitat: wildlife and birds (includes threatened and endangered species) roosting, nesting, and foraging utilization potential, wildlife corridors, sustainability of the Mississippi Flyway, restoration of the natural ecology and aesthetics of the area, and maintenance of plant community composition. Units for this metric are the percentage increase of quality fish and wildlife habitat in acres.

4) Non-tidal Habitat Lost- This metric measures (as functional units) adverse impacts to the non-tidal ecosystem that results from the implementation of a measure or plan. This has a negative impact of implementation of an array of alternatives as part of the comprehensive plan. Ecosystem components included in this metric are maritime forests, beach and dunes, threatened, endangered and other species and their non-tidal habitats, and related losses that require mitigation due to implementation of structural plans. There are numerous functions provided that will be evaluated and include: breaks in natural wildlife corridors, fragmentation of habitat, loss of critical habitat for threatened and endangered species, loss of foraging and roosting areas, loss of vegetation resulting in increased erosion, reduction in water quality and air quality. Units for this metric are the percentage decrease of quality fish and wildlife habitat in acres.

National Economic Development (NED) Metrics

5) Monetary Damages Reduced/Avoided (Expected Annual Damages) - The amount of storm damages reduced/avoided by a plan expressed as annualized dollars. Annualized dollars are calculated by comparing a future without a project in place versus a future with a project in place. Damages are calculated by using the Hydrologic Engineering Center-Flood Damage Analysis (HEC-FDA) model. This metric has become standard practice in the evaluation of the value of measures with respect to estimating damages to assets (i.e., residential, commercial, and industrial infrastructure and their contents) over the period of analysis. For more detail about the HEC-FDA model see Economics Appendix.

6) Residual Damage – This metric describes what a plan does not account for (or what happens if a plan is exceeded). Residual damage is defined as the storm damage that is not prevented with the implemented plan in place (expressed as annualized dollars).

7) Cost to Implement Plan – The amount of money in dollars needed to implement the plan. This metric measures the cost in today's dollars to local and Federal governments to implement the recommended plan.

Other Social Effects (OSE) Metrics

These metrics focus on the preservation of people's quality of life. OSE metrics were developed to address impacts to cultural heritage and preservation of historical structures, disruptions to public service and infrastructure and impacts to personal effects.

8) Cultural and historical heritage impacts – This metric addresses impact to social groups, church congregations, and groups with common heritages. This metric also includes impacts to aesthetics and the destruction of the human-created landscape such as historical structures. The units for this metric will be a unitless quantitative scale (0-10). A score of 10 is best, 1 is bad.

9) Public service and infrastructure disruptions – This metric includes disruptions to schools, fire and police service, access to hospitals, libraries and community centers, and use of roads, bridges, and utilities. The units for this metric will be a unitless quantitative scale (0-10). A score of 10 is best, 1 is bad.

10) Personal impacts – This metric includes loss of family possessions, photographs, and impacts to people's emotional and mental health. The units for this metric will be a unitless quantitative scale (0-10). A score of 10 is best, 1 is bad.

Regional Economic Development (RED) Metrics

The RED metrics measure both positive and negative impacts to the regional economy. Positive impacts are captured by impacts to sales volume, personal income and employment and negative impacts by local cost burdens. Sales volume, income and employment will be sub-metrics under RED, and will be equally weighted. This metric is termed Positive regional economic benefits and will combine these 3 sub-metrics. The local cost burdens metric is also a sub-metric under RED and will receive a weight equal to combined weighting of the positive metrics under regional economic benefits.

11) Local Cost Burdens – This metric represents the costs and burdens to the local governments due to implementing a measure. This includes cost-sharing requirements with the Federal government to implement the plan and local costs for ongoing operations and maintenance (O&M) related to the implemented plan. The local cost burdens may also include those associated with additional workforce needed to maintain features of an implemented plan. This metric will be based on a unitless quantitative scale (0-10). A score of 10 is best, 1 is bad.

12) Positive regional economic benefits – Economic benefits to the region with regards to sales volume, income and employment. This metric was evaluated using the economic impact forecasting system (EIFS) model. This model is an economic analysis tool that given the inputs for a particular plan will assess potential impacts of sales volume change and personal income in dollars and regional employment change in number of jobs to the local economy. Uncertainty will be based on several factors such as population, implementation cost, and social behavior of people in the region. This metric will be based on a unitless quantitative scale (0-10). A score of 10 is best, 1 is bad.

Risk Metrics

The following risk metrics serve as additional information to decision makers. They are a way to address extreme cases of uncertainty.

13) Long-term Sustainability of Plan – The risk that features associated with the recommended plan will not perform as intended (over time) due to factors such as cost, human behavior, technical level of maintenance required, political concerns, resource availability, local funding per year, and operational reliability. The units for this metric will be a unitless quantitative scale (0-10). A score of 10 is best, 1 is bad.

14) Residual Risk – This metric describes what a plan does not account for (or what happens if a plan is exceeded). Residual risk is defined as the storm damage risk that remains with the implemented plan in place (expressed as annualized dollars). It accounts for the following factors: erosion, wildlife species, wildlife habitat, salt water intrusion, surge damages, drainage, wind, maximum probable intensity (MPI) plan (accounts for more intense storm), cultural heritage, and infrastructure. The units for this metric will be a unitless quantitative scale (0-10). A score of 10 is best, 1 is bad.

15) Consequences of Plan Failing – This criterion describe what happens if a plan does not work as intended. In other words, it describes consequences to humans and the environment due to a catastrophic failure of an implemented plan under design conditions or other sets of circumstances from a storm event. The greatest risk is risk of failure to structural measures, such as levees, flood gates, etc. Consequences and likelihood of failure vary depending on the line of defense. For example, risk of Line 2 failure is more likely, but consequences are relatively low; risk of Line 4 failure is highly unlikely, but consequences are very high. It includes the following factors: injuries to population, loss of infrastructure, loss of habitat, and loss of wildlife species. The units for this metric will be a unitless quantitative scale (0-10). A score of 10 is best, 1 is bad.

Once the 15 metrics were described, the study team developed the values associated with each measure. The team calculated the acres associated with each measure for the metrics within the Environmental Quality Account as discussed above. The NED metrics were developed through the use of the Corps' HEC-FDA program (further described in the Economics Appendix) and are expressed in dollars.

As mentioned above, the RED, OSE, and Risk metrics are based on a scale from 1-10. Guidelines for these metrics were given to the team to help provide consistency amongst the different measures and are defined in the following tables.

Table 20.

Regional Economic Development Scoring Definitions

Score		Regional Economic Benefits
1	All Local Government funds are exhausted to cover the cost-shared portion, an extremely large workforce must be hired to perform maintenance of plan features, and the plan results in increased support of the area infrastructure.	Little or no economic benefits, or increase in sales volume, income and employment to the region.
2	A very large percentage of local funds would be required for cost-share and a very large workforce must be hired to perform maintenance of plan features. The plan results in a large burden on local government to support the area infrastructure.	Very small economic benefits, and increases in sales volume, income and employment to the region.
3	A large percentage of local funds would be required for cost-share and a large workforce must be hired to perform maintenance of plan features. The plan results in a large burden on local government to support the area infrastructure.	Minor economic benefits, and increases in sales volume, income and employment to the region.
4	A significant percentage of local funds would be required for cost-share and maintenance support of plan features. Plan also puts a significant burden on local governments to maintain infrastructure.	Some economic benefits, and increases in sales volume, income and employment to the region.
5	A moderate percentage of local funds are required for cost-share and maintenance support of plan features. Plan puts moderate burden on local governments to maintain infrastructure.	Moderate economic benefits, and increases in sales volume, income and employment to the region.
6	Some local funds are required for cost-share and	Significant economic benefits, and increases in sales

Score		Regional Economic Benefits
	maintenance support of plan features. Plan puts mild burden on local governments on infrastructure.	volume, income and employment to the region.
7	A minor percentage of local funds are required for cost-share and maintenance support of plan features. Plan also puts a minor burden on local governments to maintain the infrastructure.	Large economic benefits, and increases in sales volume, income and employment to the region.
8	A very small percentage of local funds will be required for cost-share and maintenance support of plan features. Plan puts mild burden on local governments to maintain the infrastructure	Very large economic benefits, and increases in sales volume, income and employment to the region.
9	Extremely small disruption to local funding, infrastructure, or maintenance support of plan.	Extremely large economic benefits, and increases in sales volume, income and employment to the region.
10	No burdens on Local Government to cost-share, operate and maintain plan features, or support infrastructure.	Tremendous economic benefits, and increases in sales volume, income and employment to the region.

Table 21

Other Social Effects Metric Scoring Definitions

Score		
1	Total Loss of Community and Cultural and Historical Heritage.	All Public Services are interrupted and are interrupted during all events that currently affect them; no police or fire service or schools that would be affected would be available; hospitals, libraries, etc., would remain closed indefinitely. Roads, bridges, utilities, and other infrastructure destroyed.
2	A portion of community exists but much of what is culturally and or historically significant would continue to be lost.	Significant Disruptions that last for weeks to months. Measure may provide a very small measure of improvement.
3	A portion of community exists but most of the Cultural and Historical Significance is lost.	Severe Interruptions to Public Services. Significant amount of damage to roads, bridges, and utilities.
4	Significant Losses, or Changes to - - - Historical Setting (i.e. Aesthetics – view, Loss to Community Defining Landmarks and/or Structures, Change in Land Use (i.e. : A complete change in how they use their community)	Very limited public services would still be provided. Hospital offers emergency services. Schools and other services may close. Road and Bridges damaged and could remain closed for moderate amount of time.
5	Moderate Loss to, or Change to Historical Setting (i.e. Aesthetics – view, Loss to Community Defining Landmarks and/or Structures, Change in Land Use (i.e. : An almost complete change in how they use their community)	Limited public services provided. Small portion or numbers of hospitals are able to operate. Schools and other services remain closed. Road and Bridges damaged but most are usable in a few weeks.
6	Low Chance of Loss to, or Change to Historical Setting (i.e. Aesthetics – view, Loss to Community Defining Landmarks and/or Structures, Change in Land Use (i.e. : Almost complete change in how they use their community)	Mild Disruption to public services. Most everything back to normal operations within 7 days
7	Divide Community Cohesiveness – Community still exists but functions separately. Some of cultural and historical essence and features are lost, but community may still retain some of what makes it culturally and historically significant.	Minor Disruption to public services. Most everything back to normal operations soon after the event.
8	Community Still Functions and retains Cultural and Historical Heritage Significances but Notable Changes are Be Community Still Functions and retains Cultural and Historical Heritage Significances but Subtle Changes may occur that do impact community integrity.	Very minor disruption to public services. Most everything back to normal operations soon after the event.
9	Community Still Functions and retains most Cultural and Historical Heritage Significance; There may be small, subtle changes.	Extremely small disruption to public services. All services back to normal operations within days.
10	Complete Preservation of Community values, historical	No impacts to normal way of life. Virtually no

Score		
	significance, and cultural heritage.	impacts to public services.

Table 22.

OSE / Risk Metric Scoring Definitions

Score	Personal Impacts	Long-Term Sustainability
1	Total Loss of Family Possessions due to Continued Hurricane Occurrence or to Plan Implementation (i.e. Property and Livelihood, Irreplaceable Items, Sense of Security, Mental Stability & Emotional Well-being) – Everyday Life no longer exists - Numerous Persons would be affected by events and might require professional therapy; most persons would likely not overcome effects of events	Complete failure (lack of sustainability) of plan (i.e. - will not perform as intended (over time) due to factors such as cost, human behavior, technical level of maintenance required, political concerns, resource availability, local funding per year, and operational reliability), is a certainty, at some time within period of analysis.
2	Majority of Family Possessions Lost (i.e. Property and Livelihood, Irreplaceable Items, Sense of Security, Mental Stability & Emotional Well-being) – Everyday Life no longer exists - Numerous Persons would be affected by events and might require professional therapy; many persons would likely not overcome effects of events	Will almost certainly fail within lifetime of project due to some factor associated with sustaining the plan. The plan will likely not be politically supported for funding or be reliably and fully maintained during its intended project life. Human behavior will almost certainly interfere with project performance sometime during project life, very high technical level of maintenance will be required, and very high risk that plan will not be operated correctly during time of need.
3	Significant Amount of Family Possessions Lost (i.e. Property Severely Damaged, Livelihood Significantly Changed, Many Irreplaceable Items Lost, Sense of Security, Mental Stability & Emotional Well-being Significantly Altered – Everyday Life no longer exists - Many people would be affected by events and could require professional therapy; many would likely not overcome effects of events for a very long time	Plan failure highly likely within project life. Minimal political support and project sustainability highly unlikely (i.e. maintenance and funding). Human behavior will interfere with project performance sometime during project life, high technical level of maintenance will be required, and high risk that plan will not be operated correctly during time of need.
4	Moderate Amount of Family Possessions Lost (i.e. Property Damaged, Livelihood Changed, Some Irreplaceable Items Lost, Sense of Security, Mental Stability & Emotional Well-being Shaken – Everyday Life Changed - Many people would be affected by events and might require professional therapy; a significant number of people would likely not overcome effects of events; some would benefit from professional therapy	Plan could possibly fail within project life. Minimal political support resulting in reduced funding and/or maintenance abilities. Human behavior may negatively affect project performance, moderate technical level of maintenance is required, and moderate risk of plan not being operated correctly.
5	Some loss of personal possessions remains likely over period of analysis; livelihood may be changed; irreplaceable items might be lost; some loss of security; property damages do affect one's sense of well-being; life for most could be altered; some loss of family possessions remains likely	Plan should perform as intended over entire project life, but possibility exists that it would not be sustained. Plan may not get sufficient political support for either sustained funding or maintenance over the life of the project. Human behavior may negatively affect project performance, moderate technical level of maintenance is required, and moderate risk of plan not being operated correctly.
6	Some loss of personal possessions is somewhat likely over period of analysis; livelihood could be changed at some point; irreplaceable items could be lost; some would suffer from loss of security; property damages could potentially affect one's sense of well-being; life for some would be altered at some point;	Plan will likely perform as intended over entire project life. There is general political support to implement the plan, but there is a risk of funding and maintenance being interrupted over project life. Negative human behavior may have some effect on project performance, and technical maintenance is required. There is also a moderate risk of the plan not being operated correctly.
7	Some loss of personal possessions could happen during period of analysis; chance exists that livelihood could be changed; irreplaceable items could be lost, but chance is not good; some might suffer from loss of security, but although shaken, overall emotional well-being is good for vast majority of period of analysis; property damages affecting one's sense of well-being is not likely; life for	Plan will most likely perform as intended over entire project life. There is general political support to implement the plan, but there is a moderate risk of funding and maintenance being interrupted over life of project. Negative human behavior has some effect on project performance, and a moderate level of technical maintenance is required. There also remains some risk

Score	Personal Impacts	Long-Term Sustainability
	small number of people could be altered at some point; Family Possessions could be impacted but most would be recoverable.	of the plan not being operated correctly.
8	Some loss of personal possessions could happen during period of analysis; small chance exists that livelihood could be changed; irreplaceable items have low likelihood of being lost; sense of security would not be shaken for vast majority, overall emotional well-being is good to very good; property damages affecting one's sense of well-being is highly unlikely; Family Possessions might be impacted, but most would be recoverable.	Plan is very unlikely of not performing as intended over entire project life. There is general political support, but some issues could arise causing delay to fully implement the plan. There is low risk of funding and maintenance being interrupted over life of project. Negative human behavior has some effect on project performance, a low to moderate level of technical maintenance is required, and there is a low to moderate risk of plan not being operated correctly.
9	Very low likelihood that loss of personal possessions would happen during period of analysis; chance exists that livelihood could be changed; irreplaceable items could be lost, but chance is extremely unlikely; very few would suffer from loss of security; overall emotional well-being is very good to excellent for vast majority of period of analysis; property damages affecting one's sense of well-being is extremely unlikely; life for very small number of people could be altered at some point; family possessions impacted but most recoverable; Recovery is Immediate.	Plan will almost certainly perform as intended over entire project life. There is strong political support and will to implement the plan, and an extremely low risk of funding and maintenance being interrupted over life of project. Negative human behavior would have extremely low likelihood of having any effect on project performance, an extremely low technical level of maintenance is required, and an extremely low risk of plan not being operated correctly.
10	Complete preservation of family possessions (i.e. Property and Livelihood, Irreplaceable Items, Sense of Security Mental Stability & Emotional Well-being)	Plan will absolutely perform as intended over entire project life. It is fully politically supported; resources are more than adequate to maintain the project, human behavior will not negatively affect project performance, minimal to no maintenance required, extremely low risk of funding being interrupted, and extremely low risk of plan not being operated correctly.

Table 23

Risk Metric Scoring Definitions

Score		Residual Risk
1	Plan failure would result in extremely widespread and extensive injuries and large number of deaths; enormous number of structures destroyed, and almost all of remainder damaged significantly; community would suffer total loss of infrastructure; wildlife would suffer severely as result of plan failure; habitat loss would be extreme as result of plan failure	Tremendous residual risk; All or almost all damages and risks remain unaddressed; Risks of continued damage to ecosystems, infrastructure, erosion or saltwater intrusion remain unabated; threats to cultural or historical heritage remain extremely high.
2	Plan failure would result in extremely widespread injuries and significant number of deaths; Very large number of structures destroyed, and most of remainder damaged significantly; total infrastructure loss, wildlife, and habitat loss throughout Coastal Mississippi	High to extremely high residual risk; almost all damages and risks remain unaddressed; risks of continued damage to ecosystems, infrastructure, erosion or saltwater intrusion remain unabated; threats to cultural or historical heritage remain very high.
3	Plan failure would result in widespread injuries, large number of deaths, and large number of structures destroyed, with many of remainder damaged; significant damage to infrastructure, and loss of wildlife; widespread habitat damage or loss would occur	High residual risk; vast majority of damages and risks remain unaddressed; risks of continued damage to ecosystems, infrastructure, erosion or saltwater intrusion remain high; threats to cultural or historical heritage remain high, and cultural heritage could be severely compromised.
4	Very numerous people would be injured; moderate to large number of deaths; fairly large number of structures destroyed, and some of remainder damaged significantly; loss of infrastructure would be moderate to highly significant; much wildlife would be impacted; habitat damage or loss would be moderate to highly significant	Moderate to high residual risk; majority of damages and risks remain unaddressed; risks of continued damage to ecosystems, infrastructure, erosion or saltwater intrusion remain high; threats to cultural or historical heritage remain moderate to high, and cultural heritage could be compromised.

Score		Residual Risk
5	Numerous people could be injured; moderate number of deaths; fair number of structures destroyed, and some of remainder damaged; loss of infrastructure would be moderate, but would require significant amount of time for recovery; wildlife would be impacted, but much would recover; habitat damage or loss would be moderate	Moderate residual risk; much of damage and risks remain unaddressed; risks of continued damage to ecosystems, infrastructure, erosion or saltwater intrusion remain moderate, but for a significant number, risk is reduced; threats to cultural or historical heritage remain moderate, and little of cultural heritage would be compromised. Environmental habitat could suffer but most could be restored with minor effort.
6	Moderate to minimal number of injuries as a result of plan failure, small to moderate number of deaths; some structures destroyed, and some number of remainder damaged; still substantial potential impacts to infrastructure, but much would recover quickly; habitat damage or loss would be moderate to small	Small to moderate residual risk; some of damage and risks remain unaddressed; risks of continued damage to ecosystems, infrastructure, erosion or saltwater intrusion are at small to moderate risk, but significant amount of risk is reduced; threats to cultural or historical heritage would be small to moderate, and very little risk of cultural heritage being compromised. Environmental habitat could suffer but most could be restored with very little effort.
7	Minimal number of injuries as a result of plan failure, small number of deaths might result; small number of structures destroyed, some damaged; moderate potential impacts to infrastructure, but almost all would recover quickly; habitat damage or wildlife loss would be small, and could recover quickly, impacts to infrastructure would be minimal, and recovery of most would be rapid	Small amount of residual risk; some damage and risks remain unaddressed; risks of continued damage to ecosystems, infrastructure, erosion or saltwater intrusion are at small risk, but most risk is reduced; threats to cultural or historical heritage would be small, and almost no risk of cultural heritage being compromised. Limited risk of environmental habitat impact and that which did would be restored with very little effort.
8	Very small number of injuries would occur as a result of plan failure, very small number of deaths; minimal number of structures damaged or destroyed; minimal potential impacts to infrastructure, and almost all would recover quickly; habitat damage or wildlife loss would be very small, and would recover quickly, impacts to infrastructure would be minimal, and recovery of majority would be rapid	Very small amount of residual risk; very limited amount of remaining risk or potential damages would remain unaddressed; risks of continued damage to ecosystems, infrastructure, erosion or saltwater intrusion are at very small risk; vast majority of risk is reduced; threats to cultural or historical heritage would be very small, and cultural heritage at very low risk of any compromise. Very limited risk of any environmental habitat suffering over project life, and that which did would be restored with very low effort.
9	Extremely small number of injuries would occur as a result of plan failure; Few to no deaths would result; very small number of structures, if any, destroyed, and small number of remainder damaged; minimal impacts to infrastructure, and all would recover quickly; habitat damage or wildlife loss would be extremely small, and would recover quickly; and recovery of majority would be rapid. No Injuries, very minimal infrastructures, wildlife, and habitat impacts	Extremely small amount of residual risk; extremely limited amount of remaining risk or potential damages would remain unaddressed; risks of continued damage to ecosystems, infrastructure, erosion or saltwater intrusion are at extremely small risk; almost all risk is reduced; threats to cultural or historical heritage would be extremely small, with cultural heritage at almost no risk of compromise. Extremely limited risk of any environmental habitat suffering over project life.
10	Complete Performance of Plan No Impacts due to Failure	Almost no residual risk would remain unaddressed; risks of continued damage to ecosystems, infrastructure, erosion or saltwater intrusion are almost non-existent; threats to cultural or historical heritage would be almost non-existent, with cultural heritage at no risk of temporary or permanent compromise. Almost no risk of any environmental habitat suffering significantly over project life.

Using these definitions, the planning team starting developing metrics for the different measures. These metrics were used to help refine the measures.

7.3 “Weighting” of Risk metrics by Stakeholders of coastal Mississippi

Three sequential “risk weighting” workshops were held in July, September, and December of 2007 with various stakeholder groups. The first workshop was used primarily to make sure that the stakeholders understood the RIDF process and that the metric definitions were sound and easily understood. At this workshop, the stakeholders were subjected to two different weighting (or scoring) techniques and their feedback helped to refine the process. This process was repeated at the September workshop, where the stakeholders used example metric data to aid their understanding of the measures. Again, feedback from this workshop allowed the team to finalize the weighting process and in the December, the stakeholders were able to see the actual data for the metrics associated with the final list of alternatives. The MsCIP weight elicitation workshops yielded 45 complete sets of weights on fifteen metrics. These initial weights were used to establish the importance of each factor as determined by the stakeholders, and are shown in Table 24. An exploratory data reduction technique called a cluster analysis was used to group stakeholders with similar preference patterns expressed through their allocation of weights to metrics. These results, as shown in Figure 15, enabled the MsCIP team to compare the different stakeholder preferences that exist for potential solutions. A more detailed description of how the weights of these metrics were developed can be found in the RIDF Appendix.

Table 24.

Point Allocation to Metrics

Cluster	Session	Tidal Habitat Restored	Tidal Habitat Lost	Non-Tidal Restored	Non-Tidal Lost	Damage Reduced	Residual Damage	Implementation Cost	Local Cost Burdens	Regional Benefits	Cultural Heritage	Disruptions	Personal Impacts	Sustainability	Consequences	Residual Risk
A	Business	1	1	1	1	35	3	5	5	5	4	2	2	15	16	4
A	Business	5	3	5	3	5	4	9	10	10	6	8	8	15	3	6
A	Federal	2	1	2	1	20	4	10	4	10	1	10	4	17	10	4
A	Local	2	2	2	2	7	7	12	24	10	5	10	5	5	2	5
A	Local	1	1	1	1	3	3	25	25	10	10	5	1	7	3	4
A	Local	1	2	1	2	13	8	1	12	13	1	8	5	12	12	9
A	Local	3	4	1	2	15	5	5	3	4	3	12	8	18	13	4
A	Local	1	1	1	1	20	8	12	9	10	6	7	2	15	5	2
A	Local	1	1	1	1	10	10	10	16	3	7	7	7	15	10	1
B	Business	8	6	6	2	15	6	10	8	8	8	5	7	4	3	4
B	Business	10	8	1	1	7	10	10	12	5	3	8	5	9	6	5
B	USACE	12	12	10	10	12	7	2	2	2	5	5	2	7	7	5
B	USACE	10	12	10	14	10	9	8	5	7	3	2	4	2	3	1
B	USACE	5	5	5	5	10	5	10	10	5	5	5	5	7	15	3
B	Federal	6	6	5	5	20	6	6	4	7	4	5	3	9	8	6
B	Federal	5	5	5	5	10	10	10	5	5	5	5	5	10	10	5
B	Federal	10	10	5	5	10	1	10	7	5	1	5	1	5	5	20
B	Local	1	10	1	10	10	12	18	1	8	4	8	3	1	12	1
B	Local	15	9	5	2	8	5	6	8	3	8	5	5	8	5	8

Cluster	Session	Tidal Habitat Restored	Tidal Habitat Lost	Non-Tidal Restored	Non-Tidal Lost	Damage Reduced	Residual Damage	Implementation Cost	Local Cost Burdens	Regional Benefits	Cultural Heritage	Disruptions	Personal Impacts	Sustainability	Consequences	Residual Risk
B	NGO	5	10	5	10	17	1	10	5	2	3	3	3	18	7	1
B	State	5	5	5	5	10	10	10	10	10	5	10	5	10	0	0
B	State	7	12	7	12	6	3	11	6	3	3	2	2	16	5	5
B	State	5	4	5	3	9	5	5	7	6	5	10	10	8	6	12
B	State	3	15	2	2	8	10	8	8	7	1	5	12	5	6	8
C	Business	8	30	1	1	5	1	10	10	9	5	5	3	10	1	1
C	USACE	11	12	11	12	5	7	6	6	4	2	3	2	9	8	2
C	Federal	12	12	12	12	5	5	3	3	2	5	5	5	10	5	4
C	Federal	10	10	12	15	4	4	1	1	1	15	1	1	5	15	5
C	NGO	16	16	11	11	4	3	3	1	1	2	1	1	18	8	4
C	NGO	10	20	5	20	6	3	5	3	5	2	5	2	5	8	1
C	State	12	15	11	13	9	1	10	9	2	2	1	2	10	2	1
C	State	8	15	8	16	5	5	5	10	2	5	4	4	8	3	2
C	State	15	20	10	10	5	0	10	0	3	2	3	2	10	10	0
C	State	15	15	5	5	5	5	5	5	5	5	10	10	4	4	2
D	Federal	15	20	15	15	10	5	1	2	3	4	2	4	1	1	2
D	Federal	30	25	12	8	1	1	1	1	1	1	1	1	7	5	5
D	Federal	50	1	20	2	6	5	2	2	1	2	2	2	2	1	2
D	NGO	14	20	14	20	1	1	1	3	7	2	1	1	5	8	2
D	NGO	14	25	15	24	2	1	3	2	1	2	2	3	2	3	1
D	State	5	15	2	40	1	10	5	1	1	2	1	1	10	1	5

1

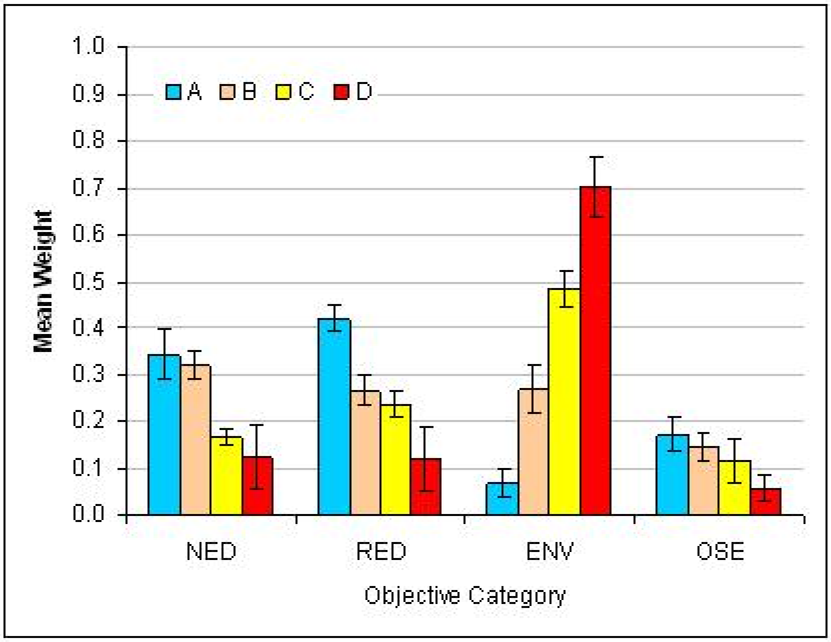


Figure 15. Stakeholder Weights for Clusters by Planning Objective

8 Formulation Round Two

The refinement of measures consisted of modifying measures to achieve higher desired outputs (better benefits, more damage reduction, more ecosystem benefit), and to better serve the original intended purpose, based on feedback from modeling efforts or better data availability. This refinement process also included the development of data at a higher level of detail on remaining measures, and the development of data on additional areas of concern, such as cultural and environmental effects, for technical considerations not developed in detail in the first round of measure development, and for other factors.

If all of the earlier screening criteria were met, each remaining measure for a given problem area was then forwarded on for further analysis and to be evaluated and compared at a higher level of detail, in the next phase (Round Two) of analysis. This refinement process included the development of more detail in design, cost estimation, environmental components and potential impacts, potential damages prevented, site considerations, more detailed technical requirements, source material and source area considerations, variations in materials that could be used to solve the problem in a similar way, species benefits or impacts considerations, and many other technical, environmental, or economic issues.

The list of measures developed during this round by zone is presented in Table 25 below.

Table 25.

Round 2 Measures

Offshore Zone	
Deer Island Restoration	Complete Restoration of Island back to its pre-Camille footprint
Increasing Islands Footprint (Option A)	Restore islands by sand dredged from off-shore
Placing River Sand in Littoral Zone (Option B)	Restore islands by placing dredged river sand in the littoral zone
Placing Off-shore Sand in Littoral Zone (Option C)	Restore islands by placing dredged sand in the littoral zone
Creating 2 FT Island Dunes with Beach Sand (Option D)	Restore islands by shaping existing beach sand into 2' high dunes
Creating 6 FT Island Dunes with Off-shore Sand (Opt E)	Restore islands by creating 6' high dunes with off-shore sand
Barrier Island No Action	
Barrier Island Restoration to Protect MS Sound Estuary	Study to recommend optimal solution to protect the MS Sound Estuary
Emergency Ship Island Restoration	Phased Advanced Engineering and Design to protect Ft. Mass. and Estuary
Sub Aquatic Vegetation Pilot Project	Tests various methods of planting SAVs in MS Sound
MS Sound Sub Aquatic Vegetation Restoration	Restore 4400 acres of lost SAVs in MS Sound using pilot results
Coastal Zone	
Hancock 40' Dune @ Elevated Roadway (Option A)	Dune adjacent to the seawall with a 40' crest at elevation 10
Hancock 50' Dune @ Elevated Roadway (Option B)	Dune adjacent to the seawall with a 50' crest at elevation 8
Hancock 20' Dune @ Elevated Roadway (Option C)	Dune adjacent to the seawall with a 20' crest at elevation 10
Hancock 30' Dune @ Elevated Roadway (Option D)	Dune adjacent to the seawall with a 30' crest at elevation 8
Hancock Dune Option A plus sea oats (Option E)	Like option A + plantings on toe of dunes
Hancock Dune Option B plus sea oats (Option F)	Like option B + plantings on toe of dunes
Hancock Dune Option C plus sea oats (Option G)	Like option C + plantings on toe of dunes
Hancock Dune Option D plus sea oats (Option H)	Like option D + plantings on toe of dunes
Hancock 55' Dune and beach berm (Option I)	Dune w/ 55' crest at elev. 10 & beach berm on south side
Hancock Dune Option I plus sea oats (Option J)	Like Option I but with plantings on toe of berm
Coastal Beach No Action	
Comprehensive 60' wide x 2' high Dune plus sea oats (Option K)	60' wide X 2' high berm with sea oats planted on 30" centers
Harrison 40' Dune @ Elevated Roadway (Option A)	Dune adjacent to the seawall with a 40' crest at elevation 10
Harrison 50' Dune @ Elevated Roadway (Option B)	Dune adjacent to the seawall with a 50' crest at elevation 8
Harrison 20' Dune @ Elevated Roadway (Option C)	Dune adjacent to the seawall with a 20' crest at elevation 10
Harrison 30' Dune @ Elevated Roadway (Option D)	Dune adjacent to the seawall with a 30' crest at elevation 8
Harrison Dune Option A plus sea oats (Option E)	Like option A + plantings on toe of dunes
Harrison Dune Option B plus sea oats (Option F)	Like option B + plantings on toe of dunes
Harrison Option C plus sea oats (Option G)	Like option C + plantings on toe of dunes
Harrison Dune Option D plus sea oats (Option H)	Like option D + plantings on toe of dunes
Harrison 55' Dune and beach berm (Option I)	Dune w/ 55' crest at elev. 10 above datum and add beach berm
Harrison Dune Option I plus sea oats (Option J)	Like Option I but with plantings on toe of berm
	[redacted]
Hancock Seawall/Elevated Roadway at Elevation 11	Seawall and Elevated Beach Road to Elevation 11
Harrison Seawall/Elevated Roadway at Elevation 16	Seawall and Elevated Beach Road to Elevation 16

Jackson Seawall/Elevated Roadway at Elevation 11	Seawall and Elevated Beach Road to Elevation 11
Biloxi Bay Surge Gate at Elevation 20	Required for LOD3 (same as LOD4 Biloxi Surge Barrier Option A)
St Louis Bay Surge Gate at Elevation 20	Required for LOD3 (same as LOD4 St Louis Bay Surge Option A)
Pearlington No Action	
Pearlington Nonstructural at ABFE (Reach 6)	Buyouts and/or raising structures accounting for a 20' surge
Pearlington Ring Levee at Elev. 20 (Reach 6)	Ring levee around Pearlington 20' above datum (NAVD 88)
Pearlington Nonstructural for Elevation 20 (Reach 6)	Buyouts and/or raising structures accounting for a 20' surge
Pearlington Ring Levee at Elev. 30 (Reach 6)	Ring levee around Pearlington 30' above datum (NAVD 88)
Pearlington Nonstructural for Elevation 30 (Reach 6)	Buyouts and/or raising structures accounting for a 30' surge
ABFE Nonstructural for (Reach 5)	Includes everything in Reach 5
ABFE Nonstructural for (Reach 36)	Includes everything in Reach 36
Pearlington Ring Levee for up to a 'Moderate to Low Risk Event'	Ring levee around Pearlington designed for a 100-500 year event
Pearlington Nonstructural for up to a 'Moderate to Low Risk Event'	Nonstructural options for Pearlington to handle a 100-500 year event
Pearlington Ring Levee plus NS up to a 'Moderate to Low Risk Event'	Reach 5-6
Pearlington Ecosystem Restoration with NS Buyouts	Buyouts and Ecosystem Restoration of high risk properties
ABFE Nonstructural for Reaches 5,6,36)	Nonstructural buyouts / elevation of structures
Pearlington North Eco Restoration Plan - 1	76 Acres - residential infrastructure
Pearlington South Restoration Plan - 2	11 Acres - residential infrastructure
Port / West Ecosystem Restoration Plan - 3	49 Acres - residential infrastructure
Ansley Ecosystem Restoration Plan - 4	2024 Acres - residential infrastructure
Heron Bay Ecosystem Restoration Plan - 5	595 Acres - residential infrastructure
Bayou Caddy Ecosystem Restoration Plan - 8	362 Acres - residential / commercial infrastructure
	[redacted]
Bay St. Louis / Waveland No Action	
ABFE Nonstructural for Reach 4	Nonstructural buyouts / elevation of structures
Clermont Harbor Ecosystem Restoration Plan - 9	210 Acres - residential infrastructure
ABFE Nonstructural for Reach 3	Nonstructural buyouts / elevation of structures
ABFE Nonstructural for Reaches 3,4	Nonstructural buyouts / elevation of structures
	[redacted]
Henderson Point No Action	
Henderson Point Nonstructural for Reach 9	
Henderson Point B Accelerated Buyout	Nonstructural buyout of properties
Pass Christian Nonstructural for Reach 10	Nonstructural buyouts / elevation of structures
Pass Christian Beach Front Eco Restoration Plan - 20	21 Acres - Low forested drainage area / residential
Pass Christian Nonstructural for Reach 13	Nonstructural buyouts / elevation of structures
Pass Christian Nonstructural for Reach 15	Nonstructural buyouts / elevation of structures
Biloxi Front Beach Ecosystem Restoration Plan - 26	41 Acres South of Hwy 90 (commercial retail outlet)
Pass Christian Nonstructural for Reach 18	Nonstructural buyouts / elevation of structures
Nonstructural for Reaches 10,13,15,18	Nonstructural buyouts / elevation of structures
	[redacted]
Ocean Springs No Action	
Ocean Springs Ring Levee at Elev. 20	Ring levee around Ocean Springs 20' above datum (NAVD 88)
Ocean Springs Nonstructural for Elevation 20	Buyouts and/or raising structures accounting for a 20' surge

Ocean Springs Ring Levee at Elev. 30	Ring levee around Ocean Springs 30' above datum (NAVD 88)
Ocean Springs Nonstructural for Elevation 30	Buyouts and/or raising structures accounting for a 30' surge
Ocean Springs Nonstructural for Reach 22	Nonstructural buyouts / elevation of structures
Ocean Springs Nonstructural for Reach 24	Nonstructural buyouts / elevation of structures
Nonstructural for Reaches 22,24	Nonstructural buyouts / elevation of structures
	[redacted]
Gulf Park / Belle Fontaine No Action	
Pine Island Plan - 30	238 Acres - restore to emergent tidal marsh
Nonstructural for Reach 28	Nonstructural buyouts / elevation of structures
Nonstructural for Reach 26	Nonstructural buyouts / elevation of structures
Nonstructural for Reach 27	Nonstructural buyouts / elevation of structures
Nonstructural for Reach 31	Nonstructural buyouts / elevation of structures
Gulf Park Estates Ring Levee at Elev. 20 (Option A)	Ring levee around Gulf Park Estates 20' above datum (NAVD 88)
Gulf Park Estates Alternate Ring Levee at Elev. 20 (Option C)	Ring levee around Gulf Park Estates 20' requires ABO plan
Gulf Park Estates Nonstructural for Elevation 20	Buyouts and/or raising structures accounting for a 20' surge
Gulf Park Estates Ring Levee at Elev. 30 (Option B)	Ring levee around Gulf Park Estates 30' above datum (NAVD 88)
Gulf Park Estates Alternate Ring Levee at Elev. 30 (Option D)	Ring levee around Gulf Park Estates 30' require ABO plan
Gulf Park Estates Nonstructural for Elevation 30	Buyouts and/or raising structures accounting for a 30' surge
Gulf Park Estates Nonstructural ABO Plan	Nonstructural Advanced Buyout Plan for areas not in Ring Levee
Belle Fontaine Ring Levee at Elev. 20 (Option A)	Ring levee around Belle Fontaine 20' above datum (NAVD 88)
Belle Fontaine Alternate Ring Levee at Elev. 20 (Option C)	Ring levee around Belle Fontaine 20' require ABO plan
Belle Fontaine Nonstructural for Elevation 20	Buyouts and/or raising structures accounting for a 20' surge
Belle Fontaine Ring Levee at Elev. 30 (Option B)	Ring levee around Belle Fontaine 30' above datum (NAVD 88)
Belle Fontaine Alternate Ring Levee at Elev. 30 (Option D)	Ring levee around Belle Fontaine 30' require ABO plan
Belle Fontaine Nonstructural for Elevation 30	Buyouts and/or raising structures accounting for a 30' surge
Belle Fontaine Nonstructural ABO Plan	Nonstructural Advanced Buyout Plan for areas not in Ring Levee
Belle Fontaine Ecosystem Restoration Plan - 31	1517 Acres (Contained in ABO area named Belle Fontaine)
Nonstructural for Reaches 26,27,28	Nonstructural buyouts / elevation of structures
	[redacted]
Gautier No Action	
Nonstructural for Reach 29	Nonstructural buyouts / elevation of structures
Nonstructural for Reach 30	Nonstructural buyouts / elevation of structures
Gautier Ring Levee at Elev. 20	Ring levee around Gautier 20' above datum (NAVD 88)
Gautier Nonstructural for Elevation 20	Buyouts and/or raising structures accounting for a 20' surge
Gautier Ring Levee at Elev. 30	Ring levee around Gautier 30' above datum (NAVD 88)
Gautier Nonstructural for Elevation 30	Buyouts and/or raising structures accounting for a 30' surge
Nonstructural for Reaches 29,30	Nonstructural buyouts / elevation of structures
	[redacted]
Moss Point / Pascagoula No Action	
Pascagoula/Moss Point Ring Levee at Elev. 20 (Option A)	Ring levee around Pascagoula/Moss Point 20' above datum
Pascagoula / Washington St. Ring Levee at Elev. 20 (Option C)	Ring levee around Pascagoula/Washington Street @ 20'
Moss Point Alternate Ring Levee at Elev. 20 (Option E)	Ring levee around Moss Point 20' above datum (NAVD 88)
Washington St + Moss Point Alternate Ring Levee at	Ring levee around Washington St + Moss Point Alt at Elev 20

Elev. 20 (Opt G)	
Pascagoula / Moss Point Nonstructural for Elevation 20	Buyouts and/or raising structures accounting for a 20' surge
Pascagoula/Moss Point Ring Levee at Elev. 30 (Option B)	Ring levee around Pascagoula/Moss Point 30' above datum
Pascagoula / Moss Point Nonstructural for Elevation 30	Buyouts and/or raising structures accounting for a 30' surge
Pascagoula / Washington St. Ring Levee at Elev. 30 (Option D)	Ring levee around Pascagoula/Washington Street @ 30'
Moss Point Alternate Ring Levee at Elev. 30 (Option F)	Ring levee around Moss Point 30' above datum (NAVD 88)
Washington St + Moss Point Alternate Ring Levee at Elev. 30 (Opt H)	Ring levee around Washington St + Moss Point Alt at Elev 30
Nonstructural for Reach 54	Nonstructural Plan for areas not inside Ring Levee
Nonstructural for Reach 53	Nonstructural Plan for areas not inside Ring Levee
Nonstructural for Reach 52	Nonstructural Plan for areas not inside Ring Levee
Nonstructural for Reach 51	Nonstructural Plan for areas not inside Ring Levee
Nonstructural for Reaches 51,52,53, 54	Nonstructural buyouts / elevation of structures
Griffin Point Ecosystem Restoration Plan - 32	183 Acres - restore to emergent tidal marsh
Bayou Chico Ecosystem Restoration Plan - 33	259 Acres - restore to emergent tidal marsh
Grand Bay / Bayou Cumbest Ecosystem Restoration Plan - 34	1517 Acres (Contained in ABO area named Belle Fontaine)
	[redacted]
Inland Zone	
Inland Zone No Action	
Inland Barrier A Levee at Elev. 20	3 County Levees at Elev. 20' plus surge gates
Inland Barrier D Levee at Elev. 20 with Roadway	3 County Levees at Elev. 20' plus surge gates with roadway on top
Inland Barrier F Menge Ave. Levee at Elev. 20	3 County Levees at Elev. 20' with no Bay St. Louis Surge gate
Inland Barrier I Menge Ave. Levee at Elev. 20 w/ Roadway	3 County Levees at Elev. 20' with no Bay St. Louis Surge gate w/ roadway
Nonstructural at Inland Barrier Footprint for Elevation 20	Coast-wide Nonstructural comparison for inland barriers
Inland Barrier B Levee at Elev. 30	3 County Levees at Elev. 30' plus surge gates
Inland Barrier E Levee at Elev. 30 with Roadway	3 County Levees at Elev. 30' plus surge gates with roadway on top
Inland Barrier G Menge Ave. Levee at Elev. 30	3 County Levees at Elev. 30' with no Bay St. Louis Surge gate
Inland Barrier J Menge Ave. Levee at Elev. 30 w/ Roadway	3 County Levees at Elev. 30' with no Bay St. Louis Surge gate w/ roadway
Nonstructural at Inland Barrier Footprint for Elevation 30	Coast-wide Nonstructural comparison for inland barriers
Inland Barrier C Levee at Elev. 40	3 County Levees at Elev. 40' plus surge gates
Inland Barrier H Menge Ave. Levee at Elev. 40	3 County Levees at Elev. 40' with no Bay St. Louis Surge gate
Nonstructural at Inland Barrier Footprint for Elevation 40	Coast-wide Nonstructural comparison for inland barriers
	[redacted]
Nonstructural for Reach 7	Nonstructural buyouts / elevation of structures
Nonstructural for Reach 37	Nonstructural buyouts / elevation of structures
Nonstructural for Reach 38	Nonstructural buyouts / elevation of structures
Nonstructural for Reach 1	Nonstructural buyouts / elevation of structures
Nonstructural for Reach 2	Nonstructural buyouts / elevation of structures
Lower Bay Rd Ecosystem Restoration Plan - 6	227 Acres - residential infrastructure
Lakeshore Ecosystem Restoration Plan - 7	275 Acres - residential / commercial infrastructure
	[redacted]
Bay St. Louis No Action	
Bay St. Louis Ring Levee at Elevation 20	Ring levee around Bay St. Louis 20' above datum (NAVD 88)

Bay St. Louis Nonstructural for Elevation 20	Buyouts and/or raising structures accounting for a 20' surge
Bay St. Louis Ring Levee at Elevation 30	Ring levee around Bay St. Louis 30' above datum (NAVD 88)
Bay St. Louis Nonstructural for Elevation 30	Buyouts and/or raising structures accounting for a 30' surge
Shoreline Park ABO Plan	buyouts of structures in high risk zones
Shoreline Park Ecosystem Restoration Plan	Restore tidal marsh - Requires buyout
Bayou LaCroix Ecosystem Restoration Plan - 10	260 Acres - residential infrastructure
Admiral Island DSS Ecosystem Restoration Plan - 11	245 Acres - (ABO area in Shoreline Park B and 2/3 of site is demo project and state owned)
State's Admiral Island Ecosystem Restoration	Exotic control and Debris Removal
Chapman Road Ecosystem Restoration Plan - 13	146 Acres - (ABO area in Shoreline Park C)
Diamondhead Ecosystem Restoration Plan - 15	434 Acres
	[redacted]
Henderson Point / Pass Christian No Action	
Henderson Point A Nonstructural ABO Plan	Nonstructural Advanced Buyout Plan for areas not in Ring Levee
Delisle Ecosystem Restoration Plan - 16	Harrison County 121 Acres - removal of residential infrastructure
Ellis Ecosystem Restoration Plan - 17	443 Acres
Pine Point Shores East Ecosystem Restoration Plan - 18	103 Acres - removal of residential structures
Pine Point Shores West Ecosystem Restoration Plan - 19	84 Acres - removal of residential structures
Bayou Portage Ecosystem Restoration Plan - 21	44 Acres - Restore to emergent tidal marsh
Nonstructural for Reach 8	Nonstructural buyouts / elevation of structures
Nonstructural for Reach 39	Nonstructural buyouts / elevation of structures
Nonstructural for Reach 40	Nonstructural buyouts / elevation of structures
	[redacted]
Gulf Port No Action	
Nonstructural for Reach 12	Nonstructural buyouts / elevation of structures
Nonstructural for Reach 40	Nonstructural buyouts / elevation of structures
Turkey Creek Ecosystem Restoration Plan - 22	948 Acres - Restore Wet Pine Savannah
Brickyard Bayou at Courthouse Rd Eco Plan - 23	15 Acres - Restore to emergent tidal marsh
Biloxi River - Shorecrest Eco Restoration Plan - 24	15 Acres - Restore to emergent tidal marsh
Biloxi River - Eagle Point Eco Restoration Plan - 25	17 Acres -
	[redacted]
Biloxi No Action	
Nonstructural for Reach 14	Nonstructural buyouts / elevation of structures
Nonstructural for Reach 17	Nonstructural buyouts / elevation of structures
Nonstructural for Reach 19	Nonstructural buyouts / elevation of structures
Nonstructural for Reach 16	Nonstructural buyouts / elevation of structures
Nonstructural for Reach 20	Nonstructural buyouts / elevation of structures
Nonstructural for Reach 48	Nonstructural buyouts / elevation of structures
Nonstructural for Reach 50	Nonstructural buyouts / elevation of structures
Nonstructural for Reach 47	Nonstructural buyouts / elevation of structures
Keegan Bayou Ecosystem Restoration Plan - 27	55 Acres - restore to emergent tidal marsh
	[redacted]
Ocean Springs No Action	
Nonstructural for Reach 21	Nonstructural buyouts / elevation of structures

Nonstructural for Reach 23	Nonstructural buyouts / elevation of structures
Nonstructural for Reach 25	Nonstructural buyouts / elevation of structures
Nonstructural for Reach 32	Nonstructural buyouts / elevation of structures
Nonstructural for Reach 33	Nonstructural buyouts / elevation of structures
Nonstructural for Reach 34	Nonstructural buyouts / elevation of structures
Nonstructural for Reach 35	Nonstructural buyouts / elevation of structures
Nonstructural for Reach 41	Nonstructural buyouts / elevation of structures
Nonstructural for Reach 42	Nonstructural buyouts / elevation of structures
Nonstructural for Reach 43	Nonstructural buyouts / elevation of structures
Nonstructural for Reach 44	Nonstructural buyouts / elevation of structures
Nonstructural for Reach 45	Nonstructural buyouts / elevation of structures
Nonstructural for Reach 46	Nonstructural buyouts / elevation of structures
Nonstructural for Reach 49	Nonstructural buyouts / elevation of structures
Nonstructural Elevations for Waveland	Elevation of Houses in the City of Waveland
Moss Point Municipal Structures Relocation	Relocating Municipal services to higher ground
Escatawpa Freshwater Diversion	Decrease salinity to wetlands / MS Sound by diverting freshwater
Pearl River Freshwater Diversion	Decrease salinity to wetlands / MS Sound by diverting freshwater
Bonnie Carrie Freshwater Diversion	Decrease salinity to wetlands / MS Sound by diverting freshwater
Violet Freshwater Diversion	Decrease salinity to wetlands / MS Sound by diverting freshwater
St. Martin Ecosystem Restoration Plan - 28	Jackson County 468 Acres - restore to emergent tidal marsh
Fort Point Ecosystem Restoration Plan - 29	84 Acres - restore to emergent tidal marsh
	[redacted]

8.1 Refinement of Damage Reduction Measures

During early discussion with the public, many people stated the opinion that the barrier islands could be “armored”, or otherwise modified to produce a greater damage reduction effect than their current or even pre-Camille condition. Suggestions for their modification included adding additional height or length, closing off the gaps between them, or armoring them. While some thought that this idea was not a valid means of reducing damage on the mainland, the idea had a great deal of credence among numerous residents. In fact, there is a strong feeling among many that the erosion of the barrier islands contributed to the level of damage created by Katrina. While the application of armor would not be possible (due to their environmental value and inclusion in the National Parks system), the concepts of adding additional height or length were examined, to determine what degree, if any, of surge or wave reduction the barrier islands do contribute, and what they might also contribute if restored to their former dimensions and elevation. The various configurations of the barrier islands were modeled in a sensitivity analysis and are presented in Section 2.10 of the Engineering Appendix.

In conjunction with the development of various barrier islands damage reduction modeling scenarios, a structural “Lines of Defense” concept was drafted that started with an initial (or outermost) line along the alignment of the barrier islands, progressing inland to offshore breakwaters, beaches with elevated dune systems, seawalls or elevated roads (immediately inland from the beach), levees or embankments along the shoreline, or levees on various inland alignments (Highway 90, the railroad alignment, Interstate 10).

These same “lines” could also be designed to provide an increasing level of damage reduction (by increasing height) as one progressed inland.

The “Lines of Defense” (LOD) concept was modeled using both the ADCIRC model, to determine the degree of surge height reduction, and also the Beach-FX model, which was used to determine beach behavior (primarily the erosion resulting) during a hurricane event. In addition to numerous separate “lines” (barriers to surge), additional combinations of measures were also modeled to determine the most productive package of measures.

Although all iterations of the process of creating and modifying “lines” are placed under this single section of “Round Two”, there were dozens of rounds of iteration of the LODs that occurred.

The first Line of Defense, designated as LOD-1, included restoration to a pre-Camille condition, restoration to a pre-Katrina condition, restoration to a condition equivalent to the 1920’s, and one in which additional height and length was created on each island. In 1969, Hurricane Camille caused extensive erosion on the islands and created a large breach in Ship Island. This breach began to heal from the east as the littoral drift of sand added land mass to the west end of East Ship Island. This large scale breaching occurred again during Katrina, eroding away all the sand that had collected over the previous 35 years. After Katrina, it was widely expressed that if the islands had been in a pre-Camille condition, the storm surge would have been much less along the mainland coast. This scenario was modeled to help predict what effects the islands play in storm reduction. These results are discussed in Section 2-10 of the Engineering Appendix. There are a total of seven different options included in this report covering a wide range of possible ways to mitigate erosion of the islands.

The beaches (manmade in the 1950s) that extend along much of the coast were also considered as a feature that could be modified to provide some level of protection by construction of dunes on the beaches. Other projects are underway to improve the some of the beaches and proposed projects would construct small dunes on most of the beaches. Improving on these features by adding higher dunes and/or dune vegetation was designated as LOD-2. These would not provide protection from large storms, but would be beneficial for smaller storms and would provide recreational and environmental benefits. Each of the three counties has beaches that fit this scenario for adding dunes. For each county, 11 options were considered for adding some measure of dune creation. Most of the options have versions that included adding vegetation and sand fencing as well as dunes without these features. Eight of the options in each county have the dune placed against roadways that parallel the beaches with the assumption that these roadways would be elevated as a separate measure. Each of these options have a dune crest elevation less than the adjacent roadway(possibly raised in the future under LOD-3 options) to prevent sand from constantly being blown onto the road These options have some value as protection for the road, but more value as an ecological benefit. Two other options include a stand-alone dune out on the beach that could provide some level of surge defense along with ecological benefits. Each county also has an option with a wide sand berm fully planted with sea oats, the preferred vegetation to help stabilize dunes. This option will allow the sea oats to trap wind-blown sand and naturally build a dune with time. The dune options in all three counties total 33 different measures that could be considered.

As mentioned above, another existing condition along much of the coast is roadways that coincide with the beaches. It was envisioned that raising these roadways would have minimal environmental impact and provide the first hardened barrier to surge damage. These roadways, while not continuous along the coast, were designated as LOD-3. The new road elevations would not be as high as to act as a seawall for very large storms, but like LOD-2, they would be beneficial for smaller, more frequent storms. While different elevations were initially considered for the roadways, the technical difficulty of raising the roads over six feet was realized. This is due to the numerous intersecting roads, driveways, and parking areas that could not be constructed without extreme grades. The existing beachfront roads in Hancock and Jackson have a typical grade elevation of 5.0 and the general grade elevation for US 90 in Harrison County is 10.0 although it varies from elevation7.0 to 16.0 depending on the exact location. With the existing road elevations, a top elevation of 11.0 was selected for study in Hancock and Jackson County and a top elevation of 16.0 was selected for study in Harrison County for a total of three options. It was also recognized that LOD-3 would require that a barrier be placed at the mouths of the bays to be effective against back-flooding. The location of the barriers is shown in Section 2-1 of the Engineering Appendix.

Some areas of the coast were not associated with beaches or existing roadways that allowed for a continuous defense line. When including environmental and/or technical reasons, these areas could only be viewed as stand-alone projects such as ring levees. These areas included five communities in Jackson County and two in Hancock County. For discussion purposes, these were also included in LOD-3. Each of the conceptual ring levees have been evaluated for construction at two elevations, 20.0 and 30.0 (except for the Forest Heights neighborhood). The costs also included interior drainage, pumping stations, gates for roadways and overtopping protection. Some sites also have one or more alternate alignments. The alternate alignments were selected to lessen the impacts on wetlands, lessen the intensity of wave action or to decrease the construction costs versus adding non-structural solution areas. With all ring levee elevations and alternate alignments, there are 24 different options for further consideration.

Further inland, an existing railroad grade provided a levee-like barrier to storm surge from Katrina in some areas. This railway extends all the way across the State crossing both St. Louis Bay and Biloxi Bay. In Harrison County, the railway parallels the coastline just a few blocks inland. Using a parallel, high-ground alignment as the railway system, an inland barrier was envisioned that could be constructed to such an elevation as to protect from a large storm surge, even larger than Katrina. Like LOD-3, this system would require that the bays be closed off with barriers from surge to be effective. As LOD-4, this barrier was studied at elevations up to the maximum storm surge or maximum possible intensity (MPI) storm that could be predicted based on simulated hurricane events. These selected elevations are 20.0, 30.0 and 40.0. Possible options for LOD-4 also included omitting the surge barrier across St. Louis Bay. This would require that LOD-4 be terminated along the east side of the bay. An alternate alignment to satisfy this option was selected at Menge Avenue in Pass Christian where the LOD-4 levee could be extended northward to higher ground. This option would also leave the town of Bay St. Louis without any type of surge protection. If this alternate alignment is used, Bay St. Louis hurricane defenses could be included as a ring levee with an option under LOD-3. Many alignments for project termination on the western and eastern sides of the state were considered before one that was selected, mostly due to technical and environmental reasons. This system would not cross the Pearl River on the western side of the state nor the Pascagoula River in Jackson County. Including all the different elevations and alignments for LOD-4, there are a total of 22 options including the six options for the surge gates. A general discussion of the LODs is included in Section 2.1 of the Engineering Appendix. A more detailed discussion can be found in Part 3 of the Engineering Appendix.

As high-level protection from the largest storm surge event, the limits of surge predicted from the MPI event was transposed to maps. While actually a non-structural measure, it was designated as LOD-5. It would be an area north of any potential surge damage that would be recommended for location of critical infrastructure such as hospitals, long-term care facilities, and emergency facilities.

To proceed with initial cost estimates, various components of the structural options were conceptually designed to the selected elevations described in previous paragraphs. The initial elevations selected for each component of the lines of defense are assumed to bracket a wide range of potential storms with corresponding surge elevations. Using these preliminary designs, rough order of magnitude cost estimates were completed for each of the structural options. These cost estimates can used to develop cost curves for future use to estimate rough estimates after final design elevations are selected. With these cost curves, future studies can also select varied levels of protection based on risk assessments as well as taking into account future estimates of relative sea level rise.

8.2 Evaluation of Measures – Formulation Round Two

Evaluation of measures carried forward into Round Two focused on the discussion about modeling results and technical analyses on each measure and site or problem area. The study team then discussed their evaluations as a group to arrive at consensus as to what was being discovered about the benefits or issues with each remaining measure, and its conceptual application to the site or problem area in question. This evaluation process also involved the application of numerous technical models, to determine, for instance, the behavior of waves, under both a without-project and with-project condition, or the benefit over time to a particular ecosystem created by a particular measure.

At the same time as the lines of defense were being modeled and evaluated, it was also realized that some measures would not provide damage reduction from large storms. As an example, a dune placed on the beach could only be constructed to a height far short of what would be required to prevent surge resulting from a large storm event. It was also evident that several areas of the coast could not be included in continuous line of defense and would have to be addressed with either a ring levee system, or a non-structural solution. An example of this would be the original concept of a series of state-wide barriers along the coast following any one of several alignments (LODs). One concept that was initially discussed was a hard seawall type barrier southward (seaward) of any development across the entire coast, but later modified to follow only existing beach-front roadways. This eliminated the technical and environmental problems of crossing sparsely populated marshes and blocking extensive river systems. Locally populated areas were included, but defended with barriers not included with the continuous lines. These areas were included in the LOD system with individual ring levees.

The planning session of five conceptual lines of defense, resulted numerous refined variations of each of the lines. The evaluation of these concepts was made in a study team meeting that included engineers, environmentalists, planners, and geologists. Information from along the coastline was utilized that included large scale aerial photography, topographic maps, navigation maps, and a large collection of pre and post-Katrina photographs.

The list of measures developed for each problem area was refined once more, and additional data presented for consideration, based on their continued technical, environmental, and cost-effectiveness feasibility, based on more detailed input from the resource agencies, public and private entities, and technical staff, with consideration of their ability to be combined into multi-purpose alternatives, capable of dealing with more than one identified problem at a given site. The screened list of measures was then combined into a group of well-balanced alternatives, that included both non-structural and if applicable, structural measures that could potentially address the entire suite of environmental problems plaguing an individual site or problem area. Formulation of these alternatives also incorporated the following criteria:

- Does a potential alternative provide for an improvement in function and/or habitat values of significant resources that might also provide for potential preservation of fish and wildlife and their habitats?
- Does a proposed action or project negatively impact low income or minority populations and/or children [i.e. Executive Orders (EOs) Environmental Justice and Protection of Children)?
- Does a proposed alternative provide a potential reduction in coastal erosion?
- Does a proposed alternative provide a potential reduction in the extent or level of saltwater intrusion (encroachment)?

- Does the proposed project fit in, with, or complement the objectives of the State of Mississippi and/or locals' plans and desires for the area?
- Does the proposal contribute to the short-term or long-term recovery of coastal Mississippi?

Using these questions, as continued evaluative tools, the PDT provided for consideration, the additional criteria:

- effectiveness;
- completeness;
- acceptability; and,
- efficiency (cost-effectiveness).

Additional evaluative questions being asked by the study team, in its development of information on potential measures, but not considered screening criteria, also included:

- Does that measure provide a reduction in risk at that specific site, or in other locations?
- Does that measure provide a reduction in damage at that specific site, or in other locations?
- Can that measure be combined as a component of a multi-purpose alternative?
- Can that measure be capable of dealing with more than one identified problem at a given site?
- Does a proposed measure or alternative provide an increase in the level of education on hurricane risks?
- Does a proposed measure or alternative provide a decrease in time before one would be warned of an impending hurricane event (i.e., more time to prepare)?
- Does a proposed measure or alternative provide an increased level of precision in information on the level of threat (i.e., better information on landfall location and magnitude of the event)?
- Does a proposed measure or alternative provide an increase in the effectiveness of hurricane/storm warning to area residents and visitors?
- Does a proposed measure or alternative provide better education as to evacuation options, required items a family or business might want to evacuate, and definitive information on routes to safety?
- Does this effort duplicate or compliment the work of others?
- Does the problem (or would lack of a solution to the problem) enhance protection of life?
- Does the problem (or would lack of a solution to the problem) enhance protection of property?
- Is a potential alternative sustainable after implementation?
- Does a potential alternative still provide a potential reduction in hurricane or storm damage (if applicable)?
- Does a potential alternative still provide a potential reduction in coastal erosion (if applicable)?
- Does a potential alternative still provide a potential reduction in the extent or level of saltwater intrusion (if applicable)?
- Does a potential alternative still provide for potential preservation of fish and wildlife and their habitats (if applicable)?

- Does a proposed action or project negatively impact low income or minority populations?
- Is the cost reasonable in the light of the risk and consequences of not implementing the project?
- Are there unresolved issues (with other groups or organizations) regarding this problem or proposed solution that may lead to longer implementation times?
- Would a proposed activity or project have potential regulatory and/or environmental issues that would preclude being implemented in the near-term?
- Does the proposed project fit in with, or complement the objectives of the State and/or locals plans and desires for this area?
- Would the implantation of the proposed project preclude other future options that may have a higher level of contribution or damage reduction?
- Does the proposed project contribute to the short or longer-term recovery of coastal Mississippi?

8.3 Comparison of Measures – Formulation Round Two

Comparison of Round Two measures consisted of presentation of conditions and potential change in conditions, under "No-Action", future "without-project", and future "with-project" conditions for each site or problem area. Data presented for comparison in Round Two included preliminary costs, benefits (monetary, or economic, environmental outputs, societal, etc.) to be derived from measure implementation, problems related to implementation, more detailed design considerations, environmental outputs and potential impacts, potential damages prevented, geotechnical/site considerations, more detailed technical requirements, source material and source area considerations, variations in materials that could be used to solve the problem in a similar way, species benefits or impacts considerations, and many other technical, environmental, or economic issues.

Comparison of damage reduction measures centered on the performance of a given measure in regards to how effectively it reduced surge height and extent, compared to other measures of similar output. This involved numerous iterations of potential height and geographic coverage, since literally thousands of potential alignments of levee or embankment might be created. The goal in damage reduction measure formulation was to reduce damages to the maximum extent possible for a given type of structural or non-structural measure. While many different measures such as levees, gates, seawalls, relocations, or structure elevations might produce a similar monetary damage reduction benefit, numerous iterations were necessary to develop the best measure of a given type, given the large number of variations that might be required to produce the least costly and most productive measure. The most notable differences in flood damage reduction measures were found when comparing 3rd line of defense (elevated seawall and beach roadways) with nonstructural measures along the same area (see Table 26). The structural measures are very costly for the amount of damages reduced compared to the nonstructural measures, especially when taken in consideration that they must be constructed in tandem with surge barriers across the bays.

Table 26.
Expected Annual Damage Reduction

Measures	Expected Annual Damage Reduction (Annual $)[1]	Residual Damage (Annual $)[1]	Implementation Cost ($)	Annual O&M (Annual $)	Average Annual Cost (Annual $)
(No Action)	$0	$0	$0	$0	$0

Measures	Expected Annual Damage Reduction (Annual $)[1]	Residual Damage (Annual $)[1]	Implementation Cost ($)	Annual O&M (Annual $)	Average Annual Cost (Annual $)
					$306,127,051
ABFE Nonstructural at Seawall/Elevated Roadway Footprint	$200,860,000	$225,180,000	$8,483,400,000	$110,000	$417,249,166

1/ Expected annual damages reduced are rounded to the nearest thousand dollars.
2/ The elimination of the seawall and elevated roadway option also eliminate the beach and dune placement options that are dependent on the raising of the seawall and roadway.

Comparison of ecosystem restoration measures involved the comparison of costs versus outputs, expressed in functional capacity units, FHIs, and other measures of benefit output, such as achievement of a critical level of restoration in regards to the number of a certain plant required to sustain long-term restoration of a specific ecosystem, or removal of an invasive plant that would prevent full restoration of that ecosystem.

The following four models were once again utilized by the MsCIP environmental team to evaluate the performance comparison of potential ecosystem restoration measures:

- Mississippi and Alabama Gulf Coast Tidal Fringe HGM;
- Wet Pine Savannah HGM;
- FHI Coastal Maritime Forest/Beach-Dune Evaluation Model; and
- GIS-based Wetland Restoration SDSS.

Future with-project conditions were established by the study team, in analysis of the specific functions that would be modified, either positively or negatively, at each site. Those scores are presented in the Environmental Appendix, and summarized below.

Table 27.

Summary of Environmental Benefits.

Site	Restoration Acres	Plan	Average Annual Functional Unit Benefit
Turkey Creek	879	Existing Condition (plans 1-2)	0
Turkey Creek	689	Existing Condition (plans 3-4)	0
Turkey Creek	190	Existing Condition (plans 5-6)	0
Turkey Creek	879	No-action plan (plans 1-2)	0
Turkey Creek	689	No-action plan (plans 3-4)	0
Turkey Creek	190	No-action plan (plans 5-6)	0
Turkey Creek	879	plan 1	2,046
Turkey Creek	879	plan 2	1,352
Turkey Creek	689	plan 3	1,565
Turkey Creek	689	plan 4	815

Site	Restor ation Acres	Plan	Average Annual Functional Unit Benefit
Turkey Creek	190	plan 5	481
Turkey Creek	190	plan 6	327
Bayou Cumbest	373	No-action plan	0
Bayou Cumbest	373	plan 1	647
Bayou Cumbest	373	plan 2	637
Bayou Cumbest	373	plan 3	622
Bayou Cumbest	373	plan 4	582
Bayou Cumbest	373	plan 5	572
Bayou Cumbest	373	plan 6	557
Dantzler	385	No-action plan	0
Dantzler	385	Plan 1	1,244
Dantzler	385	Plan 2	943
Dantzler	151	Plan 3	488
Dantzler	151	Plan 4	370
Dantzler	234	Plan 5	756
Dantzler	234	Plan 6	573
Admiral Island	118	No-action plan	0
Admiral Island	118	Plan 1	1,244
Admiral Island	118	Plan 2	943
Admiral Island	118	Plan 3	488
Admiral Island	118	Plan 4	370
Admiral Island	118	Plan 5	756
Franklin Creek	149	No-action plan (plans 1-2)	0
Franklin Creek	56	No-action plan (plans 3-4)	0
Franklin Creek	149	plan 1	516
Franklin Creek	149	plan 2	399
Franklin Creek	56	plan 3	194
Franklin Creek	56	plan 4	150

(1) AAFU's are based on a 50-year period of analysis.

(2) See Economic Appendix for cost-effective analysis.

8.4 Screening of Measures – Formulation Round Two

Screening of remaining measures again involved comparison of the relative benefits, impacts, costs, societal impacts, or other outputs of a given plan, as compared to each other and the "No-Action" Plan. Screening of measures during Round Two also included the incorporation of data presented to the public and other local decision-makers, as part of the public involvement process.

Screening in Phase Two eliminated a large number of site-specific measures, such as certain seawall or beach berm/dune alternatives, based on their failure to achieve significant damage reduction. Screening also eliminated a large number of embankment/levee options, as simply too environmentally damaging or technically infeasible for further consideration. These included levees, embankments, and floodwalls across embayments and channels in western Hancock and eastern Jackson Counties, levees across Grand Bay Marsh, or the Pearl River delta systems, and across wetland areas along other parts of the coast, as shown in Table 28.

Table 28.

Summary of Round2 Measures Screened

Measures Screened During Round 2
Increasing Islands Footprint (Option A)
Hancock 40' Dune @ Elevated Roadway (Option A)
Hancock 50' Dune @ Elevated Roadway (Option B)
Hancock 20' Dune @ Elevated Roadway (Option C)
Hancock 30' Dune @ Elevated Roadway (Option D)
Hancock Dune Option A plus sea oats (Option E)
Hancock Dune Option B plus sea oats (Option F)
Hancock Dune Option C plus sea oats (Option G)
Hancock Dune Option D plus sea oats (Option H)
Hancock 55' Dune and beach berm (Option I)
Hancock Dune Option I plus sea oats (Option J)
Harrison 40' Dune @ Elevated Roadway (Option A)
Harrison 50' Dune @ Elevated Roadway (Option B)
Harrison 20' Dune @ Elevated Roadway (Option C)
Harrison 30' Dune @ Elevated Roadway (Option D)
Harrison Dune Option A plus sea oats (Option E)
Harrison Dune Option B plus sea oats (Option F)
Harrison Option C plus sea oats (Option G)
Harrison Dune Option D plus sea oats (Option H)
Harrison 55' Dune and beach berm (Option I)
Harrison Dune Option I plus sea oats (Option J)
Hancock Seawall/Elevated Roadway at Elevation 11
Harrison Seawall/Elevated Roadway at Elevation 16
Jackson Seawall/Elevated Roadway at Elevation 11
Biloxi Bay Surge Gate at Elevation 20
St Louis Bay Surge Gate at Elevation 20

The screening of measures also included the dropping of large-scale modifications (i.e., adding additional height, closing off the channels between them) to the barrier islands or Mississippi Sound, as not creating a significant (or even moderate) reduction in damages and being too environmentally destructive. In addition, measures, such as offshore breakwaters and other offshore features designed for damage reduction, were also dropped from further consideration due to their inability to significantly affect surge height or extent.

The Corps' SDSS tool further allowed the team, in cooperation with the USFWS and MDMR, to further screen those potential wetland restoration areas that were forwarded from earlier phases of study. A subset of potential restoration sites were identified by use of SDSS then ground-truthed by the MsCIP environmental team, including ERDC, Corps, MDMR, and USFWS, for verification of appropriate properties, the degree of environmental damage, and to further refine the applied No-Action and With-Project functional scores for each area and each potential alternative output.

This effort was also further coordinated at this stage with the ongoing efforts of the MsCIP non-structural damage reduction committee, and their results were used as the team identified potential restorations sites in coastal Mississippi that had been previously developed residential or commercial sites that no longer hosted significant amounts of development and were, therefore, subject to analysis as both buy-out and restoration sites. Thirty-four restoration sites were selected for further analysis based on this screening process, based on a combination of results from the SDSS tool and input from MDMR and USFWS personnel using personal local knowledge of the study area and adjacency to existing sensitive protected natural areas (i.e. State and/or Federal lands). In addition, eleven sites that also appeared as State of Mississippi Initiative Projects were additionally evaluated for inclusion as part of the next round of evaluations by the MsCIP study team.

9 FORMULATION ROUND THREE

The final refinement of measures consisted of incorporating comments from team members and stakeholders, as well as making adjustments based on the last set of evaluations, to narrow the list down to a small set of alternatives to be analyzed at the highest level of detail. This final refinement was directed at maximum effort to identify the most cost-effective options within the four key areas of study:

- Ecosystem restoration for preservation of fish, wildlife and habitat functions and values;
- Saltwater intrusion/encroachment reduction;
- Hurricane Storm Damage Reduction;
- Coastal Erosion Reduction.

Each was refined to achieve better benefits, more damage reduction, more ecosystem benefit, greater freshwater inflow or better salinity reduction, particularly during the period of greatest importance in the life cycles of select organisms.

9.1 Refinement of Damage Reduction Measures in the Lines of Defense Framework

Based on the screening of measures in Formulation Round Two, many of the options presented in the Engineering Appendix were dropped from further consideration. After the evaluation of the many measures, the screening process has reduced the ones that will be either recommended for construction, accelerated engineering and design, or further study. In some cases, the measures being carried forward are alternates of options that were initially proposed, but modified to accommodate enhanced damage reduction, environmental reasons or technical problems. As presented in the Engineering Appendix, the following discussions are listed by order in the defined "Lines of Defense" (LOD).

Modifications to the Mississippi barrier islands were identified as LOD-1. The islands were among the first storm reduction aspects that were discussed in Mississippi's Recovery Plan. Calls to restore the islands to a pre-Camille condition presented an option that encompassed work on all four islands, but was met with resistance from the National Park Service who has ownership of the vast majority of the islands. Through many meetings with the Park Service, a selection of options were formulated that could be combined into an alternative that would meet the objectives of Mississippi's plan plus win the endorsement of the Park Service. This alternative also meets three of the four key areas defined above. The alternative selected for accelerated engineering and design consists of the restoration of Ship Island, littoral zone sand additions at the east ends of Petit Bois and East Ship Island, changes in maintenance dredging practices that meet the requirements of the Regional Sediment Management Practice, and a study to define the best restoration option for Cat Island.

With the consideration that the Park Service has an immediate need to mitigate storm damage to two historical sites on the islands; an emergency project has also been included to help protect these sites until the full comprehensive project is completed. Without support of the NPS, the other options were screened out from further consideration.

Measures that would provide some degree of protection along the mainland beaches (LOD-2) initially included constructing dunes in several configurations, some with planted dune vegetation and other without, and elevating adjoining roadways (LOD-3). Having either of these measures at sufficient elevation to avoid requiring non-structural storm damage elements in areas landward was found to be technically difficult without major modifications to the immediate coastline. The results of the surge modeling has indicated that unless the top elevation of the dune or roadway is comparable to a levee with certification, the property owners behind the structures would still be required to elevate or relocate as if these structures were not in place. Due to the technical problems and associated non-structural requirements, most of these options were screened from further consideration. The remaining option associated with the beaches and adjoining roadways is the addition a low dune with dune vegetation onto the existing beaches due to environmental benefits.

Many parts of the Mississippi coast do not have the topography or population density that would support the concept of a continuous barrier such as a levee parallel to the coast. To help provide some storm defense for these areas, ring levees could be used. The alignment of these ring levees was initially selected to provide the maximum protection for the population centers. As these alignments were evaluated, alternate alignments were selected in some cases to minimize impact on wetlands, provide attenuation from direct wave attack, or decrease the quantity of fill required fro levee construction. Examples of this can be found in the alternate alignments at Gulf Park Estates, Belle Fontaine, and Pascagoula in Jackson County. The crest elevations for these ring levees could vary depending on the amount of risk that that community wanted to assume. The recommended crest elevation is typically designed for a surge and waves with a 0.2 percent annual chance of being exceeded.

As a set of options that could provide an inland defense from larger storms (LOD-4), a conceptual design has been completed that would be comprised of inland levees with surge barriers across the mouths of the two large bays in Mississippi. In combination, this barrier could extend from the first watershed divide east of the Pearl River in Hancock County westward to the last watershed divide west of the Pascagoula River following parallel to an existing railway. This barrier could be designed to provide a defense from a very large storm, but would have some aspects that may not have public or political support. Depending on the selected crest elevation, the levee may be hardly noticeable in some areas with naturally high topography such as portions of Biloxi, but may be a very high feature in areas with low topography such as Pass Christian. Another feature is the surge gates that would be required to prevent back-flooding into the bays. Evaluation of the requirements to have the gates as a component revealed that the closure of St. Louis Bay could be omitted provided that the levee did not cross into Hancock County, but the closure of Biloxi Bay is required to provide any beneficial defense for Gulfport or Biloxi. The surge gate evaluation provided an alternate levee alignment in Harrison County that could omit this defense in western Harrison County and Hancock County. The alternate alignment would parallel the railway through Harrison County westward to the Menge Avenue crossing where the levee would turn north to high ground. Due to its east-west extent in Harrison County, this portion of the levee system could also be used to support the construction of a major roadway on top of the levee by widening the crest.

Due to the accelerated nature of this study, the study team was unable to develop a sufficient level of detail for any of the structural measures to recommend for construction. Further, based on input received at the various public and stakeholder meetings, the structural measures did not receive a majority of support. Therefore, the study team feels that should decision makers like to see any of the structural measures further developed, a full feasibility study would be required. There is, however, sufficient information to make basic comparisons with nonstructural flood damage reduction measures.

9.2 High Hazard Area Risk Reduction Plan

While the discussion of nonstructural measures at public meetings was emotionally charged, there was a general consensus that any relocations resulting from the 2005 storms not displace large portions of communities. This resulted in the development of multiple non-structural elements of the comprehensive plan, including evacuation planning, building codes etc. and acquisition or flood proofing of properties within the area identified as having a 1% annual chance of inundation from hurricane and storm surges (aka '100-yr' floodplain). A portion of this area is designated the high-hazard zone and in this area flood proofing by elevation is not considered appropriate due to the forces associated with the surge therefore permanent acquisition of properties and removal of structures is the only option for risk reduction. Permanent acquisition of coastal properties is an effective way to reduce flood damages and loss of life due to drowning as a result of hurricane surge. Parcels within the designated area (with or without structures) can be purchased at fair market value under the provisions of the Uniform Relocations Assistance and Real Property Acquisition Policies Act of 1970 (P.L. 91-646).

Last resort housing benefits may be available to those displaced persons who relocate to a DSS structure located above the Katrina inundation elevation (or the 500 yr. flood event as defined on FEMA NFIP mapping) to further the objectives of migrating the population northward and away from the coast. Specific recommendations for implementation of provisions of the Uniform Relocations Act as they may apply to acquisitions of property in the project area are contained within the Real Estate Appendix.

Acquisition or flood proofing of all properties within the '100-yr' floodplain equates to approximately 59,000 parcels. Obviously it is not realistic to consider that this action could be undertaken within a short timeframe due to impacts on local tax base, ability to acquire, cost etc. It is more realistic to consider that this component could be phased in over a 25 – 40 year period. Therefore, a phased implementation of separable elements was developed, including a flood proofing demonstration, a municipal acquisition and relocation project, a high hazard area risk reduction plan (HARP Phase I) and a long-term risk reduction plan (HARP Phase II). The flood proofing demonstration could lead to further study of specific areas of the coast and subsequent implementation by the Federal government or it could lead to increased involvement of local government or residents in providing for the risk reduction. Each of these elements is described in more detail below.

High Hazard Area Risk Reduction Plan (HARP) Phase I

The first phase of the non-structural High Hazard Area Risk Reduction Plan (HARP Phase I) involves the buyout of those properties that have been frequently flooded, or are at very high probability of future damage due to storm surge. The HARP would target parcels within the high-hazard zone that are currently occupied or could be re-occupied by new structures or those interspersed vacant parcels that could be occupied in the future. Of the total approximated 15,000 parcels located in the high-hazard zone, 2,000 parcels would be included in the first phase HARP. That number of parcels could be addressed by Corps real estate resources over approximately a 5 year period, provided that Federal funds would be appropriated. Further information on the High Hazard Area Risk Reduction Plan can be found in the Nonstructural and Real Estate Appendices.

Also within the HARP footprint are 4 municipal structures in Moss Point, MS that have been identified as being public facilities that would be eligible for replacement through the Real Estate "substitute facility doctrine" in lieu of acquisition. The Moss Point municipal complex is discussed in more detail in Section 3.15.5.3 below.

High Hazard Area Risk Reduction Plan Phase II

During public involvement sessions a significant portion of the population believed that the rebuilding process might already be too far advanced to relocate a significant number of residents to another location at this time. Therefore, the second phase of the HARP is to develop a strategy where buyouts along the coast can occur quickly over a long period of time as properties and funding become available. This could also occur after the next significant storm event, and before another major reconstruction effort within the high-hazard surge-plain begins. The long-term risk reduction plan is envisioned as a coordinated effort between HUD, FEMA, and the Corps that would be applied as future storms impact the area. .Further information on the High Hazard Area Risk Reduction Plan can be found in the Nonstructural Appendix.

9.3 Elevating Structures and Relocating Municipal Services

In addition to the High Hazard Area Risk Reduction Plan, the team developed alternatives for projects involving relocating municipal facilities and evaluating new methodologies in elevating structures in the hardest hit areas of the coast.

Relocating Municipal Services

During the delineation of the coastal high-hazard zone (HARP footprint) and the non-floodproofing zone (where surge inundation depths would exceed 13 feet at the BFE), it became apparent that a number of structures within the municipal facilities complex of Moss Point, MS would be included in the area where permanent acquisition would be the recommended action to reduce flood damages. As discussed below, public facilities, when determined to be eligible for substitution in lieu of acquisition, can be relocated to a flood-safe area. For public facilities that are considered to be critical components of a local or regional post-disaster response and recovery system, relocation to a flood-safe site enables that facility to operate both during and immediately after the disaster to reduce loss of life and maintain essential emergency services.

In acquisition situations where the existing structure or facility is determined by Corps Real Estate staff to be a publically-owned and operated building or facility, the Corps of Engineers Real Estate regulations (ER 405-1-12) concerning the disposition of public facilities and structures would establish the methodology for determining value. Under this regulation, acquisition of publically-owned facilities and structures required to be purchased to meet the project design objectives should be based upon the “Substitute Facility Doctrine”. Since just compensation for an acquisition is based upon fair market value at the time of purchase and since publically-owned and operated structures and property may not have a “market value” such as do residential and commercial structures, the cost of constructing a substitute facility may be used as a measure of just compensation.

Generally the substitute facility will serve the owner in the same manner as the existing facility with regard to size, usage and functionality. Typically the substitute facility doctrine is used to address the acquisition of schools, city halls, police and fire stations, and other state, municipal and county owned and operated facilities and structures and they are all collectively referred to as “relocations” in Corps water resources projects. Within the zones identified by the Corps to be too hazardous to elevate structures (high-hazard zone and non-floodproofing zone), there are likely to be publically-owned and operated facilities and structures that will fall under the category of “relocations”.

Coincidently, the team became aware of local efforts by the leadership of Moss Point, MS to address surge inundation damages to several public buildings within that same municipal complex. Members of the team met with the Mayor of Moss Point and other city officials to discuss whether the proposed acquisition of those structures under the Corps MsCIP may lead to a plan for relocating those facilities that would be in concert with the replacement concepts described above.

As a result of those meetings, a preliminary public facilities replacement plan for Moss Point, MS. The purpose of this replacement component of the HARP (in addition to protection of critical public facilities) would be to demonstrate to the other 10 affected municipalities that replacement of critical facilities is an effective way of maintaining services within the community while protecting those structures from flood damages. Communities that face such issues outside of the delineated Corps' HARP area could use their Capital Improvements Programs to fund fully or partially (cost-sharing situation) the necessary relocations. For those public structures that may be located in the high-hazard zone (HARP) or where surge inundation depths would preclude floodproofing, the Moss Point Public Facilities Replacement would yield valuable information to the Corps on new building construction costs under the latest IBC requirements.

The public buildings replacement project would include the Moss Point city hall, police station, fire station and community recreation center. Each of these four facilities was severely damaged during Katrina by surge inundation and waves and prevented local authorities from assisting citizens during the emergency. The City of Moss Point identified several strategic locations within the city where relocated public facilities would be safe from future events. Tentative replacement locations for each of the four facilities to be relocated are shown on Figure 16. The final arrangement of the replacement facilities (multi-use single structure, multiple-structure complex or dispersed facilities) would be determined in collaboration with the municipal officials during the relocations planning phase of the project. Should other similarly situated facilities by identified during the implementation of the HARP Phase I they would be included as part of that comprehensive plan element.

Figure 16: Moss Point Public Facilities Relocation Pilot Project

Waveland Floodproofing Project

In an effort to demonstrate the feasibility and effectiveness of wet floodproofing as a means of reducing flood damages in the project area, a project has been formulated as a part of the overall nonstructural program. This project would provide an opportunity to evaluate the technical aspects of the FEMA 550 guidelines as a basis for elevating structures in the program, allow for the public and local officials to see first-hand the application of floodproofing measures by elevating residential structures and affirm Corps cost data and contracting procedures that would support expanded applications of this flood damage reduction method in the MsCIP project area. Given the large number of parcels which would be eligible for floodproofing by elevation and other methods, innovative contracting methods would need to be tested to assure that good quality construction that was both acceptable to the structure owner and that limited the liability of the Corps could be applied in an efficient manner across the project area.

Using available GIS data a geographic area within one of the most hard hit areas of the coast, Waveland, was identified where wet floodproofing would be an effective method of reducing flood damages. This selected area is outside of the identified high-hazard zones where wave action and surge would endanger an elevated residential structure and its occupants. In this initial study phase the ABFE-2 feet was used as the design flood elevation for elevating approximately 25 residential structures. Prior to implementation (if the project is approved), the newest approved local ordinance (City of Waveland local floodplain management ordinance) base flood elevation (or higher) would be used to set the raised elevation of the first habitable floors of the structures.

The 25 residential structures are mainly single-family, wood frame structures on structural slab foundations (two observed crawl-spaces). Many of the residences have a brick veneer exterior. Heights of elevation range between 4 and 6 feet at the ABFE-2 feet inundation level. Using the elevation methods described above, it is anticipated that a combination of the segmented block foundation (0-4 feet high) and the concrete column foundation (> 4 feet elevation) would be used in the project.

The results of this project, including design aspects and costs, would be made available to local municipal officials as well as residents for their use in applying the 550 Guidelines or in developing local ordinances governing the wet floodproofing of structures within appropriate areas of the 100 year floodplain.

9.3.1 Maximum Possible Intensity Line

The one option that will provide a very low degree of risk from storm surge is in moving all future critical or emergency infrastructure construction northward of the extent of the surge based on the “Maximum Possible Intensity” (MPI) storm event modeling. While this is only a recommendation without a program requirement, it has no direct cost.

9.4 Refinement of Ecosystem Restoration Measures

The environmental PDT was faced with assessing the three counties in coastal Mississippi, which consists of hundreds of thousands of acres of uplands, wetlands, urban, coastal forest, etc. This assessment had to be conducted in a consolidated amount of time in order to meet the MsCIP condensed schedule; therefore, the team quickly began compiling various data, such as topographic maps, navigational charts, water quality reports, soil maps, etc, that would be useful in assessing potential restoration efforts. The environmental PDT also had ERDC develop the GIS-based SDSS analysis tool that could effectively assist the team in quickly narrowing down restoration sites.

The plan formulation process began with defining the overall comprehensive natural system and its current state post-hurricane season of 2005. The MsCIP environmental PDT compared the post-hurricane conditions to the pre-hurricane conditions. In some cases, environmental contrasts were very great while in other instances not much change had occurred. The environmental team worked with a variety of Federal, state, and local entities to adequately address the magnitude of problems plaguing coastal Mississippi. Minor problems to complex integrated problems were identified and discussed amongst the team members – structural, environmental, and non-structural. Development of a comprehensive list of problem areas consisted of single or multiple problems associated with a given site that were first identified as having been caused or exacerbated by the 2005 hurricane events. These sites were identified with damage to fish and wildlife resources, and/or saltwater intrusion. The following measures were carried forward.

9.4.1 Freshwater Diversion

A freshwater diversion project may serve to enhance the wildlife resources of the area. While there is some disagreement to the benefits of freshwater diversion projects (Turner 2006), further study will assist in determining if such diversions are ecologically feasible in eastern Jackson County, Grand Bay Savannahs and Marshes, and in western Hancock County, Hancock County Marshes. Freshwater diversions enable redistribution of freshwater and much needed sediments to these systems that are experiencing losses and erosion. Hydrodynamic circulation, salinity, and water quality model calibrations have been conducted for Mississippi Sound. Existing or baseline salinity and water quality distributions were established for March – September 1997 and 1998. Alternative freshwater diversion scenarios were developed and simulated with the calibrated models to examine changes to the baseline salinity and water quality distributions. Freshwater diversion did impact the environment in Jackson and Hancock Counties. Oysters are sensitive to specific ranges of salinity; therefore, freshwater diversions have the potential to either enhance or threaten the resource.

Several projects are presently being considered to divert freshwater from the Mississippi River or other sources as a mechanism to promote reversing a historic increase in salinity in the Mississippi Sound/Biloxi marshes area in order to support fresher marshes and oyster reef health and productivity; thus, enhancing both their economic value and the ecological services they provide.

Oysters not only support a commercial fishery but interact directly with local hydrodynamic conditions, affecting currents, flow conditions, and sedimentation patterns (Lenihan 1999). They filter large amounts of phytoplankton and detritus exerting a powerful influence on water quality, phytoplankton productivity, and nutrient cycling of estuaries (Dame 1996). Oyster reefs provide habitat for a wide range of other invertebrates present either on the oyster shell itself or in the interstices between shells. Oyster reefs also support numerous resident, transient, and juvenile fish and decapod species and may provide a refuge from predation and poor water quality conditions.

Oysters are sensitive to specific ranges of salinity; therefore, freshwater diversions have the potential to either enhance or threaten the resource. For instance, where the average salinity exceeds 15 ppt oysters often experience increased predation rates by oyster drills whereas young oysters are more susceptible to certain diseases at salinities greater than 9 ppt (Cake 1983; Chatry et al. 1983). Similarly, salinities averaging below 7.5 ppt can inhibit oyster growth and sexual maturation while salinities that persist for extended periods of time below 2 ppt can result in direct mortality (Sellers and Stanley 1984). The relationship between oyster productivity and river flow is a complex one and there does not appear to be a close link between oyster harvests and freshwater inflow (Turner 2006).

Alternately, the water diverted from riverine sources not only has lower salinity, but it usually carries more sediment and nutrients. Diversions may result in areas of excess nutrients and thus cause algal blooms, lower light attenuation and other signs of eutrophication. Therefore, any proposed diversion project needs to be carefully evaluated in order to insure the maximum probability that proper habitat and water quality conditions are met. Because of the potentially large number of projects that might require evaluation, it is essential that a screening tool be developed to cost-effectively identify those proposals which warrant the level of detailed study required to make informed decisions. It is essential that proposals that have no likelihood of success are eliminated early in the evaluation process in order to maximize the effectiveness, eliminated negative impacts from poorly designed projects, and reduce costs of evaluating the remaining candidates.

In an effort to initiate the proper evaluation of freshwater diversions, a water quality model, which is based on the CE-QUAL-ICM water quality model code, is coupled to output from a three-dimensional hydrodynamic model of the region, which is based on the CH3D hydrodynamic model (Dorth et al 2007). The version of CH3D with sigma coordinate in the vertical dimension is being used. The model grid extends seaward beyond the Chandeleur Island and includes Mobile Bay, Lake Borge, Lake Pontchartrain, the Inner Harbor Navigation Channel of New Orleans and the Mississippi river Gulf Outlet Channel. Predicted water quality constituents, including nutrients, phytoplankton, dissolved oxygen, temperature, salinity, and underwater light intensity, were evaluated for several scenarios and compared to modeled existing baseline conditions to assess relative changes.

The water quality model was applied for three alternative scenarios: (1) diversion of freshwater flow from the Mississippi River at Bonnet Carre' spillway, (2) diversion of freshwater flow from the Mississippi River at Violet Marsh, and (3) diversion of all of the Escatawpa River flow into Grand Bay. The Bonnet Carre' diversion varied by month while the Violet Marsh diversion was a constant flow of 7,500 cubic feet per second. The Escatawpa diversion is the flow that occurred in the Escatawpa River during 1998, and those values were varied daily in the model. The water quality model was applied for the period April through September 1998 using the same inputs as the final calibration run except for different hydrodynamics and different boundary conditions for the diverted flow and associated concentrations of the flow. The hydrologic model was run with the same conditions as used for the base conditions used in the water quality model calibrations for 1998 except that the additional freshwater flows were introduced.

In an effort to apply this water quality data to ecological issues, MsCIP and ERDC convened a panel of representatives from TNC, MDMR, and USM at the Gulf Coast Research Laboratory. The aim of the panel is to suggest simplistic ecological models that can be incorporated with projections from the combined hydrodynamic and water quality models to identify simulations which might result in an improvement in oyster habitat quality. The panel has identified several key attributes that need to be incorporated into the evaluation of freshwater diversion options. The first is that salinities average as closely as possible to the optimal range for oyster health and productivity. This is clearly of critical importance since the primary purpose for contemplating freshwater diversions is to improve habitat conditions for oysters. Second, a diversion should not result in extended periods of low salinity resulting in mortality or poor growth and reproduction. This consideration is particularly critical during times of high river flow or other extreme conditions. Third, a diversion should not unduly influence habitat conditions for other critical resources. Diversions that result in favorable conditions for oyster health may not be conducive to other equally important resources. For instance, most seagrasses do poorly at salinities less than 20 ppt. A diversion that results in excellent conditions over the prime commercial beds but drives salinities below 20 ppt in the seagrass elsewhere would not be acceptable. Other important habitat requirements that should also be considered for seagrass health include light availability and nutrient concentrations. These environmental concerns associated with water diversions, in addition to potential impacts on important fisheries species of those areas, require conservative actions and more study of potential impacts (positive and negative) of such practices for the long-term sustainability of nearshore and estuarine resources.

As an example, the results from a simulated diversion of 7,500 cubic feet per second of Mississippi River water near Violet, Louisiana is presented in Figure 17. The results suggest that 180 days after initiation of the diversion salinities were lowered in western Mississippi Sound. Dortch et al. (2007) sufficiently warrant additional examination. However, at present, absolute salinity values predicted by the model poorly match calibration data. Further refinement of the models should correct this limitation and must be made to allow the usefulness of the model results for estimating potential beneficial or deleterious effects on oysters and other coastal resources.

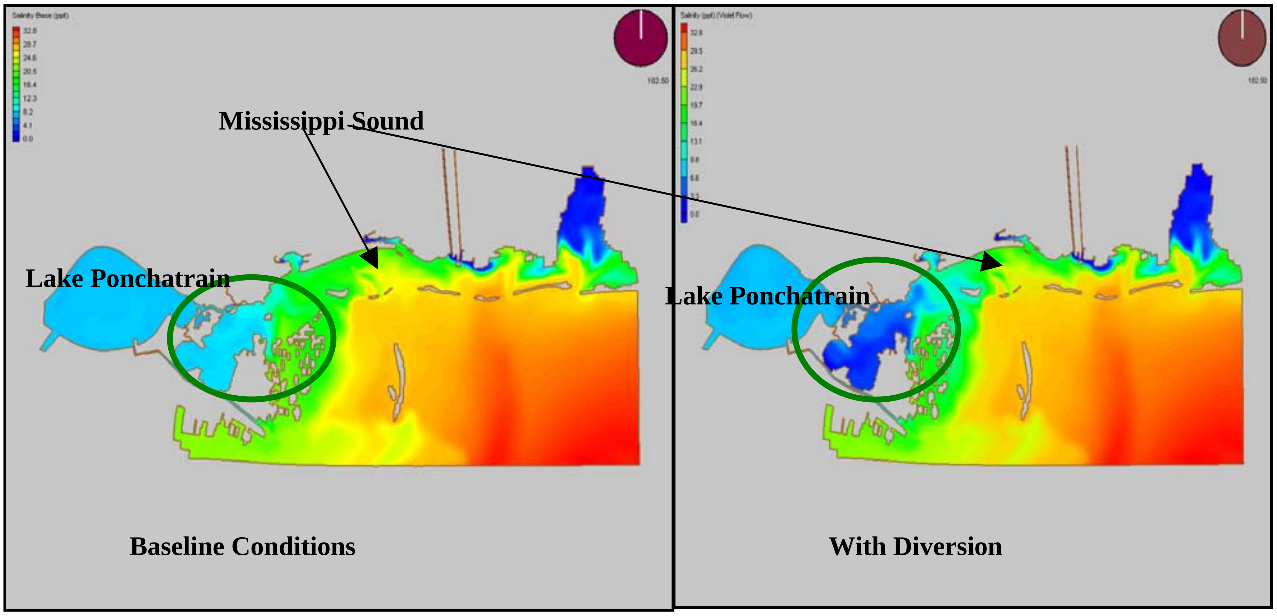


Figure 17. Projected Salinity Values 180 days after initiation of a diversion of 7,500 cfs of Mississippi River water at Violet, LA Simulated Diversion of Mississippi River into Lake Borgne Near Violet, Louisiana

Results also showed that diversion through the Bonnet Carre and through the Escatawpa/Grand Bay system have the potential to significantly influence coastal salinities. The more freshwater (i.e. 0 to about 20 ppt) areas are designated with blue and green colors while more saline (i.e. 20 to 33 ppt) conditions are designated with yellow, orange and red colors.

Ongoing and future studies can be used to refine the hydrodynamic and water quality model and tighten the calibrations. This will allow for better integrating the water quality results to ecological concepts. Also, this preliminary effort just developed information for some possible discharge scenarios in order to do a sensitivity analysis as to whether diversion could potentially affect the areas of concern. These efforts showed the potential for freshening the systems. Future studies and model runs will need to be performed to test precise operational discharge plans and seasonal influences.

Historically, the estuarine marsh within the Grand Bay NERR represented the former deltaic environments of the Pascagoula and Escatawpa Rivers in eastern Jackson County. The outlets of these rivers have shifted westward over time, severely limiting the inflow of freshwater, nutrients, and sediments into the Bayou Cumbust area of the reserve.

Currently, it is speculated that much of the freshwater entering the Grand Bay NERR estuary is from surface runoff through Bayou Heron and Bayou Heron, within the Bangs Lake Hydraulic Unit, measuring approximately 21,374 acres. Human disturbances to the area have also altered historic sheet flow and surface water flows into the area, as well as the natural migration of the Pascagoula and Escatawpa Rivers. A freshwater diversion project in the area, if feasible, may serve to enhance the wildlife resources of the area. The need for freshwater diversion at the Grand Bay savannahs and marshes would help restore the predominant wet pine savannah habitat. Shoreline erosion along the Grand Bay area (i.e. loss of the Grand Batture Islands) has also contributed to the increased salinity in the area.

The proposed project will seek to develop a refined hydrodynamic model for the area, inputting biological, water quality, and physical data into the model to evaluate a variety of freshwater diversion scenarios. This work represents a critical first step in the final assessment of potential water diversion projects for this area. Community information will be solicited and a public workshop will be held to share the results.

Diversion of Mississippi River freshwater and/or sediments in the vicinity of Violet, Louisiana has been strongly considered because of a number of positive factors. These include proximity of the river to target coastal wetlands restoration areas, strong public support, and high confidence in potential environmental benefits. The Violet Diversion Project is under consideration by the MsCIP (Corps, Mobile District) and Corps, New Orleans District as a freshwater diversion project that could potentially have a positive impact to the Hancock County Marshes. Preliminary results from modeling a simulated diversion of 7,500 cubic feet per second of Mississippi River water near Violet, Louisiana, suggest that after 180 days of initiation of the diversion, salinities were lowered in Western Mississippi Sound sufficiently to warrant additional examination (Dortch et al 2007). Further refinement of the models should address current limitations and must be made to estimate potential beneficial or deleterious effects on oysters, seagrasses, marsh systems, and other coastal resources. Although the idea is viable, at this point, additional information is needed to determine current problems within Hancock County Marshes and potential impacts to existing coastal resources as well as navigational impacts.

9.4.2 Environmental Restoration of Historical Wetland Sites

The Corps, Mobile District began investigations for identifying potential environmental restoration sites for the purposes of storm and flood damage reduction, flood reduction, preservation of fish and wildlife habitat, and removal of habitable structures within high hazard areas. When residential and/or commercial structures and/or land are purchased for the purpose of restoring floodplain areas (i.e. non-structural component), the structures are demolished and the land is no longer available for residential and/or commercial development. Historically, when land is purchased across the U.S., it is left with all or some of the infrastructure at the site rather than restoring it to its historic setting. With the MsCIP environmental plan, land that is purchased (i.e. non-structural component – refer to Non-structural Appendix) would then be restored into historical functional wetlands. The Corps, Mobile District, in cooperation with ERDC, developed a tool to help identify potential restoration sites throughout the study area.

Development of a GIS based SDSS tool allowed the Corps, Mobile District, working in cooperation with the USFWS and MDMR, to identify and prioritize potential wetland restoration areas throughout coastal Mississippi (Lin 2007). A detailed discussion of this GIS based SDSS tool is included in the Environmental Appendix. A subset of potential restoration sites were identified by the SDSS tool and then ground-truthed by the MsCIP environmental team, including ERDC, Corps, MDMR, and USFWS. This interagency team allowed us to both confirm the accuracy of the SDSS results and to collect additional on-site information pertinent to restoration efforts. There are some major benefits in using a GIS-based SDSS approach to wetland restoration. First, it allows for the relatively rapid assessment of the large number of restoration sites across the wide study area. Second, potential sites can be evaluated and restored in a watershed or landscape context, which allows us to comprehensively evaluate the overall natural system. This approach can maximize the benefits of wetland restoration, as opposed to simply restoring wetlands where convenient or where property is available. Essentially use of this SDSS tool allowed the MsCIP environmental team to assess the entire coastline as a holistic natural system; thus, the team was more effectively able to analyze needs in coastal Mississippi.

The SDSS effort resulted in the following products:

1) A Model Builder based SDSS tool, which can be subsequently edited and applied to other areas along coastal Mississippi in the future as funding becomes available;

2) Maps, such as aerial photography, topographic, soil layers, etc., depicting areas in the study region that have a high probability of being successfully restored into wetland functions that buffer and/or store stormwater, and provide suitable habitat for fish and wildlife;

3) Photograph documentation and data sheets containing information on ground-truthed potential restoration sites.

This project has been further coordinated with the ongoing efforts of the MsCIP non-structural flood-proofing committee, and their results were used as the team identified potential restorations sites in coastal Mississippi. The selection of 34 restoration sites, discussed in detail in Section *4.1.5.2 Environmental Restoration of Historical Wetland Sites* of the Environmental Appendix, was based on a combination of results from the SDSS tool and input from MDMR personnel based on local knowledge of the study area and adjacency to existing sensitive protected natural areas (i.e. State and/or Federal lands).

The SDSS tool evaluated potential wetland restoration sites that had been initially selected based on having a non-natural land cover (i.e. urban, deforested, and agricultural land cover, based on MDMR 2001 land cover GIS layer) and were located in the 100-year floodplain (Lin 2007). Numerous potential environmental restorations sites were initially identified. This initial group of sites was narrowed down based on the results of the SDSS. Sites with the following characteristics were screened out:

- < 5 acres in size
- Restorability class of Low or Medium Low
- Habitat class of Low or Medium Low
- Storm Surge/Flood Protection class of Low

Initial screening yielded hundreds of sites that were then reviewed by the Corps, Mobile District, MDMR, and USFWS personnel. A more detailed discussion of the initial sites yielded is located in the Environmental Appendix. Following detailed assessment, the Environmental PDT screened these sites and selected the following 34 final restoration sites. These final environmental restoration sites include a combination of those identified based on the SDSS results, as well as some additional sites. These were made using only the non-natural land-use and 100-year flood calculations as the original site selectors (i.e. no damage layers were used), and sites were greater than or equal to 5 acres (Table 29).

Table 29.

Environmental Restoration Sites in Coastal Mississippi

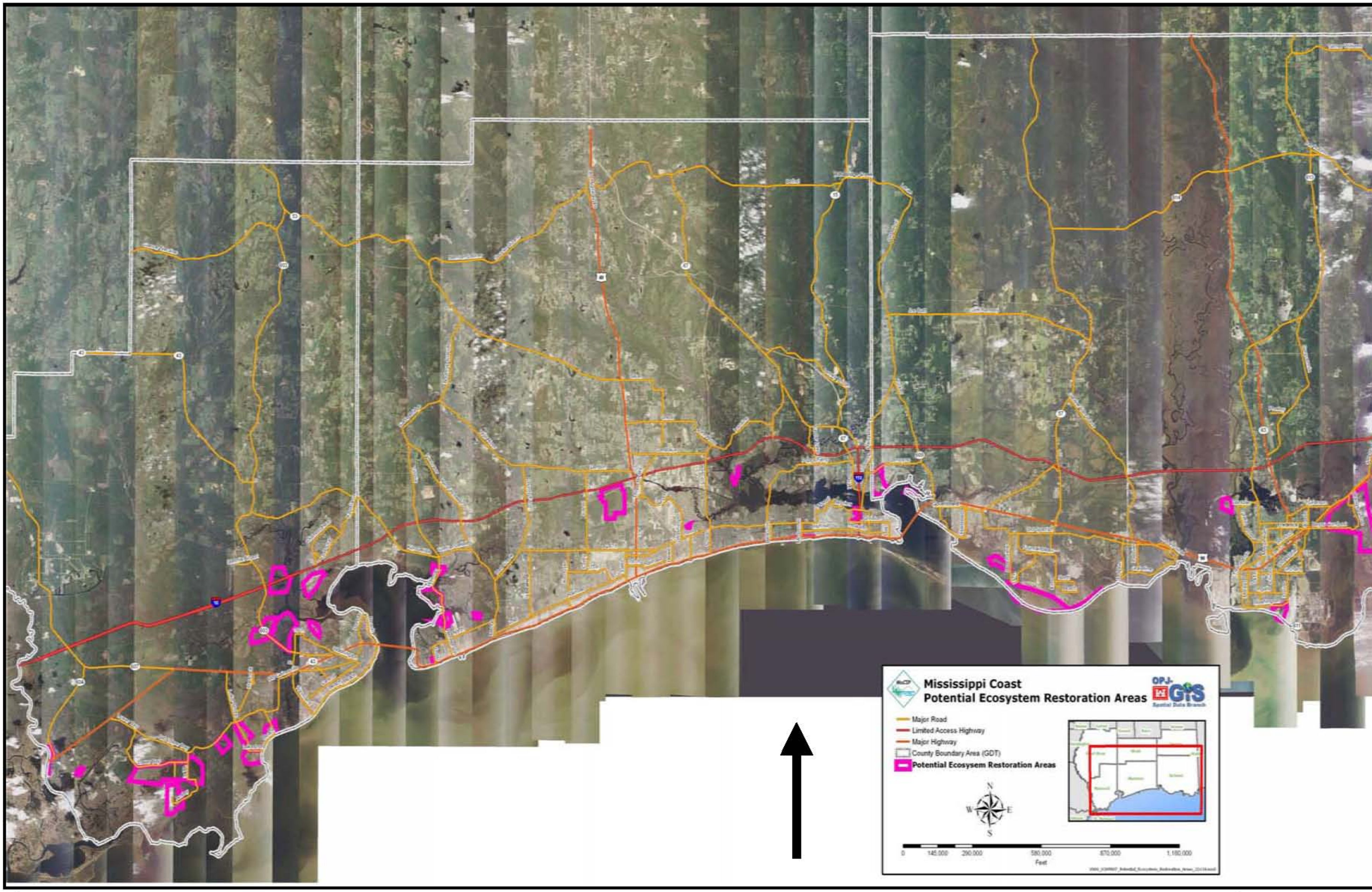
Site	Restoration Acres	Environmental Setting
(1) Pearlington, Hancock	76 acres (State owns 2,200 acres in the Pearlington area)	Emergent aquatic vegetation Bayhead Swamps trees Bayhead Swamps shrubs Riverine/levee forests

Site	Restoration Acres	Environmental Setting
(2) Pearlington South, Hancock	11 acres	Emergent aquatic vegetation Bayhead Swamps trees Bayhead Swamps shrubs Riverine/levee forests
(3) Port /West, Hancock	49 acres	Emergent aquatic vegetation
(4) Ansley, Hancock	2,023 acres (State owns 6,000 acres west of Lakeshore Road)	Emergent aquatic vegetation Wet pine savannah
(7) Lakeshore, Hancock	275 acres	Emergent aquatic vegetation
(8) Bayou Caddy/Lakeshore, Hancock	362 acres	Emergent aquatic vegetation
(9) Clermont Harbor, Hancock	209 acres	Emergent aquatic vegetation
(10) Bayou La Croix, Hancock	259 acres	Emergent aquatic vegetation
(11) Shoreline Park, Hancock	889 acres	Emergent aquatic vegetation
(12) Chapman Road, Hancock	146 acres	Emergent aquatic vegetation
(13) Jourdan River – Interstate 10 Development, Hancock	638 acres	Emergent aquatic vegetation
(14) Diamondhead, Hancock	433 acres	Emergent aquatic vegetation
(15) Delisle, Harrison	120 acres (State owns 1,000 acres)	Emergent aquatic vegetation Bayhead swamps trees Bayhead Swamps shrubs
(16) Ellis Property, Harrison	443 acres	Emergent aquatic vegetation Pine savannah - wet pine flatwoods.
(17) Pine Point East, Harrison	103 acres (State owns 40-50 tax forfeited lots)	Emergent aquatic vegetation Wet pine savannah habitat
(18) Pine Point West, Harrison	83 acres (State owns 40-50 tax forfeited lots)	Emergent aquatic vegetation Wet pine savannah habitat
(19) Pass Christian Beach Front, Harrison	21 acres	Emergent aquatic vegetation Bayhead swamps trees Bayhead Swamps shrubs
(20) Pass Christian Site – Bayou Portage, Harrison	43 acres	Emergent aquatic vegetation Bayhead swamps trees Bayhead Swamps shrubs
(21) Brickyard Bayou, Harrison	14 acres	Emergent aquatic vegetation Bayhead swamps trees Bayhead swamps shrubs
(22) Biloxi River – Shorecrest, Harrison	15 acres	Emergent aquatic vegetation Bayhead swamps trees Bayhead swamps shrubs Riverine/levee forests
(23) Biloxi River – Eagle Point, Harrison	17 acres	Emergent aquatic vegetation Bayhead swamps trees Bayhead swamps shrubs Riverine/levee forests
(24) Biloxi Front Beach - South of Highway 90, Harrison	40 acres	Dune System
(25) Keegan Bayou, Harrison	54 acres	Emergent aquatic vegetation Wet Pine Savannah habitat
(26) St. Martin, Jackson	467 acres	Emergent aquatic vegetation
(27) Fort Point, Jackson	83 acres	Emergent aquatic vegetation
(28) Pine Island, Jackson	237 acres	Emergent aquatic vegetation
(29) Belle Fontaine, Jackson	1,516 acres	Dune System
(30) Griffin Point, Jackson	182 acres	Emergent aquatic vegetation
(31) Bayou Chico, Jackson	258 acres	Emergent aquatic vegetation

Site	Restoration Acres	Environmental Setting
(32) Grand Bay/Bayou Cumbest, Jackson	2,666 acres	Emergent aquatic vegetation
(33) Wachovia, Hancock	1,200 acres total – 800 marsh, 200 forested, 200 savannah	Emergent aquatic vegetation, Bayhead Swamps trees Bayhead Swamps shrubs Riverine/levee forests
(34) Ansley, Hancock	900 acres – 800 marsh, 100 forested	Emergent aquatic vegetation, Wet pine savannah
(35) LaFrancis Camp Trenaisse, Hancock	45 acres total – all open water	Open Water
(36) DuPont, Harrison	650 acres – 170 marsh, 480 forested	Emergent aquatic vegetation, Bayhead Swamps trees Bayhead Swamps shrubs Riverine/levee forests
(37) Danztler, Jackson (Alternate)	900 acres – 500 marsh, 385 forested	Emergent aquatic vegetation, Bayhead Swamps trees Bayhead Swamps shrubs Riverine/levee forests
(38) Pascagoula River Marsh, Jackson	11,150 acres	Emergent aquatic vegetation, Bayhead Swamps trees Bayhead Swamps shrubs Riverine/levee forests

This project has been further coordinated with the ongoing efforts of the MsCIP non-structural flood-proofing committee, and their results were used as the team identified potential restorations sites in coastal Mississippi. The following selection of 38 restoration sites was based on a combination of results from the SDSS tool and input from MDMR personnel based on local knowledge of the study area and adjacency to existing sensitive protected natural areas (i.e. State and/or Federal lands). See Figure 18 for the specific identified environmental restoration sites.

Figure 18 Potential Ecosystem Restoration Site



9.4.3 Submerged Aquatic Vegetation

The continued survival and growth of seagrasses (i.e. SAVs) may be threatened by the cumulative effects of man's activities, in addition to, natural processes in the coastal marine environment. Natural causes of SAV (i.e. *D. wrightii, C. manatorum, T. testudinum*, and *R. maritime*) decline, such as disease, storm events, salinity fluctuation, and hypoxic events, coupled with declining water quality caused by anthropogenic eutrophication currently threaten the health of many SAV systems (Montague and Ley 1993, Durako and Kuss 1994, Olesen and Sand-Jensen 1994, Zieman et al 1994). These habitats provide vital refuges, feeding, resting, staging, and spawning grounds for a variety of species found in Mississippi Sound and also in the Gulf of Mexico. Past studies throughout the years have attributed anywhere from 50% to 90% of all marine species to utilize this vital habitat at some point in their life state.

In 1969, an estimated 20,000 acres of SAVs were documented and as of 1998, only 2000 acres were documented (Moncrieff 1998), see Table 30. Dramatic decreases have been noted on every Mississippi barrier island. Areas of SAV habitat loss coincide with areas where rapid coastal erosion and massive long-term movement of sand has been well-documented (Otvos 1981 and Oivanki 1994). Loss of vegetated areas corresponds with potential loss in water clarity over time due either to: (1) anthropogenic influences, (2) cyclic shifts in precipitation patterns, which would affect both salinity and turbidity, or (3) a combination of these factors (Moncrieff 1998). Primary reasons for the disappearance of SAVs are most likely an overall decline in water quality, extended periods of depressed salinities, and physical disturbances, such as tropical storms and hurricanes (Moncrieff 1998). Physical loss of habitat and decreased light availability coupled with declining water quality are the most visible features that directly affect SAVs (Moncrieff 1998). Moncrieff (1998) identified approximately 14,900 acres as being suitable SAV habitat [i.e. Potential Seagrass Habitat (PSGH)].

Table 30.

SAV Historical, 1992 and Potential Habitat

Location	1969 (acres)	1992 (acres)	PSGH
Buccaneer State Park	206	55	316
Cat Island	598	169	5,128
Ship Island	1,536	253	1,603
Dog Keys Pass	2,079	0	1,149
Horn Island	5,567	530	4,350
Petit Bois Island	1,690	364	1,810
Point-aux-Chenes Bay	1,306	627	534
Totals	12,982	1,998	14,890

Reference: Moncrieff 1998

Areas of SAV habitat loss coincide with areas where rapid coastal erosion and massive long-term movement of sand has been well-documented (Otvos 1981 and Oivanki 1994). Loss of vegetated areas corresponds with potential loss in water clarity over time due either to: (1) anthropogenic influences, (2) cyclic shifts in precipitation patterns, which would affect both salinity and turbidity, or (3) a combination of these factors (Moncrieff 1998). Primary reasons for the disappearance of SAVs are most likely an overall decline in water quality, extended periods of depressed salinities, and physical disturbances, such as tropical storms and hurricanes (Moncrieff 1998). Physical loss of habitat and decreased light availability coupled with declining water quality are the most visible features that directly affect SAVs (Moncrieff 1998). Moncrieff (1998) identified approximately 14,900 acres as being suitable SAV habitat (i.e. PSGH).

Mapping techniques have very much advanced since Moncrieff's last mapping of Mississippi Sound in the late 1990s. In discussing a potential SAV restoration project with the scientific community, the one consistent need was to re-inventory the existing SAVs in Mississippi Sound. Mississippi Sound and barrier island sedimentary processes as related to seagrass biomes are important, but not currently available. The nature, extent and volumes of sediment types within both Mississippi Sound and the barrier islands are constantly in flux, necessitating a comprehensive and ongoing assessment of sedimentary dynamics. Further studies would determine existing conditions and remaining problems that challenge establishment of SAVs within Mississippi Sound. Opportunities exist to create partnerships with other Federal and state resource agencies, and NGOs to begin identifying potential SAV restoration and establishment projects. Restoration efforts should target historical locations as a starting point to begin determining current conditions and challenges, including water quality issues, available nursery stock of plants, etc., prior to implementation of actual projects.

9.4.4 Deer Island Ecosystem Restoration

Deer Island, located within the boundaries of Harrison County, Mississippi near the mouth of Biloxi Bay and the City of Biloxi, has a history of tropical storm damage. Damages from these storms has varied based on varying degrees of storm surge, wave action and wind depending on the speed, intensity, direction of travel, and proximity of the given storm. Figure 19 displays a recent aerial photograph of Deer Island, which damage was acerbated during Hurricane Katrina.

Figure 19 Deer Island Aerial Photograph

The island is considered a mainland remnant and is not part of the coastal barrier system of islands along the Mississippi Coast. The island contains a diversity of habitat areas including beach/dune areas, marsh area, and maritime forest areas. It's proximity to the City of Biloxi provides a certain amount of protection to the city from waves generated by approaching hurricanes. This protection comes at a cost to the island as that energy affects the seaward shoreline and the interior marshes. It has been estimated that the island has lost approximately 300 acres or about 34 percent of its area since 1850, due to eroding shoreline.

In 2003, because of loss of wetland marsh areas, an aquatic restoration project was proposed near the eastern tip of Deer Island. The project was authorized under the continuing authority of Section 204 of the Water Resources Development Act of 1992, as amended. Dredged material from maintenance of Biloxi Harbor was used to create approximately 45 acres of tidal marsh on the north shore of the east end of the island. Wetland vegetation was planted by over 100 volunteers in April 2005. The created marsh area withstood Hurricane Katrina with minor scouring within the site but with a minor breach of the containment dike of the marsh area. Plants within the marsh area are thriving. Figure 20 displays the existing Section 204 project.

Figure 20. Existing Section 204 Project

Currently, the island has a large breach on its western end and a small breach has formed in the central area of the island in what is known as the Grand Bayou area. As the island degrades, the federally authorized shallow draft Biloxi West Approach and Biloxi Lateral navigation channels that run between the City of Biloxi and Deer Island will experience increased shoaling and will require more frequent, and costly, maintenance dredging activities. Dredging frequency in this area is typically as much as half the frequency of similar nearby channels. Deer Island also provides erosion protection to the mainland of the City of Biloxi. As the island continues to degrade, the impacts of increased wave action on the mainland shoreline will increase the amount of storm damages that can be suffered by commercial development congregated in this area. Figure 21 displays the general location of the west end breach and the Grand Bayou area.

In summary, there is a need to restore the shoreline of Deer Island, fill the breach areas, repair/improve existing marsh and maritime forest areas, and add additional marsh area. These efforts will provide protection to the mainland areas behind the island and improve critical coastal wetlands.

Figure 21. Areas of Concern

There are a number of possible solutions that can be implemented to provide improvements on Deer Island. Restoration of the seaward shoreline is needed with filled areas graded and planted to establish/restore marshes and maritime forest areas. Restoration of the created marsh at the eastern end of Deer Island is needed to preserve, maintain, and enhance the aquatic habitat established by that project. Listed below, in order of precedence, are the proposed actions and their approximate cost:

Because of the shoreline losses and concern about the breaches and the resulting loss of area, following Hurricane Katrina, Federal authorization and funds were provided to restore the lost seaward shoreline and fill the breaches. That project, scheduled to begin construction in early 2008, will provide for ecosystem restoration as well as preservation of critical coastal wetlands by restoring portions of the island and its shoreline lost during storm events. However, funding for this effort is not adequate to completely restore the entire seaward shoreline. The estimated cost to completely restore the seaward shoreline of Deer Island is about $4,750,000.

Repair/replace the damaged portion of the containment dike: The small failure area of the containment dike during Hurricane Katrina contributed to the loss of material within the site. Repair or replacement of this portion of the containment dike is necessary to restore the marsh area to its pre-Katrina level and would prevent further loss of marsh area. The estimated cost to repair/replace this portion of the containment dike is about $200,000.

Add/replace material in the containment area: New material is needed to restore the marsh area to its pre-Katrina level. This additional material will replace that which has been lost and will also be used to raise marsh areas that had through consolidation had become too low to sustain marsh habitat. The estimated cost to add this material is estimated to be about $600,000.

Analyze new stone training dikes on the north and south ends of the island: Initially, short training dikes were constructed on the eastern side of the Section 204 project. These dikes were to protect the containment dikes from erosive forces within the Mississippi Sound. Review of the failure of the containment dike suggests that the shortness of the training dikes may have contributed to the failure. A modeling analysis of the training dikes needs to be conducted to insure that the dikes are long enough to prevent future failures. The estimated cost to conduct this analysis is about $50,000.

Lengthen stone containment dikes on north and south ends: Lengthening the stone containment dikes may be necessary to reduce/eliminate the reoccurrence of failure of the containment dike. The modeling noted above will help in this determination. The estimated cost to lengthen the stone containment dikes is about $1,000,000.

Create additional marsh area adjacent to existing created marsh: The existing created marsh area and that which will be restored with the shoreline restoration project help to replace marsh areas that have been lost over time on Deer Island. The creation of additional marsh area will help to offset losses that have occurred and will enhance aquatic habitat on the island. The existing created marsh successfully demonstrates the durability of the design of the marsh area as well as the selection of the site for the creation of the marsh. The project proved its ability to withstand a fairly strong hurricane event during Hurricane Katrina. An additional marsh area can be created adjacent to the west side of the existing created marsh. The created marsh area will be about 20 acres in size and is estimated to cost about $2,400,000.

The total estimated cost for the proposed work items totals $9,000,000. Figure 22 displays the location of the proposed work items 2 through 6.

Figure 22. Location of Proposed Work Items

9.5 Evaluation of Measures – Formulation Round Three

Evaluation of measures carried forward into Round Three focused on the results of the final refinement of modeling results and technical analyses on each final measure or alternative. The study team then discussed their final evaluations as a group to arrive at consensus as to what alternatives would be compared in the System of Accounts analysis. This final evaluation process involved the determination of final surge and wave heights for a given event frequency, surge behavior under these same events, costs required for those structural and non-structural designs or lists of features applying to a certain design level, final determination of damage reduction benefits derived for a certain design, potential societal and other OSE benefits and outcomes fort each plan, or the benefit over time to a particular ecosystem created by a particular measure. Table 31 shows the results of the final evaluation of measures to be carried over into the System of Accounts analysis.

Measure	Tidal Habitat Restored	Tidal Habitat Lost	Non-Tidal Habitat Restored	Non-Tidal Habitat Lost	Damages Reduced / Avoided	Residual Damages	Cost to Implement Plan	Local Cost Burdens	Regional Economic Benefits	Cultural and Historical Heritage	Public Service Disruptions	Personal Impacts	Long-Term Sustainability	Consequences of Plan Failing	Residual Risk
	(Acres)	(Acres)	(Acres)	(Acres)	($)	($)	($)	(1-10)	(1-10)	(1-10)	(1-10)	(1-10)	(1-10)	(1-10)	(1-10)
Barrier Island No Action	0	4058	0	2705	$-	$426,040,000	$ -	10	1	1	1	1	1	2	1
Barrier Island Option A	644	0	2036	0	$ -	$426,040,000	$ 942,200,000	4	5	5	3	3	6	5	5
Barrier Island Option B	1029	0	686	0	$ -	$426,040,000	$ 1,013,800,000	3	5	4	2	3	4	3	4
Barrier Island Option C1 & C2	326	0	217	0	$ -	$426,040,000	$ 232,900,000	7	2	6	2	3	5	4	5
Barrier Island Option D	0	0	820	0	$ -	$426,040,000	$ 14,200,000	9	1	5	2	3	1	2	3
Barrier Island Option E	0	0	907	0	$ -	$426,040,000	$ 39,200,000	8	1	6	2	3	1	3	3
Barrier Island Option F	4400	4058	0	2705	$ -	$426,040,000	$ 264,500,000	3	2	2	2	3	1	2	3
Barrier Island Option G	130	1227	477	2453	$ -	$426,040,000	$ 114,100,000	5	1	7	2	3	3	4	3
Barrier Island Comp Plan	456	0	694	0	$ -	$426,040,000	$ 347,902,000	5	2	8	3	3	6	6	6
LOD2 No Action	0	0	0	0	$ -	$426,040,000	$ -	10	1	3	1	1	2	2	2
LOD2 Option I	0	0	351	0	$ -	$426,040,000	$ 63,880,000	3	2	4	2	2	4	5	2
LOD2 Option J	0	0	351	0	$ -	$426,040,000	$ 65,480,000	4	2	5	3	3	5	4	2
LOD2 Option K	0	0	304	0	$ -	$426,040,000	$ 15,430,000	7	1	6	3	3	7	4	2
Turkey Creek No Action	0	0	0	0	$ -	$ 16,890,000	$ -	10	1	3	1	1	10	10	1
Turkey Creek Ecosystem Plan 1	0	0	879	0	$ -	$ 16,890,000	$ 7,200,000	4	1	6	1	1	5	7	5
Turkey Creek Ecosystem Plan 3	0	0	689	0	$ -	$ 16,890,000	$ 5,900,000	6	1	5	1	1	6	6	4
Turkey Creek Ecosystem Plan 5	0	0	190	0	$ -	$ 16,890,000	$ 2,300,000	8	1	4	1	1	7	5	3
Bayou Cumbest No Action	0	0	0	0	$ -	$ 6,674,000	$ -	10	1	3	1	1	10	10	1
Bayou Cumbest Acquisition	0	0	0	0	$ 459,000	$ 6,674,000	$ 15,500,000	7	1	1	2	2	7	10	5
Bayou Cumbest Ecosystem Plan 1	373	0	0	0	$ 459,000	$ 6,674,000	$ 74,610,000	4	1	1	2	2	6	7	6
Bayou Cumbest Ecosystem Plan 2	373	0	0	0	$ 459,000	$ 6,674,000	$ 58,720,000	5	1	1	2	2	5	7	6
Bayou Cumbest Ecosystem Plan 3	373	0	0	0	$ 459,000	$ 6,674,000	$ 50,830,000	6	1	1	2	2	4	7	6
Bayou Cumbest Ecosystem Plan 6	373	0	0	0	$ 459,000	$ 6,674,000	$ 50,780,000	6	1	1	2	2	4	7	6
Admiral Island No Action	0	0	0	0	$ -	$ 150,860,000	$ -	10	1	2	1	1	10	10	1
Admiral Island Ecosystem Plan 1	118	0	0	0	$ -	$ 150,860,000	$ 42,900,000	4	1	3	1	1	6	7	6
Admiral Island Ecosystem Plan 2	118	0	0	0	$ -	$ 150,860,000	$ 38,400,000	5	1	3	1	1	5	7	6
Admiral Island Ecosystem Plan 3	118	0	0	0	$ -	$ 150,860,000	$ 36,100,000	6	1	3	1	1	4	7	6
Admiral Island Ecosystem Plan 6	118	0	0	0	$ -	$ 150,860,000	$ 36,000,000	6	1	3	1	1	4	7	6
Dantzler No Action	0	0	0	0	$ -	$ 7,130,000	$ -	10	1	3	1	1	10	10	1
Dantzler Ecosystem Plan 1	0	0	385	0	$ -	$ 7,130,000	$ 1,880,000	6	1	6	1	1	5	7	5
Dantzler Ecosystem Plan 3	0	0	151	0	$ -	$ 7,130,000	$ 870,000	7	1	5	1	1	6	6	4
Dantzler Ecosystem Plan 5	0	0	234	0	$ -	$ 7,130,000	$ 1,040,000	8	1	4	1	1	7	5	3
Franklin Creek No Action	0	0	0	0	$ -	$ 7,130,000	$ -	10	1	3	1	1	10	10	1
Franklin Creek Ecosystem Plan 1	0	0	149	0	$ -	$ 7,130,000	$ 1,630,000	6	1	6	1	1	5	7	5
Franklin Creek Ecosystem Plan 3	0	0	56	0	$ -	$ 7,130,000	$ 550,000	7	1	5	1	1	6	6	4
Forrest Heights No Action	0	0	0	0	$ -	$ 816,791	$ -	10	1	3	2	2	10	10	1
Forrest Heights Plan 1	0	0	0	9	$ 331,036	$ 485,755	$ 6,000,000	5	1	8	5	5	6	8	5
Forrest Heights Plan 2	0	0	0	20	$ 331,508	$ 485,283	$ 9,000,000	5	1	9	6	6	5	9	6
Nonstructural No Action	0	0	0	0	$ -	$426,040,000	$ -	10	1	3	2	2	10	10	1
Long-term Homeowners Assistance and Relocations Plan	0	0	0	0	$ 209,665,350	$ 216,374,650	$ 7,999,019,430	2	6	3	6	8	5	9	9
Very High Risk Homeowners Assistance and Relocations Plan	0	0	0	0	$ 22,380,000	$ 403,660,000	$ 482,000,000	6	3	5	5	5	8	9	7

Table 31 Evaluation Results of Final Plans

9.6 Comparison of Measures – Formulation Round Three

Comparison of Round Three measures consisted of presentation of conditions and potential change in conditions, under “No-Action”, future “without-project”, and future “with-project” conditions for each site or problem area, in both a descriptive presentation, and also in a “System of Accounts” comparison format. Data presented for comparison in Round Three included revised costs, benefits (monetary, or economic, environmental outputs, societal, etc.) to be derived from measure implementation, potential impacts related to implementation, detailed design considerations, environmental outputs, damages prevented, geotechnical/site considerations, more detailed technical requirements, source material and source area considerations, and other technical, environmental, or economic issues. The “System of Accounts” analysis presents information in four separate “accounts” or categories for comparison, that include “National Economic Development” (NED), which in this case only compares and contrasts the cost-effectiveness of each group of alternatives, “Regional Economic Development “(RED), which discusses the potential regional impacts of each group of alternatives, Environmental Quality (EQ), which discusses potential positive and negative environmental impacts of each group of alternatives and their environmental quality implications, and Other Social Effects (OSE) evaluations, which discusses and contrasts the potential social, and other effects of each group of alternatives.

The alternatives were also compared and contrasted according to their achievement of the additional criteria of a) effectiveness; b) completeness; c) acceptability, and d) efficiency (cost-effectiveness) according to applicable Corps guidelines.

In addition to these four traditional accounts, information on potential risks, uncertainties, and consequences, is also presented in System of Accounts format, for comparison at the same level of scrutiny of the information presented in other accounts.

After the weighting of the metrics, a multi-criteria decision analysis was made to obtain a multi-attribute utility or stakeholder risk score for each of the final plans. This number rates each alternative as a percentage of a theoretical “perfect plan” (in the eyes of the stakeholder groups). In other words, the higher the percentage, the more acceptable the alternative should be to that stakeholder group.

The stakeholder risk scores presented in the system of accounts help to identify plans that meet stakeholder expectations. The results of the metric weighting analysis identified four distinct stakeholder groups, each clearly showing which accounts are more important to them. Therefore, the “perfect plan” would show high scores from each of the cluster groups, as well as rate well in the other accounts. Table 32 summarizes how the stakeholder risk scores vary for each alternative by each cluster group.

Table 32.

System of Accounts table for Nonstructural Alternatives

	Preference Pattern			
Location	**A**	**B**	**C**	**D**
Barrier Islands	Barrier Island Comp Plan	Barrier Island Comp Plan	Barrier Island Option A	Barrier Island Option A
LOD2	LOD2 Option K	LOD2 Option K	LOD2 Option K	LOD2 Option K
Turkey Creek	Turkey Creek No Action	Turkey Creek No Action	Turkey Creek No Action	Turkey Creek Ecosystem Plan 1
Bayou Cumbest	Bayou Cumbest Acquisition	Bayou Cumbest Acquisition	Bayou Cumbest Acquisition	Bayou Cumbest Ecosystem Plan 1
Admiral Island	Admiral Island No Action	Admiral Island No Action	Admiral Island No Action	Admiral Island Ecosystem Plan 1
Dantzler	Dantzler No Action	Dantzler No Action	Dantzler No Action	Dantzler Ecosystem Plan 1
Franklin Creek	Franklin Creek No Action	Franklin Creek No Action	Franklin Creek No Action	Franklin Creek Ecosystem Plan 1
Forrest Heights	Forrest Heights Plan 2	Forrest Heights Plan 2	Forrest Heights No Action	Forrest Heights No Action
Non-Structural	Phase I High Hazard Area Risk Reduction Plan	Long-term High Hazard Area Risk Reduction Plan	Phase I High Hazard Area Risk Reduction Plan	Long-term High Hazard Area Risk Reduction Plan

The full set of system of accounts evaluation tables are presented in the Main Report. A detailed discussion of the development of stakeholder risk scores, including an example system of account evaluation table is presented in the Risk Appendix.

10 SELECTION OF RECOMMENDED MEASURES, PLANS AND ACTIVITIES

Members of the public, agencies, and local decision-makers, weighed in on the final list of alternative plans. Those plans identified by the "best-buy" analysis as possessing Federal interest in implementation, and passing all screening criteria, fell into one of these categories:

a) Inclusion as a project recommended for Construction Authorization;
b) Inclusion as a project requiring additional preconstruction engineering design (PED) for specific features (i.e. a long-term solution that needs more technical analyses based on the complexity of the system);
c) Inclusion as project(s) under a Programmatic Plan Authorization;
d) Inclusion as a project requiring additional Feasibility Studies Authorization (i.e. requiring extensive evaluation); and
e) Inclusion as a project requiring Advanced Design Studies for Innovative Concepts Authorization.

10.1 Projects Recommended for Construction Authorization

Eight (8) potential restoration sites (Barrier Islands, Deer Island, Turkey Creek, Bayou Cumbest, Franklin Creek, Admiral Island, Dantzler, and Bayou Cumbest SAV), and two flood damage reduction areas (Forrest Heights and HARP), were chosen as initial projects to be carried forward in the environmental component of the MsCIP Comprehensive Plan and Integrated Programmatic EIS. The potential restoration sites are located throughout the study area, in each coastal county. Two of the sites consist of restoring emergent tidal marsh habitat, three other sites restore wet pine savannah habitat, and one restores SAVs in Bayou Cumbest, one will restore the barrier islands, and one will complete restoration efforts on Deer Island. These sites allow the Corps, Mobile District to demonstrate the planning process involved in developing environmental restoration measures at each site and county, development of alternatives, and selection of a cost-effective restoration plan for each potential environmental restoration site. If authorized for further study, all other potential ecosystem restoration sites previously identified in this report would go through a similar planning and evaluation process under a Programmatic Authority.

In addition, two pilot projects are recommended. The Moss Point Municipal Structure Relocation Project is a pilot project involving relocating municipal services to higher ground within Moss Point. The information gained from this effort could help other communities in relocating their facilities to reduce the risk from future storm surge. The Waveland Flood Proofing Project is a pilot project involving new methods for elevating structures in the hardest hit areas of Waveland. The information gained from this effort could help other communities in elevating structures using FEMA's new 550 guidelines, thereby reducing their risk from future storm surge. These projects are discussed in more detail below, and are fully developed in the Non-structural Appendix.

10.1.1 Turkey Creek Ecosystem Restoration

This project site is located in north Gulfport, Mississippi, adjacent to U.S. Highway 49, a major north-west thoroughfare, and within the impaired Turkey Creek watershed. The area is becoming increasingly urbanized and development pressures are resulting in increased wetland degradation and loss by direct filling with the incumbent decrease in flood storage capability. The Turkey Creek site is approximately 880 acres of predominately undeveloped land. The site is divided by an east-west running railroad berm and contains a number of dirt road/paths and several miles of drainage ditches. These drainage ditches were constructed in the past in an effort to drain the site and control the drainage across the site into specified areas in hopes of making the site more attractive for development. Approximately 689 acres are south of the existing railway and 190 acres are located north. The railway berm effectively separates the two portions of the site and therefore these areas functions separately. The site is primarily comprised of degraded pine savannah wetland habitat. The elevated railway berm, miles of drainage ditches, and undeveloped fragments the wetland habitat and substantially alters the hydrology of the wetlands located to the north. Hurricane Katrina damages and/or destroyed much of the remaining habitat (wind and salt damage to vegetation as well as salinity increases in the soils from the surge) such that the area has been determined to be incapable of unassisted recovery.

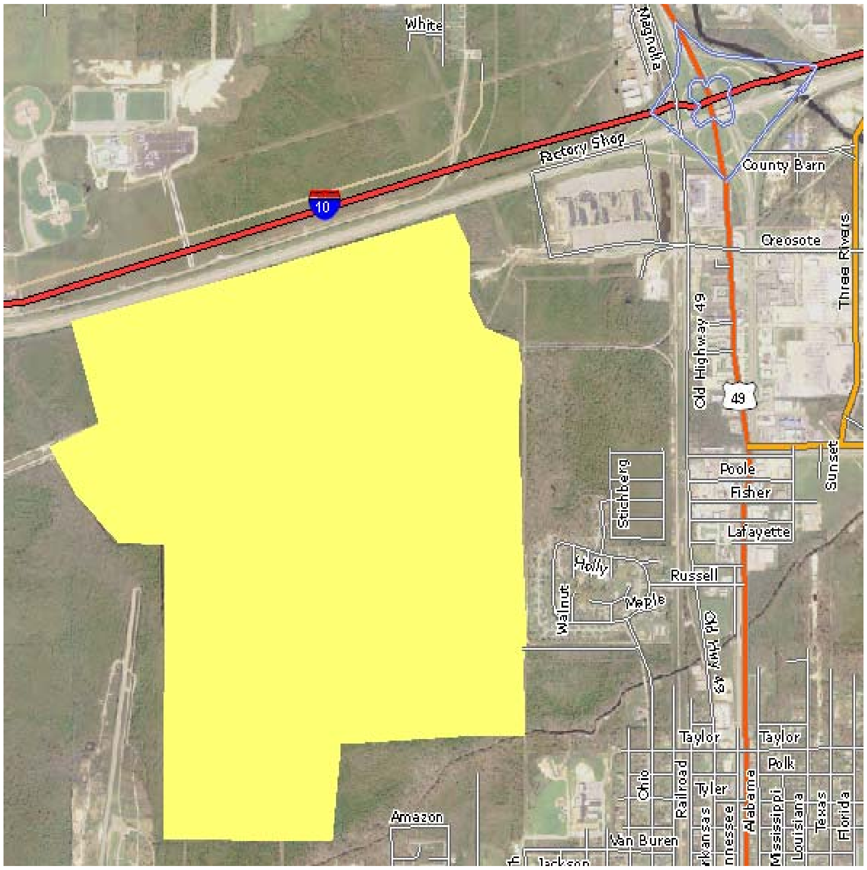


Figure 23. Location of Turkey Creek Restoration area.

Several plans were evaluated in order to determine the most cost-effective plan for restoration. The Turkey Creek site had an HGM assessment performed in 2000, using the *Regional Guidebook for Applying the Hydrogeomorphic Approach to Assessing Wetland Functions of Wet Pine Flats on Mineral Soils in the Atlantic and Gulf Coastal Plains* (Rheinhardt et al 2002). Results from this earlier assessment were used to establish baseline (current) conditions at the site.

The east-west railroad berm effectively divides the site into two distinctive areas for restoration options. These options included evaluating on the basis of addressing the degraded nature of the entire site (879 acres), the northern portion of the site (190 acres), and the southern portion of the site (689 acres). Any restoration option considered would require the acquisition of the specific portion of the site as well as any removal and/or demolition of structures.

Seven plans were developed (including no action) that considered filling in man-made ditches, maintaining native vegetation (by either burning or mowing), and excavating and removing the existing roadbeds and any additional fill placed by man. The economically ineffective plans were identified and eliminated in a cost-effective analysis which can be found in the Economic Appendix. An economically ineffective plan is a plan that costs more or the same as a subsequent plan but produces less benefit than that subsequent plan. Of the seven plans analyzed, three plans were eliminated because they produced less benefit at greater cost than a subsequent plan as shown in Figure 24. All three of the plans eliminated included the use of mowing as a management measure for restoring and/maintaining the wet pine savannah habitat.

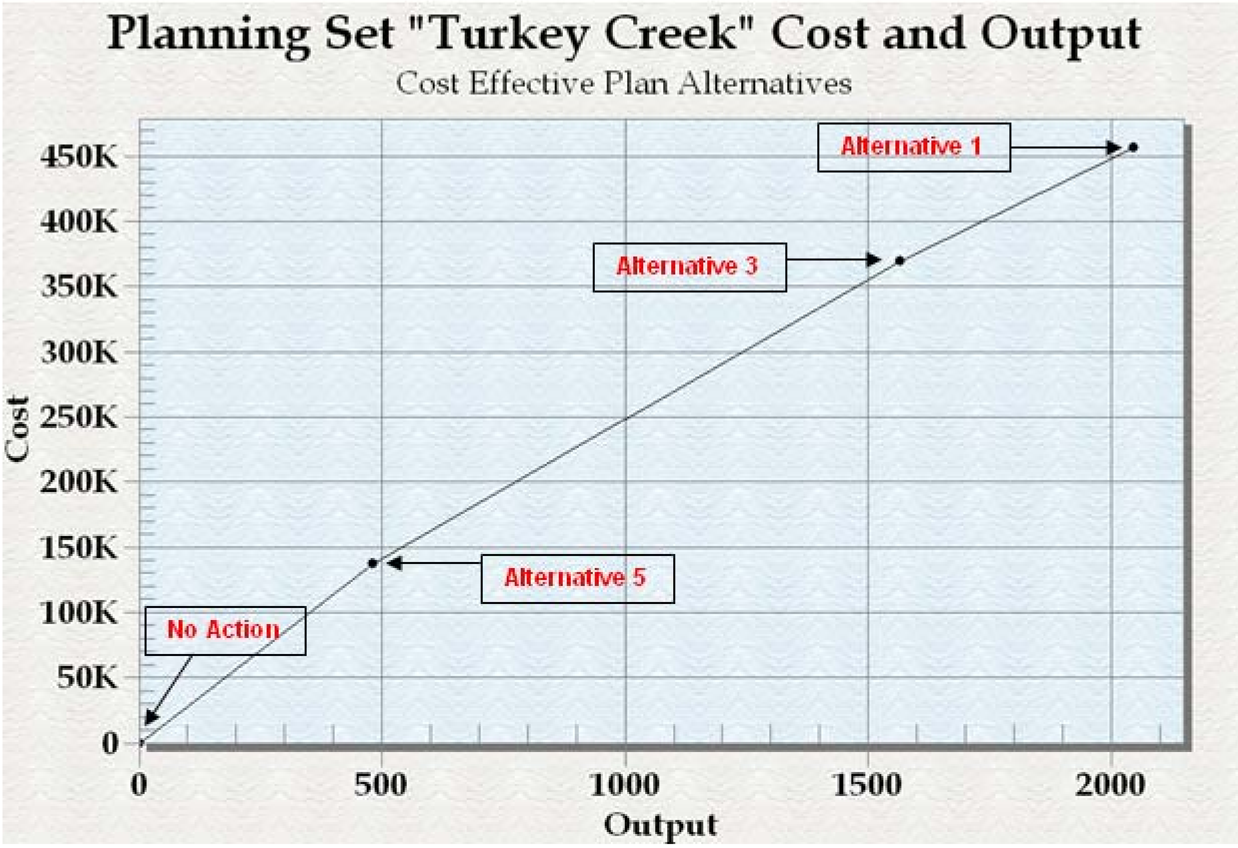


Figure 24. Display of Cost Effective Alternatives for the Turkey Creek Area

Of the three remaining plans, Plan 3 (shown as Alternative 3 above) proved to be the most cost-effective. There is not very much difference in the benefits gained in Plan 1 when compared to extra cost. There is, however, a much bigger difference in benefits for a small amount of cost when comparing Plan 3 with Plan 5, or the No Action Plan.

As shown in the System of Accounts (Table 1.18-3), the major differences between the 4 remaining plans are with the sustainability of the plan, as well as the cost to maintain the site. Again, Plan 3 has a distinct advantage over the larger Plan 1 because of the sheer volume with regards to maintenance, and in sustainability because of getting water to flow through the railroad barrier.

An essential component necessary when selecting the recommended plan at Turkey Creek was the need for burning. Burning allows the wet pine savannah environment to continue naturally as a functioning system. Although mowing does effectively keep understory plants from over colonizing the area, it does not simulate the natural conditions (i.e. seed germination, heating the pine bark, etc.) Therefore, Plan 2 is not as effective as Plans 1 and 3 due to its mowing component. The benefits are also different between Plans 1 and 3, primarily due the acreages. Plan 1 includes both the north and south parcels while Plan 3 included only the south parcel. Also, the man-made barrier within the project site will make it more difficult to maintain the necessary hydrology (water flow) for Plan 1. The MsCIP team took all of these factors into consideration and believes that Plan 3 would do the best job of achieving the desired environmental restoration outputs (i.e. a functioning wet pine savannah) while also being a cost-effective plan.

Plan 3 consists of requires the acquisition of 689 acres of predominately undeveloped land, filling the previously constructed draining ditches, excavating and removing existing roadbeds and any additional fill, and maintaining vegetation growth by burning the project area in the initial year of construction as well as maintaining it by burning every three years over the life of the project as needed. The cost of acquisition of properties and the demolition of structures and restoration work on the site will cost approximately $ 6,840,000, and the average annual cost of operating and maintaining the project is estimated to be $47,000.

10.1.2 Bayou Cumbest Ecosystem Restoration

The Bayou Cumbest site is located in the extreme southeastern portion of Jackson County adjacent to Bayou Cumbest and the Mississippi Sound. The area contains approximately 373 acres to be restored to emergent tidal marsh. The area currently consists of a degraded tidal marsh, as well as filled and developed areas (see Figure 25). Due to the severity of Hurricane Katrina, most of the residential development was severely damaged or destroyed. The area contains low elevations and since most residential structures have been destroyed, the opportunity exists reduce the risk of future hurricane and storm damage and to restore the once existent tidal marsh. Pursing this initial restoration project would relocate residents outside of the low-lying areas and would help demonstrate the environmental recovery of this area of the valuable marsh resource. In addition, this would also provide additional future storm surge protection to the overall coastal area by increasing the natural protection that marsh provides.

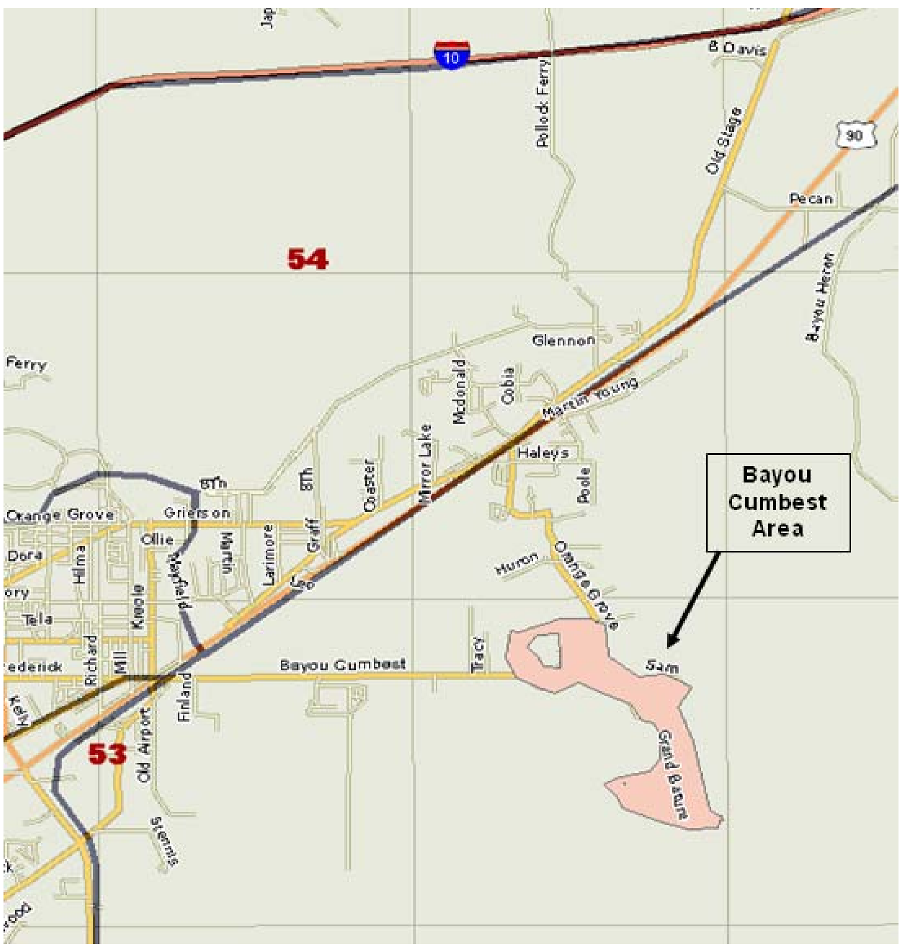


Figure 25 Bayou Cumbest Area

The acquisition of 178 parcels and the removal of 62 structures would be required for all alternatives considered for this area. The acquisition of many, if not, all of the parcels with structures for this area are being considered as part of a Jackson County request to the Mississippi Emergency Management Agency for funding via FEMA Hazard Mitigation Grams Program (HMGP). As part of all of the plans (except the no action plan) considered for this site, the Corps in cooperation with the State and Jackson County would undertake the acquisition of those properties not acquired via the HMGP which would effectively reduce the future risk of damage from hurricane and storm surges. No Ecosystem Restoration would be performed as part of the HMGP, and the 373 acre area would be allowed to remain in a degraded nature, as with the No Action alternative. Alternatives to this option include the implementation of various management measures including excavating old fill material, removing exotic species, filling in existing artificial ditches, and planting native vegetation at various densities ranging from a ½ meter to 2 meter spacing.

These management measures were combined to create seven plans (including no action) that were analyzed to determine the cost-effectiveness of each. The economically ineffective plans were identified and eliminated to determine which plans are cost-effective. An economically ineffective plan is a plan that cost more or the same as a subsequent plan but produces less benefit than that subsequent plan. Of the seven plans analyzed, Plans 4 and 5 were eliminated because they produced less benefit at greater cost than a subsequent plan. These plans lack the aspect associated with filling the artificial ditches and with native vegetation at 0.5 and 1.0 meter spacing. Similarly, Plan 6 was eliminated because it would not be a “best-buy” plan in that it produces much less benefit for only slightly less cost than Plan 3 as shown in Figure 26 below.

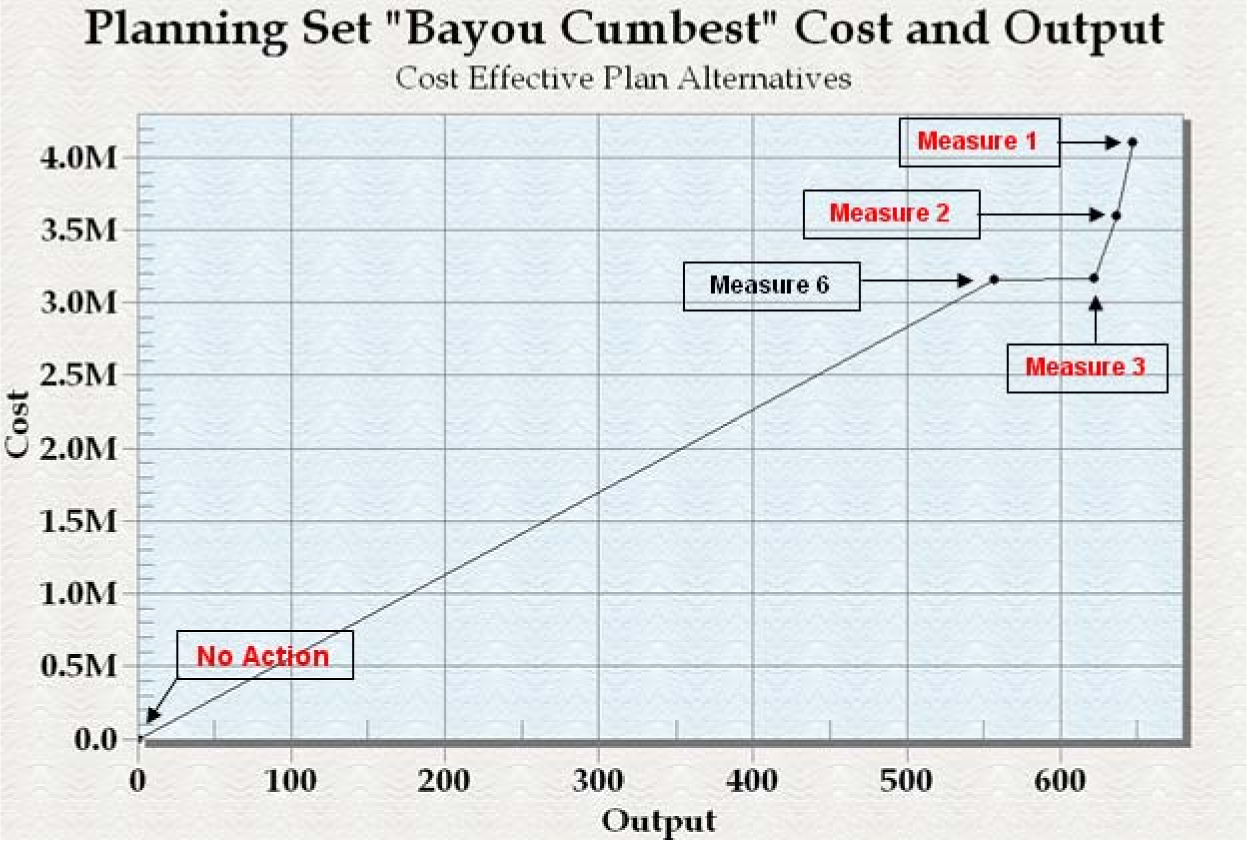


Figure 26 Cost Effective Measures (Plans) for Bayou Cumbest Area.

Plan 1 only produces slightly more benefits than Plan 2 and at a significant increase in cost. In addition, the MsCIP team has had found that the 1 meter spacing has a higher success rate than the 2 meter based on professional experience by the Corps, universities, NGOs, State, and other Federal agencies with restoration of similar emergent marsh habitats. Past experience in coastal Mississippi has proven that spacings, elevation, and hydrology are the three key essential components to obtain a successful emergent marsh site. The three spacing techniques (0.5, 1.0, and 2.0 meters) have been used recently at a local coastal Mississippi project on Deer Island in Harrison County. Although the 0.5 meter spacing may have a slightly higher success rate, the overall goal of the restoration project can be achieved by spacing the tidal emergent plants out to 1.0 meters per plant at a significant reduction in cost. The 2.0 meter spacing of Plan 3 was determined to leave the site too vulnerable to storms and/or hurricanes; thus, this spacing technique proofed to be rather risky.

The recommended plan (Plan 2) will restore 373 acres. The recommended plan consists of restoring the natural ecosystem by excavating old fill material, removing exotic plant species from non-excavated areas, filling existing artificial ditches, and planting native vegetation, such as *Spartina alterniflora* (Smooth Cordgrass) at the seaward edge of marsh; *Juncus roemerianus* (Black Needle Rush). The construction cost is estimated to be $25,530 with an annual average operation and maintenance cost of $114,000.

10.1.3 Admiral Island Ecosystem Restoration

The 118 acre restoration area is located in Hancock County adjacent to Bayou La Croix and near Bay of St. Louis (Figure 27). The property is owned and maintained by the State of Mississippi and consists of degraded wetland habitat as a result of debris and sediment deposited during the storm surge event of Hurricane Katrina.

Figure 27. Admiral Island Ecosystem Restoration Area

The tidal marshes in this area were ditched during the 1960s causing changes in the natural hydrology and subsequent changes in the species composition. Hurricane Katrina left extensive debris fields and sedimentation throughout the area and destroyed many native trees and vegetation. Due to the loss of native species, this area is experiencing a severe infestation of the invasive Chinese tallow tree, which is invading the marshes and the adjacent flatwoods. These exotic species out-compete the native vegetation, which provides food sources to the many fish and wildlife important species, including T&E species. Without any native competing species, these exotic species eventually become the only species in the area and result in a much degraded function of the wetlands.

Since the entire site is owned by the State and is not divided by any natural or manmade hydrologic divide, the entire site is evaluated with combinations of measures including no action, excavating old fill material, removing exotic species, and filling in the existing artificial ditches on the site.

The management measures were combined to create seven plans that were analyzed to determine the cost-effectiveness of each. Economically ineffective plans are identified and eliminated to determine which plans are cost-effective. An economically ineffective plan is a plan that cost more or the same as a subsequent plan but produces less benefit than that subsequent plan. Of the seven plans analyzed, Plans 4 and 5 were eliminated because they produced less benefit at greater cost than a subsequent plan (see Figure 28). The plans that were eliminated included leaving artificial ditches in place with native vegetation planted at 0.5 and 1.0 meter spacing.

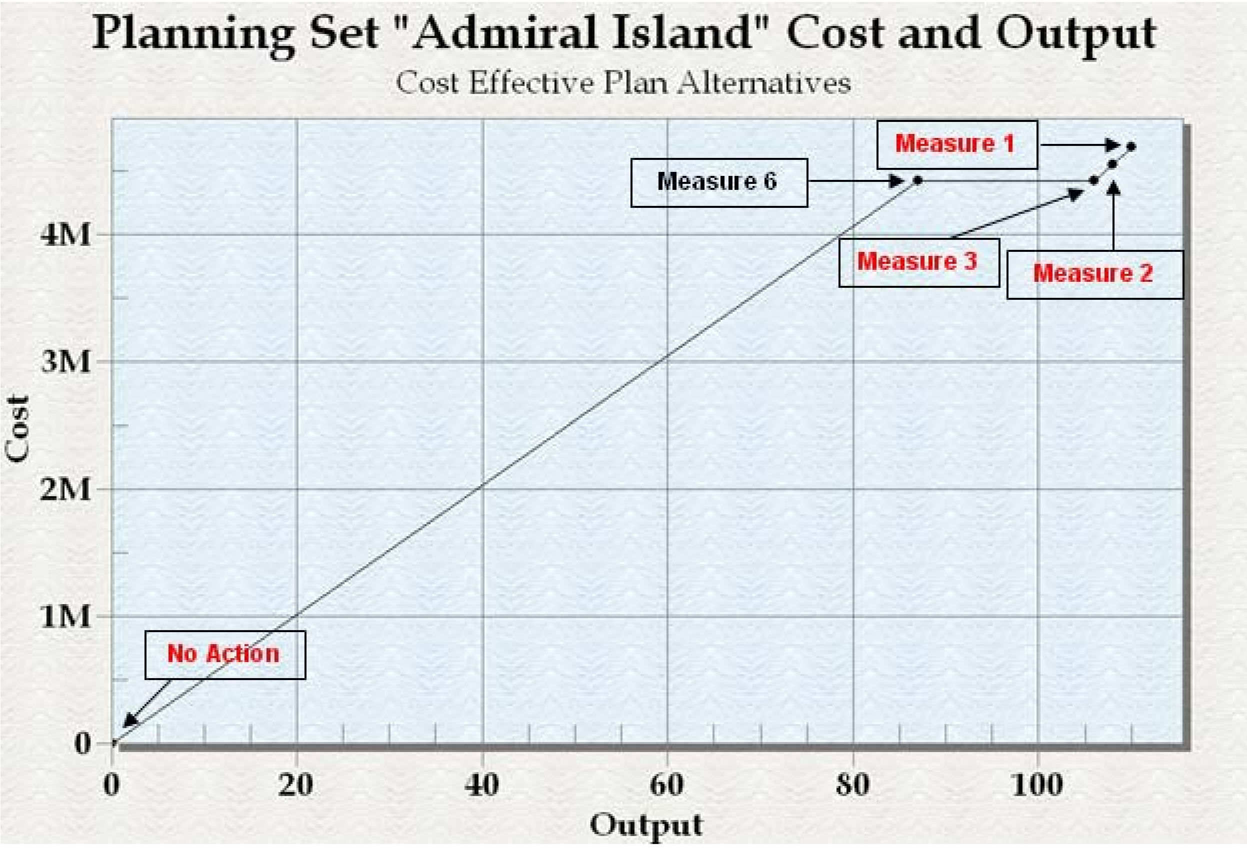


Figure 28 Display of Cost Effective Measures (Plans) for the Admiral Island Area.

Plan 1 only produces slightly more benefits than Plan 2 and at an increase in cost. In addition, the MsCIP team has had found that the 1 meter spacing has a higher success rate than the 2 meter spacing. The 2.0 meter spacing of Plan 3 was determined to leave the site too vulnerable to storms and/or hurricanes; thus, this spacing technique proofed to be rather risky.

The recommended plan (Plan 2) will restore 118 acres. The recommended plan consists of restoring the natural ecosystem by excavating old fill material, removing exotic plant species from non-excavated areas, filling existing artificial ditches, and planting native vegetation, such as *Spartina alterniflora* (Smooth Cordgrass) at the seaward edge of marsh; *Juncus roemerianus* (Black Needle Rush). The construction cost is estimated to be $21,810,000 with an annual average operation and maintenance cost of $58,000.

10.1.4 Dantzler Ecosystem Restoration

This 385-acre State-owned site is located in central Jackson County near the Pascagoula River (Figure 29).

Figure 29. Dantzler Ecosystem Restoration Area.

The site was planted in plantation pine during the 1960s and drainage ditches and stormwater lines were constructed in the early 1970s in anticipation of residential development of the site. The restorable area is split by a road, 151 of the acres are north of the road and the remaining 234 acres are south of the road. The long-term exclusion of fire and the invasion of non-native species, such as Cogon grass and Chinese tallow tree, have also severely degraded the site. These exotic species out compete the native vegetation, which provides food sources to the many fish and wildlife important species, including T&E species. Without any native competing species, these exotic species eventually become the only species in the area and result in a continuing degradation of the functional value of the wetlands. The importance of the wet pine savannah has been previously been discussed in the Turkey Creek ecosystem restoration project above.

Winds from Hurricane Katrina destroyed most if not all of the plantation pine leaving massive amounts of tree litter on the ground. In addition, debris and sedimentation resulting from the storm surge added even more litter. The exotics that were present in the site prior to the storm thrive in this type environment and it is likely that without restoration of the site they will become the dominant species inhabiting the site. Six alternative plans were developed to address the ecosystem restoration of the area.

The site is divided into two portions which could be addressed separately or in combination. Plans were evaluated on the basis of addressing the degraded nature of the entire site (385 acres), the northern portion of the site (151 acres), and the southern portion of the site (234 acres). Since the State is the owner of the site no lands would need to be acquired to accomplish this plan. The plans were also developed using a combination of measures including no action, maintaining native vegetation by burning or mowing, removing exotic vegetation, filling in artificial ditches.

These seven plans were analyzed to determine the cost-effectiveness of each. Economically ineffective plans were identified and eliminated to determine which plans are cost-effective. An economically ineffective plan is a plan that cost more or the same as a subsequent plan but produces less benefit than that subsequent plan. Of the seven plans analyzed, Plans 2, 4, and 6 were eliminated because they produced less benefit at greater cost than a subsequent plan. All three of the plans eliminated included the use of mowing as a management measure for restoring and/maintaining the wet pine savannah habitat. Of the three remaining plans, Plan 1 proved to be more cost-effective (see Figure 30) and consists of restoration of 385 acres of restoration maintained by burning. Details of the plan evaluation may be found in the Environmental Appendix to this report.

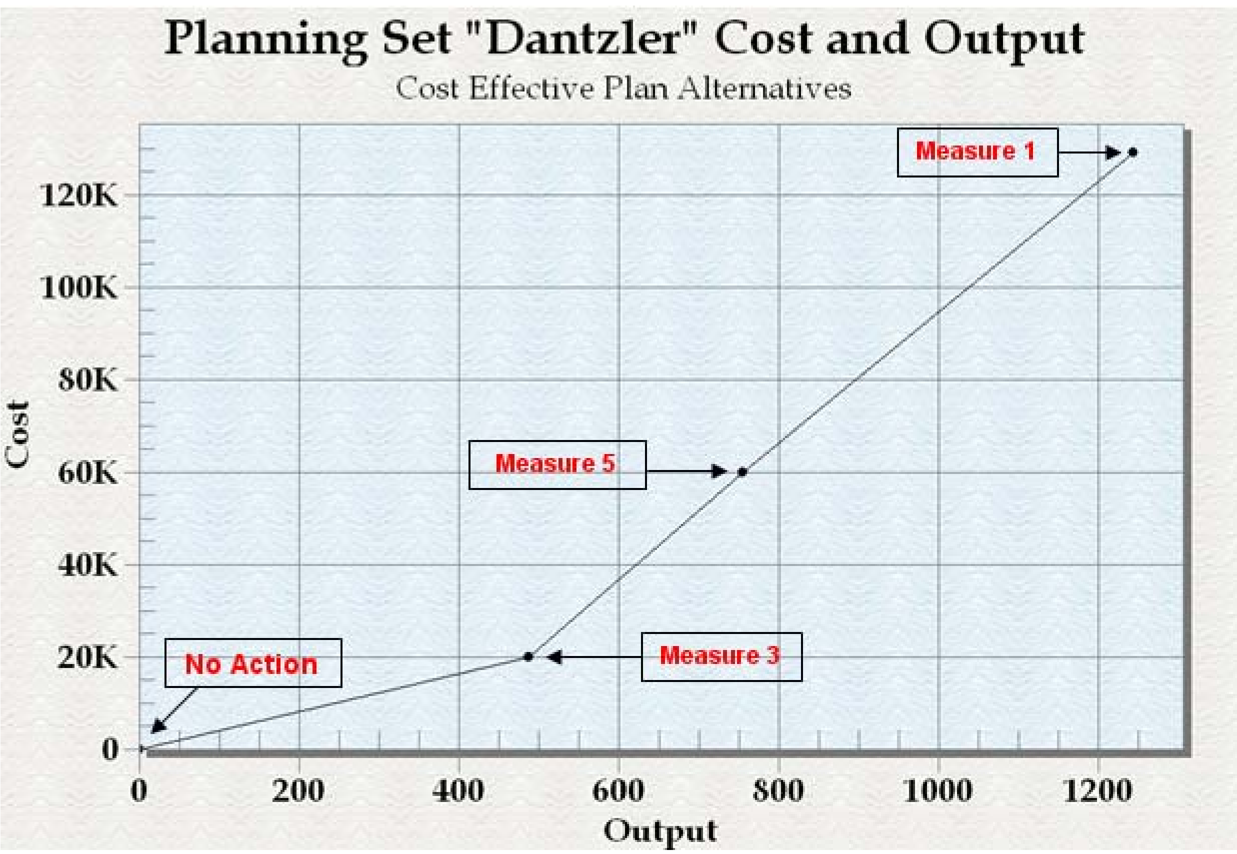


Figure 30. Display of Cost Effective Alternatives for the Dantzler Area.

An essential component necessary when selecting the recommended plan at for this restoration site was the need for burning. Burning allows the wet pine savannah environment to continue naturally as a functioning system. Although mowing does effectively keep understory plants from over colonizing the area, it does not simulate the natural conditions (i.e. seed germination, heating the pine bark, etc.) Therefore Plan 1, with its burning measure, ranked higher than that of the mowing.

Plan 1 requires filling ditches, excavating and removing existing roadbeds and any additional fill, and maintaining vegetation growth by burning the project area in the initial year of construction as well as maintaining it by burning every three years over the life of the project as needed. As with the Turkey Creek ecosystem restoration, periodic burning of the site is a critical element to the success of the restoration. The cost of this plan is estimated to be $2,210,000 with an annual average operation and maintenance cost of $26,000.

10.1.5 Franklin Creek Ecosystem Restoration

The Franklin Creek ecosystem restoration area is located near the communities of Orange Grove and Pecan, Mississippi in eastern Jackson County, near the Mississippi - Alabama state line (see Figure 31). This area has already been funded for acquisition and demolition of 30 structures as part of the MsCIP Interim Report. The restoration area consists of 149 acres located north and south of U.S. Highway 90, a major thoroughfare through the community. This area routinely floods with only a slight rainfall; thus, this would also provide additional flood storage capacity by restoring the natural habitat. Pine savannah wetlands are commonly referred to as sponges that provide floodwater retention, groundwater recharge, and water purification. This wetland habitat is under increased developmental pressures due to the extreme and urgent housing need faced by Mississippians as they are trying to rebuild. This habitat is becoming fragmented and with the increased development, fire maintenance is increasingly harder to perform.

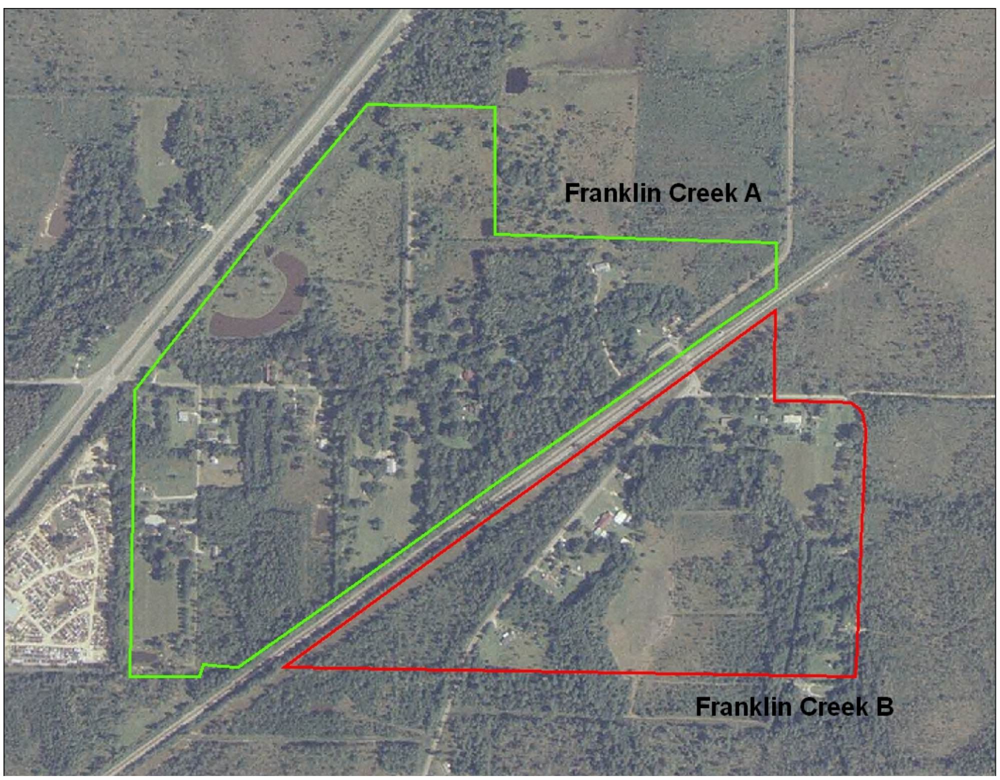


Figure 31. Franklin Creek Restoration Site.

Site evaluation options are limited to restoring the ecosystem of the entire 149 acre area or just restoring the portion of the site south of U.S. Highway 90 / L&N Railroad. Restoring the portion of the site north of the highway is not an option due to the frequent flooding of the area.

Five plans were created from a combination of measures including no action, maintaining native vegetation, excavating and removing roadbeds and fill material, filling in artificial ditches, and adding culverts to improve hydrology. The addition of culverts under the railroad berm is a necessary management measure in the restoration of the entire site as this would allow the flow of water from the frequently flooded northern area into the southern area for restoration of the natural hydrology. These plans were analyzed to determine the cost-effectiveness of each. Economically ineffective plans are identified and eliminated to determine which plans are cost-effective. An economically ineffective plan is a plan that cost more or the same as a subsequent plan but produces less benefit than that subsequent plan. Of the five plans analyzed, Plans 2 and 4 were eliminated because they produced less benefit at greater cost than a subsequent plan. These plans all involved maintenance of vegetation via mowing. Of the two remaining plans, Plan 1 proved to be by far the most cost effective and this recommended plan consists of restoration of 149 acres of restoration aided by managed water flow and maintained by burning.

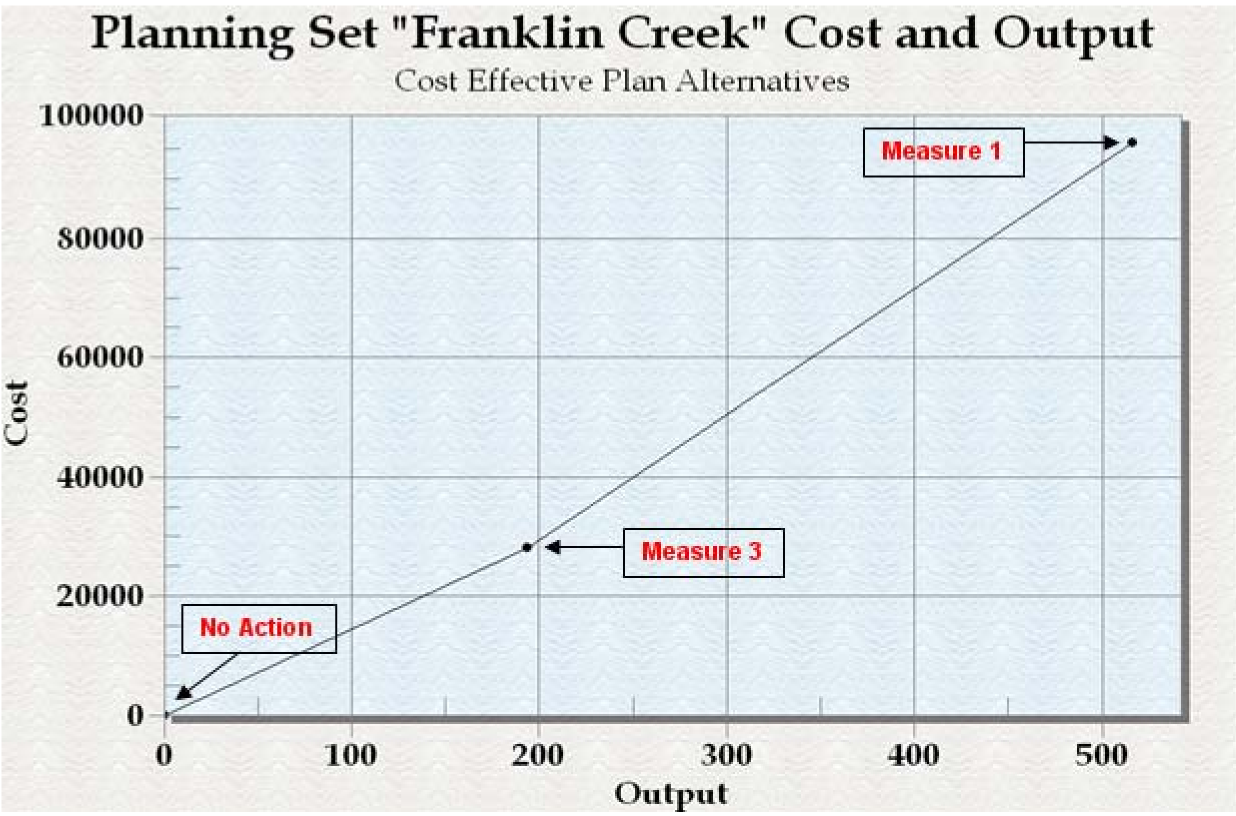


Figure 32. Display of Cost Effective Measures (Plans) for the Franklin Creek Area.

The recommended plan (Plan 1) requires filling ditches, excavating and removing existing roadbeds and any additional fill, installing culverts under the highway, and maintaining vegetation growth by burning and mowing the project area in the initial year of construction as well as maintaining it by burning every three years over the life of the project as needed. The cost of this plan is estimated to be $1,860,000 with an average annual operation and maintenance cost of $11,000 over the life of the project.

10.1.6 SAV Restoration Pilot Project

Additional study is required to assess the complex environmental make-up impacting SAVs in Mississippi Sound due to the fact that mere planting would possibly not survive. Many questions must be answered (i.e. water quality, circulation, etc.) prior to SAV restoration implementation throughout the Mississippi sound. SAV restoration efforts across the nation have proven to be rather challenging and many examples can be identified close to Mississippi over in Florida. Therefore, the MsCIP team is recommending a pilot project in the Bayou Cumbest area. Opportunities exist to partner with Federal, state, and local resource agencies as well as NGOs. Extensive coordination with the NPS, responsible for managing and operating the Gulf Islands National Seashore, would be required for areas of potential restoration within their park boundaries. Involvement of local colleges and universities with ongoing research programs would also help to identify and pinpoint specific problems for development of potential solutions.

The first goal of this proposed community-based restoration pilot project in the Grand Bay National Estuarine Research Reserve (NERR) will result in restoration of up to 5 acres of *Ruppia maritima* resulting in the recovery of an equal amount of SAV habitat to that lost during the 2005 hurricane season. The second goal is to evaluate 3 restoration techniques to demonstrate their feasibility for larger restoration projects. The third and final goal to be achieved through volunteer involvement and educational outreach will increase awareness of the importance of SAV habitat in Mississippi Sound and provide coastal managers and restoration practitioners with the knowledge of techniques to maximize their return on dollars spent.

Three transplanting methods for restoring *R*. *maritima* will be evaluated as follows: 1) direct planting from the donor site, 2) harvesting plant sprigs with one or more meristems (growth regions) from the donor site with subsequent growth in a greenhouse setting prior to planting, and 3) spreading seeds or mature flowering shoots over the restoration site. All plants and seeds would be acquired from a common donor site within the same system. After transplanting, quarterly monitoring for two years would be conducted to determine plant establishment, photosynthesis, growth, and expansion.

The education and outreach components of the project will consist of volunteer involvement and dissemination of results through a professional workshop conducted at the end of the project. Volunteers will be recruited from Grand Bay NERR's established volunteer base, which includes local schools, universities, agencies, and civic groups. This effort will help determine the most successful and cost- and labor-effective transplanting method for restoring SAV. Results will be disseminated through Grand Bay NERR's Coastal Training Program to inform coastal decision-makers and resource managers of successful restoration techniques.

This community restoration project will address the larger issue of SAV losses nationally and rates of natural recovery following disturbance versus recovery via restoration following disturbance. An estimated $900,000 would be required for the Bayou Cumbest SAV ecosystem restoration pilot and includes all effort associated with the planting and monitoring and producing a final restoration report.

10.1.7 Deer Island Ecosystem Restoration

Deer Island, located within the boundaries of Harrison County, Mississippi near the mouth of Biloxi Bay and the City of Biloxi, has a history of tropical storm damage. Damages from these storms has varied based on varying degrees of storm surge, wave action and wind depending on the speed, intensity, direction of travel, and proximity of the given storm. Figure 3-6 displays a recent aerial photograph of Deer Island, showing the damage exacerbated during Hurricane Katrina. The breach on the west end was significantly widened, coastal marshes were impacted by debris and sedimentation, and the maritime forest was killed by wind and salt spray. With all this damage, it is amazing that the wetland created via Section 204, Beneficial Use of Dredged Material, on the eastern end of the island survived and is currently thriving.

The island is considered a mainland remnant and is not part of the coastal barrier system of islands along the Mississippi Coast. The island contains a diversity of habitat areas including beach/dune areas, marsh area, and maritime forest areas. It's proximity to the City of Biloxi provides a certain amount of protection to the city from waves generated by approaching hurricanes. This protection comes at a cost to the island as that energy affects the seaward shoreline and the interior marshes. It has been estimated that the island has lost approximately 300 acres or about 34 percent of its area since 1850, due to eroding shoreline.

A second restoration effort is currently underway which will fill the western breach and provided selective restoration to critical areas on the southern shoreline. This project is authorized under Section 528 WRDA 2000 and will be complete in 2009. Funding for this effort, however, is inadequate to completely restore the island and to remediate for the additional damage to the island caused by Hurricane Katrina.

Due to the interrelated nature of some of the features, i.e. a+b, c+d, the team evaluated a total of 7 combination plans. Of these 7 the plan which best meets the planning objectives is the most cost effective is Combination Plan 7 which includes implementation of each of the alternatives.

Implementation of the combination plan would significantly improve the sustainability of Deer Island and result in the creation of approximately 20 acres of tidal emergent fringe marshes, restore beach and dune habitat, create hard bottom habitat through the use of stone containment, provide protection from coastal erosion, remove sedimentation and debris, and restore the coastal maritime forest an ecosystem of regional importance and concern. The cost of this plan is estimated to be $21,520.000 with an average annual operation with minimal maintenance over the life of the project.

10.1.8 Coastwide Beach and Dune Restoration

This report supports the recommendation for authorization to construct beach and dune restoration improvements along the Mississippi coast. Essentially all the beaches along Coastal Mississippi are man-made. Harrison County has the most beachfront with a 26-mile stretch extending from Biloxi Bay to St. Louis Bay. This beach is the longest man-made beach in the U.S. Hancock County has several miles of beach while Jackson County only has a small beach located in the Cities of Pascagoula and Ocean Springs. In total, the beaches extend along less than half of the Mississippi coastline.

Most of the dunes that previously existed along these beaches were destroyed by Hurricane Katrina and much of the beach was damaged. Many Federal, state, and local entities raised environmental concerns regarding the various Mississippi beaches during initial discussions held to receive local citizenry input. In some areas, such as in the City of Pascagoula, the beach was completely gone. Reconstruction of the dunes, where beaches exist, will provide a reduction of damaging wave action from smaller storms (i.e. normal summer storms, tropical storms, and/or lower energy hurricanes).

A project to restore the beaches in Harrison County has been funded and is underway as part of the Flood Control and Coastal Emergencies (FCCE). Other projects to construct dunes to a height of 5-foot in Harrison County and to 2-foot in Hancock and Jackson County were proposed as part of the MsCIP Interim Report. That dune restoration project has since been funded and the Corps, Mobile District is underway preparing the plans and specifications.

The beaches, situated immediately seaward of developed areas, provide an excellent location where elevated dunes could be constructed to provide some additional protection against smaller hurricanes. Furthermore, the seaward side of the dunes also provides excellent feeding grounds at the nearshore and intertidal shore areas for various birds, crabs, and other fauna.

The storms of 2005 destroyed a large percentage of critical habitat for the piping plover, various shorebirds including the Least Tern, and numerous fish and wildlife species. Beach nourishment and dune restoration would benefit piping plover as well as providing lost habitats for other shorebirds, additional eco-tourism opportunities, and enhancement to the overall quality of life in Coastal Mississippi. Placement of the dunes directly against a raised seawall or roadway would also serve aesthetically to mask the appearance of a structural barrier. Thus, adding to the public acceptance and/or appeal of this proposal.

Dunes are consistent with public preference for a more natural appearing defense mechanism rather than a hardened structure. Construction of dunes will include planting vegetation, such as sea oats (*Uniola paniculata*), and sand fencing to help stabilize the dunes. Sand dunes are naturally occurring dynamic coastal features, which are formed by the accumulation of wind blown sand. Sand is naturally carried along the beach by the wind. Sand fences help facilitate the building of sand dunes by trapping and collecting this wind driven sand. Sand fences are usually made of wood or biodegradable material. Dune plants tolerate harsh beach conditions including wind, salt spray, storms, scarce nutrients, limited freshwater, and intense sunlight and heat. The plants and/or seedlings provide feeding sources to a variety of animals while also providing nesting and roosting habitat.

The recommended plan for this element of the Comprehensive Plan was determined by a combination of cost-effectiveness analysis and achievement of key restoration objectives. The most cost-effective and functionally complete alternative was determined to consist of creation of a dune field that would be constructed approximately 50 ft seaward of the existing seawall and about 2 feet above the existing berm with a width of approximately 60 ft. The most functionally-effective alternative included dune vegetation and sand fencing to enhance establishment and survival of the dune vegetation.

Coastwide Beach/Dune Ecosystem Restoration Summary of Benefits

Plan	**Plan Description**	**Functional Habitat Index**
Existing Condition	Existing Condition	-
No Action	No Action	96
Recommended Plan	2-foot High x 60-foot Wide Dune With Planting & Sand Fencing	248

The recommended plan (Plan 1) requires placement of sand, planting of native dune vegetation and sand fencing. The cost of this plan is estimated to be $23,320,000 with minimal maintenance over the live of the project.

10.1.9 Barrier Island Ecosystem Restoration

The barrier islands have historically constituted a barrier to saltwater, maintaining a careful balance of saltwater and freshwater flows, which sustain the valuable marine resources of Mississippi Sound. The barrier islands also provide a barrier to onshore movement of waves, and to a lesser extent storm surge, by attenuation.

Alternatives being evaluated include very limited restoration of Ship Island, only in the vicinity of the endangered cultural sites of Fort Massachusetts and French Warehouse, on (the post-Katrina condition) “West” and “East” Ship Islands, respectively up to ‘massive’ restoration of the historic island dimensions. Although the protection of the cultural resource sites appears to be a justified option, this alternative would neither represent a complete solution, nor a completely effective means of addressing the larger problem faced on that island and the others. On the other hand, a more massive plan for barrier island restoration, or more direct application of sand, was rejected by many on the team, as unmanageable and potentially damaging, due to the unknown effects that might be introduced by placing sand into an area that could not be maintain by littoral drift over the long-term. More massive measures did not appear to provide a significantly greater volume of functional increase, for a much larger outlay of funds.

As part of the evaluation increasing the volumes of sand to the system is determined to be increasingly effective in achieving additional functional value, particularly when sand was provided directly into the littoral drift that created and nourishes the islands, so that “Mother Nature” can finish the job of distributing the sand in a natural way, to those areas of the island most suited to the current drift climate.

Several alternatives have been evaluated regarding the restoration of the Mississippi barrier islands. The most promising alternative for barrier island re-nourishment and protection of Mississippi Sound is the comprehensive plan. This plan would produce the greatest functional benefit per dollar expended, is a complete solution, represents an efficient use of Federal and local funds, is effective in its treatment of the problem (particularly in comparison to less effective structural wave reduction measures), and is acceptable to stakeholders in terms of existing laws, policies and priorities. In addition, the public is highly supportive of its measures to address the degradation of the barrier islands, as an element of a natural barrier to storms, and in the restoration of marine resources associated with Mississippi Sound.

This alternative includes the direct placement of sandy sediments to fill the breach in Ship Island and thereby reconnect West and East Ship Islands to their historic condition and to place sandy sediments within the littoral zones of Ship, Horn and Petit Bois Islands to ensure that the sediment budget of the islands is sufficient to maintain the islands in the future. This littoral zone placement would also benefit from the modification of dredging and disposal practices of the federally maintained Gulfport and Pascagoula Harbor navigation projects. These coupled efforts would begin the long-term process of barrier island repair and sustainability. Another consideration that still must be addressed is the best alternative for dealing with the erosion of Cat Island. This island is geomorphically different from the other 3 barrier islands and our understanding of the processes controlling Cat Island is not well developed. Additional effort would be required to add this island into an overall comprehensive barrier island restoration plan. The estimated construction cost of the barrier island comprehensive plan is $479,710,000.

10.1.10 Forrest Heights Flood Damage Reduction

In Harrison County Mississippi the Forrest Heights community is located within the city of Gulfport at the lower end of the Turkey Creek floodplain and in a part of the larger historic Turkey creek community. Harrison County was over topped and heavily damaged by the hurricanes of 2005. Particularly, the storm surge and winds generated by Hurricane Katrina on August 29, 2005, caused structural damage to the existing levee that provides inland flood protection to this low lying residential community.

Storm surge inundation reached a depth of 2-8 ft over the entire community during Hurricane Katrina. In addition, prior to Hurricane Katrina, Forrest Heights was frequently inundated by flood waters due to inland flooding along the lower reach of Turkey Creek that overtopped the existing levee. An economically justified improvement to the existing earthen levee for inland flooding protection was evaluated in July 2005, prior to landfall of Hurricane Katrina. These evaluations included 100-year, 250-year and 500-year protection and elevations up to 19.5 feet above sea level.

This plan was put on hold following Katrina in order to evaluate suitable defense of Forrest Heights from hurricane storm surge flooding. The levee was evaluated at elevations 17 ft and 21 ft above sea level.

All evaluated alternatives were also gauged against the intent of Executive Order 12898, "Federal actions to address environmental justice in minority and low-income populations". Since the establishment of the Turkey Creek Community by freed slaves and their descendants, federally funded construction programs including the Gulfport Regional Airport, US Highway 49 and Interstate Highway - 10 have impacted the Turkey Creek Watershed. In addition, numerous other constructions including hotels, shopping centers and housing developments have been federally permitted to fill wetlands and construct within the Turkey Creek watershed.

Through modeling results, a levee height of approximately 21 feet above sea level was determined to be consistent with the levee certification guidelines with the basis measure being a storm surge elevation that has a 0.2% probability (500-year event) of occurrence in any given year. The levee is estimated to be 6,500 linear feet and require 93,000 cubic yards of fill. An existing park of 12 to 14 feet in elevation would serve as a water detention area for temporary containment of rainfall during storm events. The cost of this plan is estimated to be $ 14,070,000, with an average annual operating and maintenance cost of $ 114,000 over the 100-year life of the project.

10.1.11 High Hazard Area Risk Reduction Plan

The most effective alternative for reducing the risk from future hurricane surge events is to relocate structures and population from the high risk zones. Formulation of alternatives ranged from those which would provide for a minimum level of risk reduction (approximate base flood elevation) up to those that would provide for risk reduction from increasing levels of inundation. In addition an alternative concentrating on acquisition in the high to moderately high hazard areas was evaluated.

Hurricane Katrina destroyed an estimated 32,446 structures, which were "significantly" (i.e., 51% to 100%) damaged, and caused substantial damage to another 15,000 to 25,000 structures located within the inundation footprint of the three coastal counties in Mississippi. The vast majority of all destroyed homes within the inundation footprint have not yet been rebuilt, more than two years after the event. The rebuilding rate within the inundated area is much slower than might typically be expected following a hurricane. This is due in part to a significant increase in construction costs since Katrina, higher flood insurance rates and uncertainty resulting from the fact that FEMA has only in late 2008 released the revised Flood Insurance Rate Map (FIRM) and requirements outlining the elevation future first-floor construction must adhere to in order to qualify for flood insurance through the FIP. Limited rebuilding is occurring within the surge-plain, at a variety of elevations. Those that are rebuilding at former elevations are largely self-insured (or un-insured), while those rebuilding at higher elevations are doing so with an assumptions as to what the Base Flood Elevation (BFE) may be for their area. Regardless, most of those that would need flood insurance have not rebuilt at the time of this report, due to unavailability of that BFE data.

10.1.11.1 Phase I High Hazard Area Risk Reduction Plan (HARP)

Phase I involves the buyout of those properties that have been frequently flooded, or are at very high probability of future damage due to storm surge. The first phase of the HARP would include acquisition of approximately 2,000 properties which can be implemented over the next five years. Further information on the High Hazard Area Risk Reduction Plan can be found in the Nonstructural and Real Estate Appendices. The advantages of such a program are numerous including:

- Reduces future property loss and potential loss of life;

- Eliminates costly structural alternatives and associated long term operation and maintenance costs;
- Provides a buffer and aids in reducing storm surge to adjoining properties; and
- Provides a potential opportunity to initiate alternative uses of the acquired land for fish and wildlife, ecosystem restoration and public recreation.

Benefits of the program include reduction of future damages and risks to lives within those areas, and incidental recreation and social effects benefits. Select areas within certain acquired areas would be available for ecosystem restoration, and could also produce additional restoration benefits. Regional economic benefits include an increase in sales volume of $1,171,260,000, a $246,056,800 increase in local income, and a net increase of 7,213 jobs. The estimated costs for implementation of Phase I range between $187,500,000 and $397,000,000 depending on the ultimate number of parcels acquired and range of benefits provided under P.L. 91-646.

10.1.11.2 Long-term High Hazard Area Risk Reduction Plan Evaluation

Evaluation of long term HARP is warranted to address the relocation of structures from the high to moderately high risk areas of the Mississippi coast. This program which could cover risk reduction opportunities over the next 20 to 40 years could target those properties which have been rebuilt but are still susceptible to significant future damage. A long-term HARP could involve the acquisition of large contiguous properties immediately following any large future hurricane events and be a joint effort between the USACE, FEMA, and the State of Mississippi.

The benefits of an ongoing acquisition and relocation program for coastal Mississippi could be tremendous taken into account the implications of sea level rise, continued development along the coast, and the frequency and magnitude of storms known to affect this area of the northern Gulf of Mexico. The additional study effort aimed at developing the framework and guidelines, detailed benefits, and costs would involve local and State interests as well as the Federal Emergency Management Agency.

Estimated study cost for development of a long-term HARP program is $5,000,000.

10.1.11.3 Waveland Floodproofing

This report supports the recommendation for authorization to immediately implement the flood proofing at Waveland, MS. The city of Waveland is located in Hancock County and was directly in the path of Hurricane Katrina. Because of the low lying nature of the city, the only flood damage reduction measures available to a portion of Waveland are either acquisition or floodproofing of individual structures. FEMA has released a manual for “Recommended Residential Construction for the Gulf Coast” which is meant to aid residents in rebuilding on strong and safe foundations. The design manual (FEMA 550) provides recommended foundation design and guidance for rebuilding homes destroyed by hurricanes in the Gulf Coast. The Waveland floodproofing alternatives are designed to evaluate the FEMA 550 guidelines with regards to current Corps’ floodproofing practices. In addition to showing the application of existing elevation techniques and construction practices to reduce flood damages, this alternative would evaluate the use of possible innovative contracting techniques. These techniques would be designed to improve the Corps – contractor – homeowner relationship, focusing on using more timely and customer focused approaches. The 25 structures selected for floodproofing represent an adjacent group of structures that were not destroyed by Hurricane Katrina.

In order to evaluate the different foundation and building types, 25 structures would be selected in the Waveland area that could be safely elevated out of the 1% chance storm event, and which could not be protected by any other structural measures evaluated as part of this study. Damages to these structures would be significantly reduced and the area would serve as an example of smart growth. Regional economic benefits include an increase in sales volume of $20,250,000, a $4,286,426 increase in local income, and a net increase of 129 jobs. The construction cost is $4,450,000. There are no operations and maintenance costs.

10.1.11.4 Moss Point Municipal Services Relocation

This report supports the recommendation for authorization to immediately implement the Moss Point Municipal Services Relocation component of the Comprehensive plan. The City of Moss Point is located north of the City of Pascagoula in Jackson County. All of the City's municipal services were disrupted by Hurricane Katrina, and their structures were either severely damaged or deemed uninhabitable. The MsCIP has formulated alternatives that would aid the city in providing basic community services in a more timely fashion after future storm events, and further demonstrate the effectiveness of relocations projects as a hurricane and storm damage reduction measure along the Mississippi coast. The best means of achieving these goals consists of relocating the city's municipal buildings to a lower risk site with regards to flooding within the incorporated limits. These buildings include the city hall, police station, fire station and community services building. Future use of the existing site of these buildings would be as open space that would provide a buffer between City and the Escatawpa River further reducing the damages from hurricane surge and flooding events.

The relocation of these facilities would greatly reduce future damages to the local infrastructure and provide a higher confidence in uninterrupted public service in future events. Regional economic benefits include an increase in sales volume of $20,250,000, a $4,286,426 increase in local income, and a net increase of 129 jobs. The construction cost of this project is $10,860,000. There are no operations and maintenance costs.

10.2 Studies Recommended for Further Study

Using the GIS based SDSS model, the MsCIP environmental team was able to effectively analyze needs in coastal Mississippi. A subset of potential restoration sites was identified by the SDSS tool and then ground-truthed by the MsCIP environmental team, including ERDC, Corps, MDMR, and USFWS. Using this interagency team allowed us to both confirm the accuracy of the SDSS results and to collect additional on-site information pertinent to restoration efforts. The MsCIP environmental team recommends immediate construction of the above 2 initial environmental restoration projects – Turkey Creek, Harrison County and Bayou Cumbest, Jackson County. In addition, the team recommends potential environmental restoration projects specified in *Table 1.16.2.2-1* that would be studied further and restored under a MsCIP Environmental Restoration Programmatic Authority. The Environmental PDT anticipates studies, such as Project Information Reports (PIR), would range from $100,000 to $350,000 depending upon the specific project complexness. This cost has been incorporated into the cost-estimates. A rough order of magnitude cost-estimate has been prepared so that an upward construction budget is determined. The Environmental PDT will utilize the SDSS tool to prioritize environmental restoration site construction.

Development of partnerships with Federal resource agencies, state agencies, and NGOs is crucial to the success of this program. These partnerships would provide opportunities to access local knowledge of the existing environment. Specialists in specific restoration techniques would be available as well as opportunities to build on existing programs.

Once the restoration sites have been prioritized, a sequencing plan would need to be developed identifying the events necessary to accomplish restoration. This would ensure prioritized sites received immediate attention and further details developed for the required analysis. This plan would serve as an outline of the programmatic authority structure.

Once the PIR received approvals, a contracting mechanism would need to be put forward. The District PDT would need to incorporate Contracting Division in order to establish the most efficient type and beneficial use of contracting options and/or existing construction contracts. Oversight and quality assurance would ensure restoration was accomplished as envisioned.

Development of individual project monitoring plans should be incorporated into each restoration project. Adaptive management of ecosystem restoration projects, which would include the implementation of adaptive measures if required, would enhance the likelihood of the project achieving its goals and interim targets.

10.3 Additional Recommendations

While not compared in a system of accounts analysis, there are other areas that warrant either additional feasibility study or implementation by others. These include education on hurricane risk, hurricane and storm warning, evacuation plans, other structural measures, flood insurance, zoning changes, and saltwater intrusion plans. These are described in detail in the Main Report.

11 REGIONAL CONSIDERATIONS AND ACROSS-REGION INFLUENCES OF MSCIP AND LACPR ALTERNATIVES

11.1 MSCIP-LACPR COORDINATION ON REGIONAL ISSUES

11.1.1 Interaction/Coordination Between the Study Teams

The hurricanes of 2005 affected the entire region of the northern Gulf of Mexico from the panhandle of Florida to the Texas coast causing direct destruction to the immediate coast and its population centers. It also had unprecedented impacts to the much broader region from the subsequent migration of the affected population, wholesale disruption of the region's economy, disruption of the region's educational infrastructure, and untold impacts on the human resources of the region. In essence, these impacts were not only local, but regional, and system wide as well. In its response to this disaster, the Congress of the United States authorized the U.S. Army Corps of Engineers (USACE) to initiate two important and comprehensive planning efforts to address the impacts caused by these storms and to plan actions that would make the region more resilient and less susceptible to future risk from such disasters. In formulating these actions, the USACE has taken a systematic and regional approach and has required that both the Louisiana Coastal Protection and Restoration (LaCPR) and Mississippi Coastal Improvements Program (MsCIP) efforts be fully coordinated with each other. In addition, both efforts used the same plan formulation strategy, as well as shared the use of the many technical tools required to perform the evaluations.

To this end, both teams are considering structural, nonstructural, and coastal restoration measures during the plan formulation. To ensure consistent communication and coordination, both teams have attended critical meetings regarding study goals and objectives, plan formulation, and Independent Technical and External Peer Review efforts. All modeling used in both efforts has been well coordinated, and both teams made use of, and jointly coordinated, the efforts of those USACE laboratories, Centers of Expertise, and ITR and EPR teams involved in these studies. In addition, the development of the Risk Informed Decision Framework (RIDF) has been a joint effort of the two studies.

All potential impacts, both adverse and beneficial impacts, are being considered without regard to geographic boundaries. Any measures which induce adverse impacts must be eliminated from further consideration or their impacts satisfactorily mitigated on a regional basis. Several measures may have beneficial impacts outside specific study boundaries. For example, the diversion of freshwater from the Mississippi River to Lake Borgne via the Violet marsh area could not only reduce saltwater intrusion in the Mississippi Sound south of Hancock County, but it could also provide much needed sediments to the Biloxi marshes of Louisiana. Also, the systematic restoration of the coastal sediment budget and sand transport system along the Mississippi barrier islands could provide benefits to eastern Louisiana.

11.1.2 Identification of Key Regional Issues

There are several key issues that are common to both Mississippi and Louisiana. These include problems with shoreline erosion, wetlands loss, salinity intrusion, and storm surge and waves. Besides the obvious economic and societal impacts associated with hurricanes, both states have a significant problem with eroding barrier islands. These islands reduce wave energy and help significantly in reducing erosion to the mainland. The loss of wetlands along the coast is also a critical issue. Wetlands, including marshes and near shore marine and estuarine habitat, are the nursery grounds for the entire marine food chain in the Gulf of Mexico. And, like the barrier islands, they also help to reduce wave energy. Linked to both the degradation and loss of the wetlands and barrier islands is the increase of salinity in the estuarine areas of the Mississippi, Breton, and Chandeleur Sounds. These increasingly scarce areas of the United States require a delicate mix of fresh and salt water to provide habitat for oysters, shrimp, sturgeon, and other fisheries which also provide an important economic source for both states. Both LaCPR and MsCIP teams are working together to solve these issues at the local, regional, and national levels. Multiple focus groups, public meetings, and regional workshops have been held to make sure that the solutions presented in this report are comprehensive in nature, and also maintain the delicate balance between people and their environment.

11.1.3 Coordination with FEMA

In addition to the significant coordination between the MsCIP and LACPR teams, the teams have also coordinated fully with the Federal Emergency Management Agency (FEMA) to ensure a unified approach in the development of appropriate hurricane and storm damage reduction alternatives. FEMA has different regional offices to manage different areas of the United States. FEMA Region IV serves the state of Mississippi, and FEMA Region VI serves the State of Louisiana. After Katrina, Regions IV and VI began the complex process of updating their Flood Insurance Rate Maps (FIRMS) to include storm surge. FEMA Region VI utilized the Corps, New Orleans District to provide the model for updating their FIRMS, while Region IV contracted with an Architect-Engineer firm for this effort. Both the MsCIP and LACPR teams employed a consistent methodology for storm surge modeling, and coordinated their efforts closely with both FEMA regions. FEMA Region IV's contractor adopted some slight differences in terms of the specifics of their modeling approach; however, the agencies reconciled the differences in water levels generated for Regions IV and VI, and used an averaging technique to achieve a unified approach and result.

11.2 REGIONAL STORM SURGE AND WAVE MODELING

11.2.1 Interaction of Storm Surge and Waves with Coastal Protection Measures

Large-scale levee systems; other man-made barriers; restoration of barrier islands that involve substantial increases in an island's cross section, crest elevation or length; or wetland restoration on a massive scale, all have the potential to influence storm surge levels and wave conditions produced by extreme hurricanes on a regional scale. Levees and barriers are intended to protect against storm surge, but they also can cause a build-up of storm surge by obstructing or completely blocking the movement of water that is driven by hurricane-force winds. The pocket formed by the natural barriers of the Mississippi coast, the Mississippi River delta, and, when the wetlands of the delta become inundated, the levee systems along the Mississippi River facilitates a build-up of storm surge as winds push water into the pocket. Barrier islands alter the movement of water toward the coast, providing some blocking action and by forcing the water to move through gaps between islands, an effect that is lessened once the storm surge overtops an island. The enhanced roughness of wetlands can slow the advance of storm surge somewhat, which can cause a small local increase in storm surge seaward of the wetland and slightly reduce the surge landward of the wetland or slow its arrival time slightly. Each of these processes might tend to retard the storm surge propagation in one area; but in the process of slowing the storm surge advance, the movement of water might be slightly redirected toward another location causing a local storm surge increase elsewhere. Natural and man-made protection and buffering features like wetlands and barrier islands do not decrease the mass of water driven into the region by the hurricane winds (mass is conserved); however, they do change the momentum and redistribute the storm surge.

Natural and man-made coastal protection measures can also significantly alter wave conditions during hurricanes, reducing the potential for wave-induced damage along the coastline during elevated storm surge levels. Levees and barriers can completely block wave energy; and barrier islands act to block ocean waves from reaching the mainland coastline or reduce wave energy. Even though the reduction is less, barrier islands greatly reduce ocean wave energy even when the surge has overtopped the barrier island. Wetlands reduce wave energy, although it is difficult to accurately quantify the reduction given the current lack of detailed knowledge about the physics of this process.

In both the MsCIP and LaCPR studies, the regional influences of several proposed project alternatives on storm surge levels were examined with regional storm surge and wave modeling. The regional surge/wave model was specifically designed with this requirement in mind by having model domains and grid meshes that encompassed both Louisiana and Mississippi, and by developing the models consistently (for example, adoption of similar grid resolution throughout the model domain). The process for developing the regional model is briefly described below. Additional details can be found in appropriate appendices to the LaCPR and MsCIP reports (cite references to those appendices).

11.2.2 Initial Model Development by the IPET

As part of Interagency Performance Evaluation Task Force (IPET) work to examine the response of the southeast Louisianan hurricane protection system to Hurricane Katrina, regional storm surge and wave models were set up and applied for the coasts of Mississippi and Louisiana. The suite of models included ADCIRC, the regional storm surge model, WAM, the offshore wave model (a basin-scale wave model covering the entire Gulf-of-Mexico), and overlapping STWAVE shallow-water wave models for the complete nearshore zone spanning both states. The ADCIRC and STWAVE models were coupled to treat the very important interactions between waves and storm surge. Coupling was done to maximize accuracy of the regional models.

The IPET was a community effort, drawing on experts from several federal agencies (including the USACE, FEMA, NOAA, and the USGS), state agencies, the private sector, and academia. The work involved considerable sharing of data, model technology, and expertise among all the agencies, groups, and individuals involved. Work of the IPET was reviewed by two panels: one assembled by the American Society of Civil Engineers and the other by the National Research Council. Both panels included experts from the public and private sectors, and each was comprised of individuals representing a wide range of technical disciplines. Both review panels gave extremely high marks to the regional storm surge and wave modeling approaches used by the IPET.

11.2.3 Regional Consistency Between the LaCPR and MsCIP Projects

A collaborative effort was undertaken to meet the storm surge and wave modeling needs of both the USACE MsCIP and LaCPR studies and the FEMA work to update flood insurance rate maps for the region. The MsCIP and LaCPR studies required storm surge and wave modeling for the entire coastline of both states. The IPET modeling had focused only on southeastern Louisiana and western Mississippi. Therefore, the regional storm surge and wave models that were initially developed by the IPET were expanded and refined with higher model resolution to create regional models that spanned the entire Louisiana and Mississippi coastal zone. The linked ADCIRC and STWAVE models are completely consistent from the perspectives of regional model resolution, level of model detail, and input data quality. Higher resolution enables: (1) a more detailed representation of the landscape features that influence surge and wave propagation and coastal flooding, and (2) a more accurate representation of certain wave and surge physical processes. Model accuracy is directly related to model resolution. Figure 11.2.3-1 shows the portion of the regional ADCIRC storm surge model domain for the Mississippi/Louisiana coastal region, and Figure 11.2.3-2 shows the overlapping regional STWAVE model domains.

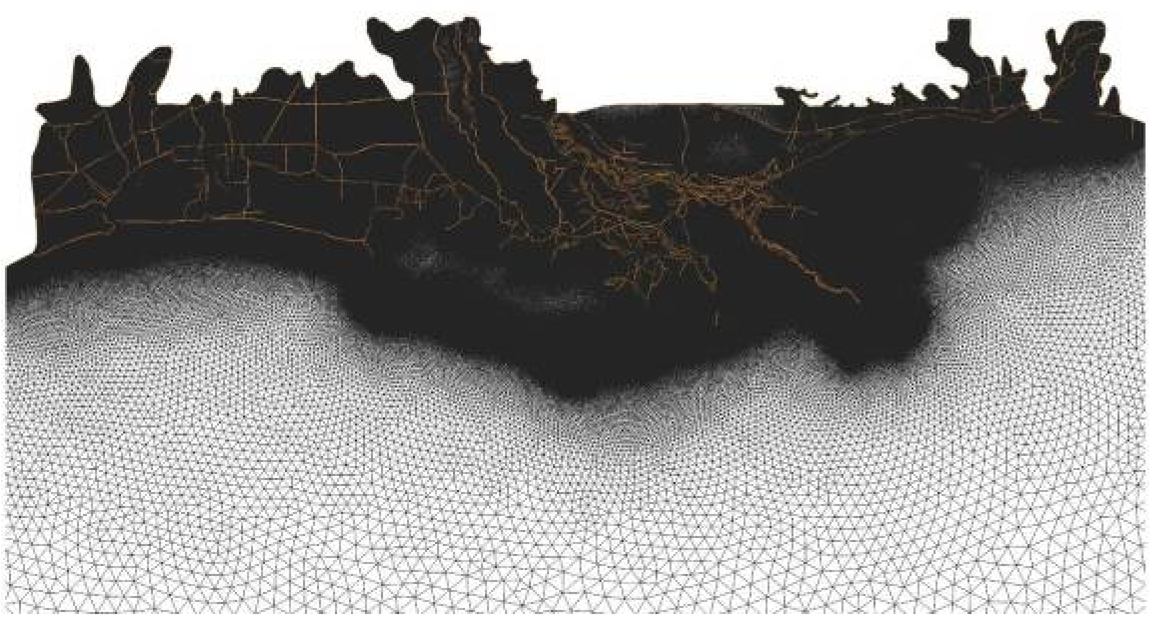


Figure 11.2.3-1. Representation of the Mississippi/Louisiana coastal region in the regional ADCIRC storm surge model

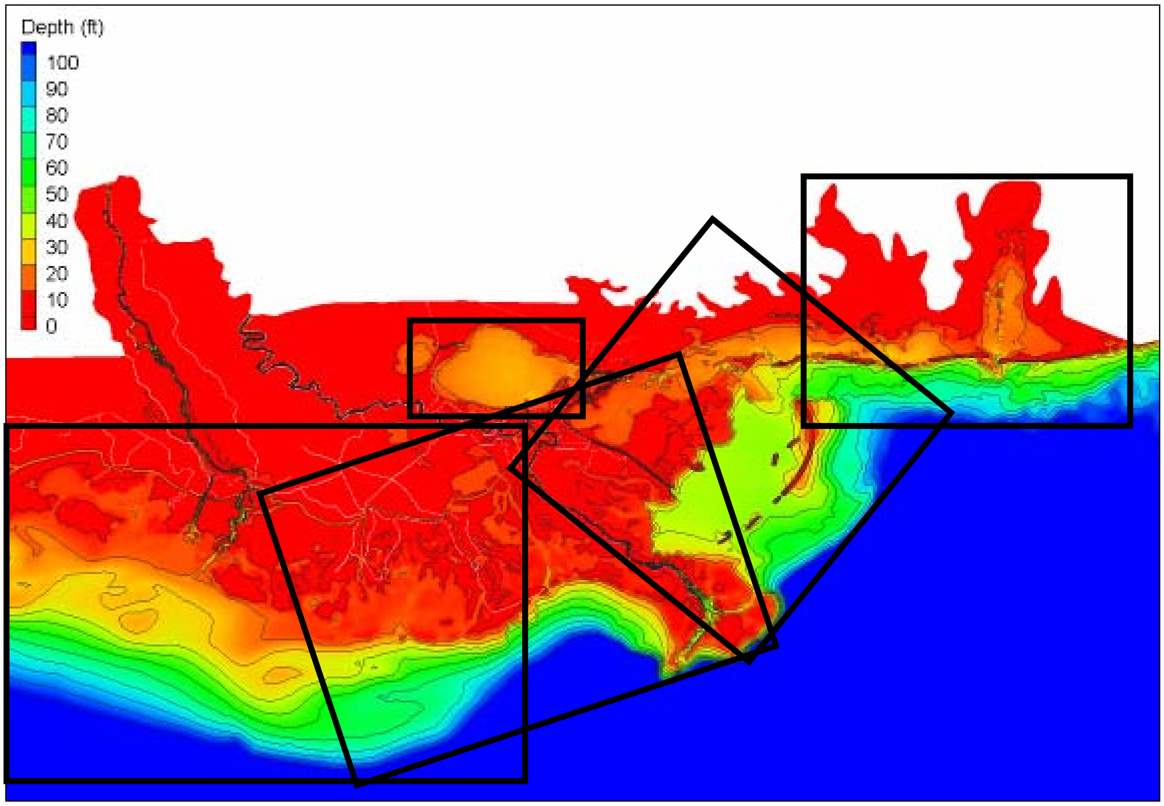


Figure 11.2.3-2. Overlapping STWAVE shallow water wave model domains spanning the Louisiana and Mississippi coasts (only the eastern portion of the westernmost Louisiana STWAVE model domain is shown here)

11.2.4 Hurricane Hazard Definition

In addition to having a regional-scale and regionally-consistent storm surge/wave model, a regionally consistent definition of the hurricane hazard was also important. A multi-disciplinary team, the Risk Assessment Group (RAG), was assembled by the Corps to characterize the probabilities of different hurricanes that can impact the northern Gulf of Mexico region. Their work fully utilized the best of today's knowledge, data and technology. Many of those involved in the work of the IPET contributed to the RAG, along with others from around the country (including members from NOAA and FEMA), in the same community spirit as the IPET. Consequently, results generated by the RAG have strong technical credibility and inter-agency acceptance. A significant achievement of the RAG, which supported both the MsCIP and LaCPR work and FEMA's remapping efforts, was the adoption of a unified general coastal flooding methodology that is being applied by USACE and FEMA. The unified approach involves coupled regional storm surge and nearshore wave models, the same approach originally taken by the IPET. The RAG developed a number of new insights into the behavior of hurricanes. One notable and extremely important finding was the tendency for all major intense hurricanes to decrease in intensity prior to landfall. The RAG developed a regionally-consistent Joint Probability Method-Optimal Sampling approach (JPM-OS) for defining hurricane probabilities and for calculating probabilities associated with hurricanes having a certain set of characteristics (track, intensity, size, forward speed). Figure 11.2.5.2-1 shows an estimate of the frequency of occurrence for major hurricanes in the north central Gulf of Mexico that was produced by the RAG. The figure shows the relatively higher probability of severe hurricane occurrence for southeastern Louisiana and Mississippi, relative to the probability of occurrence elsewhere in the Gulf of Mexico.

11.2.5 Corps-FEMA Coordination in Louisiana and Mississippi - Consistency of Hurricane Frequency Estimates

11.2.5.1 Development of Louisiana Data

Both FEMA Region VI and USACE employed the ADCIRC-WAM-STWAVE regional storm surge and wave model described above and the JPM-OS approach recommended by the RAG. The same set of model results was used in both the LaCPR work and in the FEMA Region VI remapping effort to characterize the hurricane hazard.

11.2.5.2 Development of Mississippi Data

Storm surge and wave modeling done for the MsCIP study was performed by USACE using the same regional modeling methodology as the LaCPR study (the approach outlined above). The MsCIP modeling work was coordinated with FEMA Region IV. However, results for the MsCIP project were required well before final numbers would become available from the FEMA contractor (URS Corporation) working on Region IV remapping. URS used a similar coupled surge and wave modeling

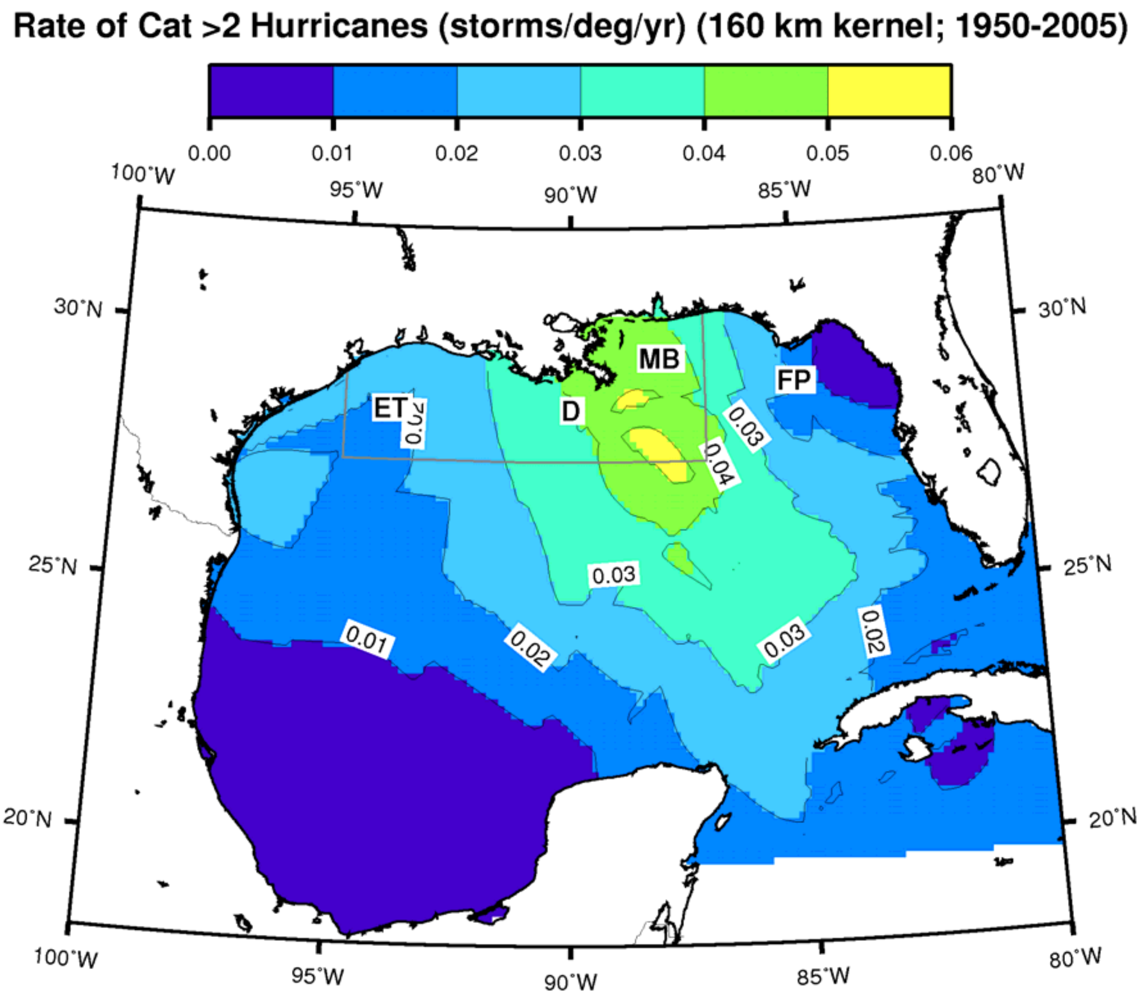


Figure 11.2.5.2-1. Analysis of hurricane frequency from Toro (Risk Engineering) from an analysis using an optimized spatial kernel (from the White Paper on Estimating Hurricane Inundation Probabilities by Resio et. al. 2006)

methodology but used the nearshore wave model SWAN, whereas USACE used the STWAVE model. However, the biggest difference in the approach used by the FEMA contractor was not in the modeling methodology, but rather in the specification of storm parameters and in the statistical computations. The FEMA Region IV/URS effort used different storm parameters and a different landfall (more inland) than USACE, which resulted in less pre- and post-landfall filling (i.e. less weakening) of the storms. In essence this resulted in stronger storms, producing higher water levels than those calculated by USACE. The agencies met and reconciled the differences in water levels for the Mississippi Gulf Coast through an averaging technique to achieve a unified Federal government set of results. Thus, there is a single Federal number for water levels corresponding to certain return periods. However, it should be noted that much of the MsCIP work proceeded with the preliminary values computed by the Corps to meet the Congressional schedule. The vast majority of storm surge-frequency curves computed by USACE and the FEMA contractor were within +/- 1 ft across the Mississippi coast. This is within the level of accuracy expected from these types of storm surge simulation models.

11.2.6 Comparison: Mississippi and Louisiana Data

When the Mississippi storm modeling results were compared to the Louisiana results near the Louisiana-Mississippi border, the Mississippi FEMA approach resulted in higher elevations around the state line than those resulting from the approach used by the LaCPR and FEMA Region VI studies. To resolve the issue, the USACE Engineer Research and Development Center (ERDC) provided a “blending algorithm” to achieve a smooth transition. As a result, the predicted still water elevations in the vicinity of the MS-LA border, corresponding to certain frequencies of occurrence, are considered scientifically accurate.

11.2.7 Present State of the Regional Storm Surge and Wave Model

A completely coupled and consistent regional storm surge and wave modeling capability is available to examine the regional influences associated with planned and proposed project alternatives being developed in the LaCPR and MsCIP studies, but only from the perspectives of project influences on storm surge levels and wave conditions. The model is based on the coupled ADCIRC-STWAVE models that were described above. The regional surge and wave model has been extensively validated using measured data acquired during Hurricanes Katrina and Rita, during the IPET and MsCIP and LaCPR projects.

This regional modeling capability was applied to examine regional-scale changes to storm surge levels associated with several of the proposed project alternatives, for example the influence of proposed barriers across Lake Pontchartrain on storm surge levels along coastal Mississippi, the influence of widespread Louisiana wetland restoration on storm surge levels in Mississippi, and the influence of Mississippi barrier island restoration on storm surges in Louisiana. Results from these applications are presented later in this chapter.

11.3 REGIONAL SALINITY/WATER QUALITY MODELING

In addition to regional influences on storm surge and waves, construction of large-scale levee systems or other man-made barriers, restoration of barrier islands that might involve increasing an island’s footprint or length, or wetland restoration on a large scale, all have the potential to influence water exchanges and current patterns during normal tidal action and typical wind conditions. Such persistent changes to the hydrodynamic regime can alter salinity and water quality regimes leading to changes to habitat. These types of influences have not yet been examined in detail in either the LaCPR or MsCIP studies.

Wetland restoration measures proposed for construction in the MsCIP study are relatively small-scale features within small estuaries, and the barrier island changes proposed for construction in the MsCIP study do not involve significant changes to the barrier island footprints. Therefore regional-scale influences on salinity and water quality due to these alternatives are not expected to be significant. Wetland restoration and barrier island restoration at a much larger and widespread scale are being considered in the LaCPR study. These restoration measures can induce significant regional changes in terms of salinity, water quality and habitat and, therefore, will be examined in more detail in the future.

11.3.1 Consideration of Freshwater Diversions

Several alternatives are presently being considered in both the MsCIP and LaCPR studies to divert freshwater from the Mississippi River or other sources as a mechanism for promoting a reversal of a historic increase in salinity in the Mississippi Sound/Biloxi Marsh area. The intent of the diversion is to build wetlands, support fresher marshes and improve oyster reef health and productivity thus enhancing both their economic value and the ecological services they provide. However, the water diverted from riverine sources not only has lower salinity, but usually carries more sediment and nutrients than marine water. Diversions may result in areas of excess nutrients and thus cause algal blooms and eutrophication, greater light attenuation, and changed substrate characteristics, so their system-wide impacts need to be carefully evaluated. Spatially-explicit evaluations of habitat change over large areas are required for such system-wide impacts.

Stated goals for the freshwater diversions in the lower Mississippi River/Mississippi Sound area include the following:

1) The enhancement of oyster resources in the Bay St. Louis area;

2) Desire to maintain oyster and shellfish resources in the Lake Borgne area;

3) The return of the ecosystem to historical salinity conditions;

4) The utilization of Mississippi River sediments to build and support wetland development;

5) The return of wetlands to a “fresher” condition, with particular emphasis in restoring areas of historical cypress forests.

These goals may in fact compete with one another, and may not be able to be met simultaneously. In addition, other competing resources in the system include the presence and location of shrimp fisheries, the survival and restoration of seagrass beds and the presence and survival of gulf sturgeon, a federally-listed, threatened subspecies. Therefore, any proposed diversion alternative needs to be carefully evaluated in order to fully understand the positive and negative aspects of various diversion scenarios and to assess their ability to meet any or some of the goals listed above.

11.3.2 Initial Model Development

To initiate evaluation of freshwater diversions, a regional water quality model (WQM) has been developed. The WQM, which is based on the CE-QUAL-ICM water quality model code, has been coupled to output from a three-dimensional hydrodynamic model of the region, which is based on the CH3D hydrodynamic model. The horizontal model grid (see Figure 11.3.3-1) extends seaward beyond the Chandeleur Island and includes Mobile Bay, Lake Borgne, Lake Pontchartrain, the Inner Harbor Navigation Channel of New Orleans and the Mississippi River Gulf Outlet Channel; and it includes all the major tributaries that introduce fresh water into the system, from the Tickfaw and Amite Rivers west of Lake Pontchartrain to the Mobile River in the east end of the grid. The model simulates changes in water quality constituents, including nutrients, phytoplankton, dissolved oxygen, temperature, salinity, and underwater light intensity.

11.3.3 Present State of the Regional Salinity/Water Quality Model

The regional salinity and water quality model has been extensively validated for the Mississippi Sound region, as part of previous work done by the ERDC and Mobile District. The model has not yet been as extensively validated for the Lake Pontchartrain and Biloxi Marsh areas; however, in light of past experience with the model in numerous studies, it is expected that the current state of the model is yielding reasonable results in this region for the purposes of the screening-level studies that have been conducted to date to examine the possible benefits of freshwater diversions.

To more accurately answer detailed questions about changes to salinity and water quality, and to answer them with greater confidence (a level which can withstand a high

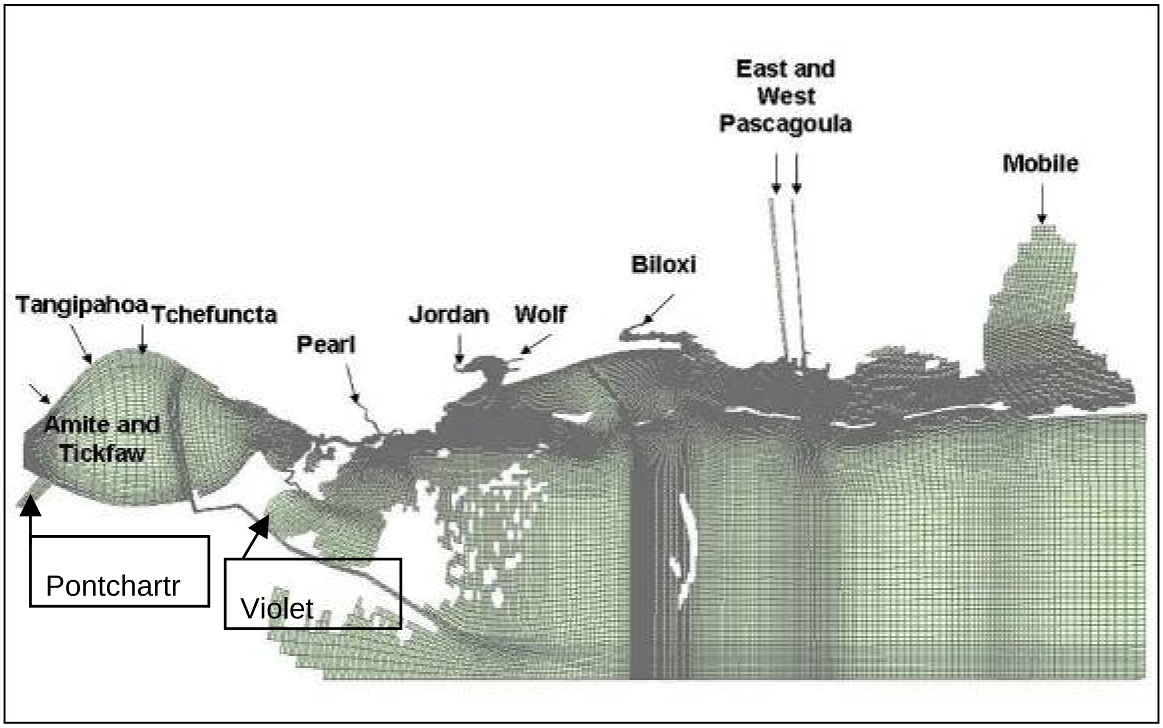


Figure 11.3.3-1. The model domain for the 3-D current hydrodynamic/water quality model, WQM

level of technical scrutiny), additional resolution and model refinement and validation, is needed. To answer more detailed questions about how changes in sedimentation, salinity and water quality translate to changes in landscape and habitat, additional model development, testing, and validation will be required. Requirements are discussed later in this chapter where the path ahead is discussed. Also note that the WQM model domain does not cover the entire coast of Louisiana. To properly examine questions regarding regional salinity, water quality and habitat questions throughout coastal Louisiana, the regional water quality model would have to be extended into those areas with a consistent level of resolution and detail, and be developed further in concert with work that is underway by Louisiana State University on habitat and ecological responses. For example, there might be regional influences in Texas associated with alternatives that are developed for western Louisiana. The need for expansion of the model will depend on the specific project alternatives that surface as preferred alternatives within the LaCPR study.

To date, the WQM has been applied to examine freshwater diversions at three locations: (1) diversion from the Mississippi River at Violet Marsh, (2) diversion of all of the Escatawpa River flow into Grand Bay, and (3) diversion from the Mississippi River at Bonnet Carre' spillway. Locations of these three diversions are shown in Figure 11.3.3-1 (annotated with boxes). Results were evaluated for several scenarios and compared to modeled existing baseline conditions to assess relative changes in the various water quality parameters. Results from these applications are discussed later in the chapter.

11.3.4 PRELINARY ASSESSMENT OF ACROSS-REGION INFLUENCES

11.3.4.1 Lake Pontchartrain Surge Reduction plan.

In general, there were four ADCIRC grids (levee alignments) used to investigate the feasibility of blocking or reducing the storm surges from entering Lake Pontchartrain via the tidal passes from Lake Borgne to Lake Pontchartrain and via overtopping of the land bridge that separates Lake Pontchartrain from Lake Borgne. The ADCIRC grids were designated as Grids A, B, C and D. See Figures 11.3.4.1-1 through 11.3.4.1-4.

Grid A was developed essentially as a theoretical plan that was designed to study the maximum reduction in surge responses in Lake Pontchartrain by eliminating any inflow into Lake Pontchartrain regardless of the intensity and surge heights in Lake Borgne. The features of this plan called for non-overtopping gated closure structures in the Chef and Rigolets Passes and connecting levees that were set sufficiently high so as to prevent overtopping from any of the storms used in the JPM-OS application. Grid A therefore isolated Lake Pontchartrain from having additional water volumes inflowing into the lake and restricted surge responses in the lake to the maximum extent possible.

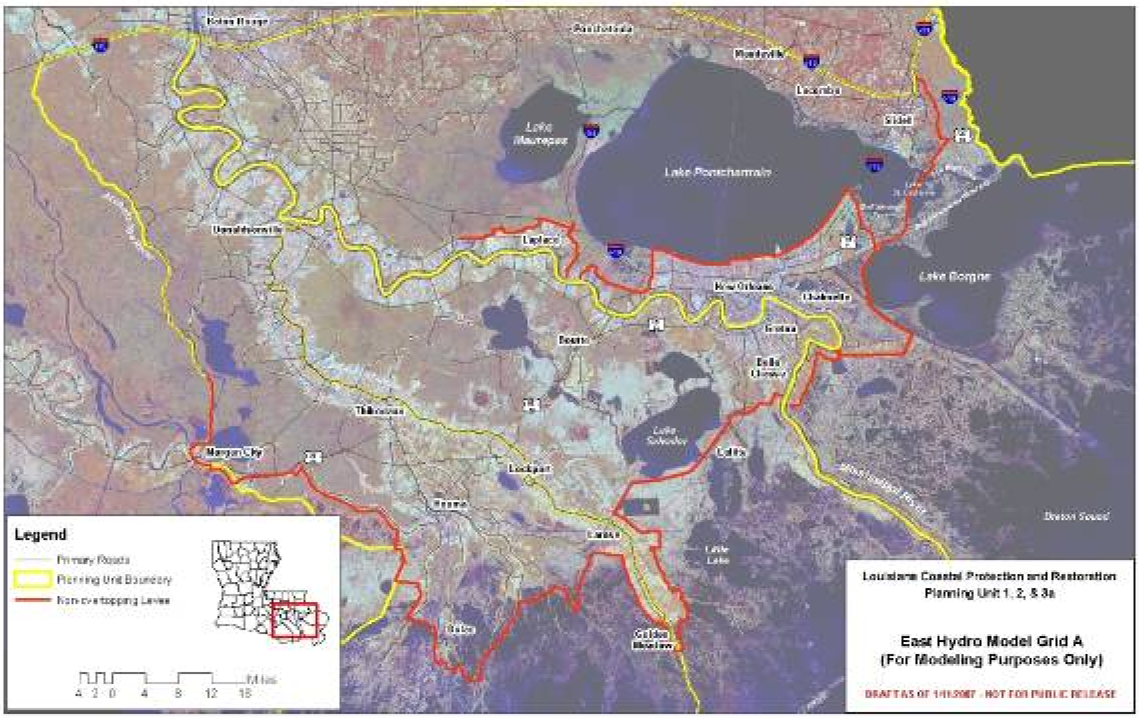


Figure 11.3.4.1-1. LACPR Model Grid A

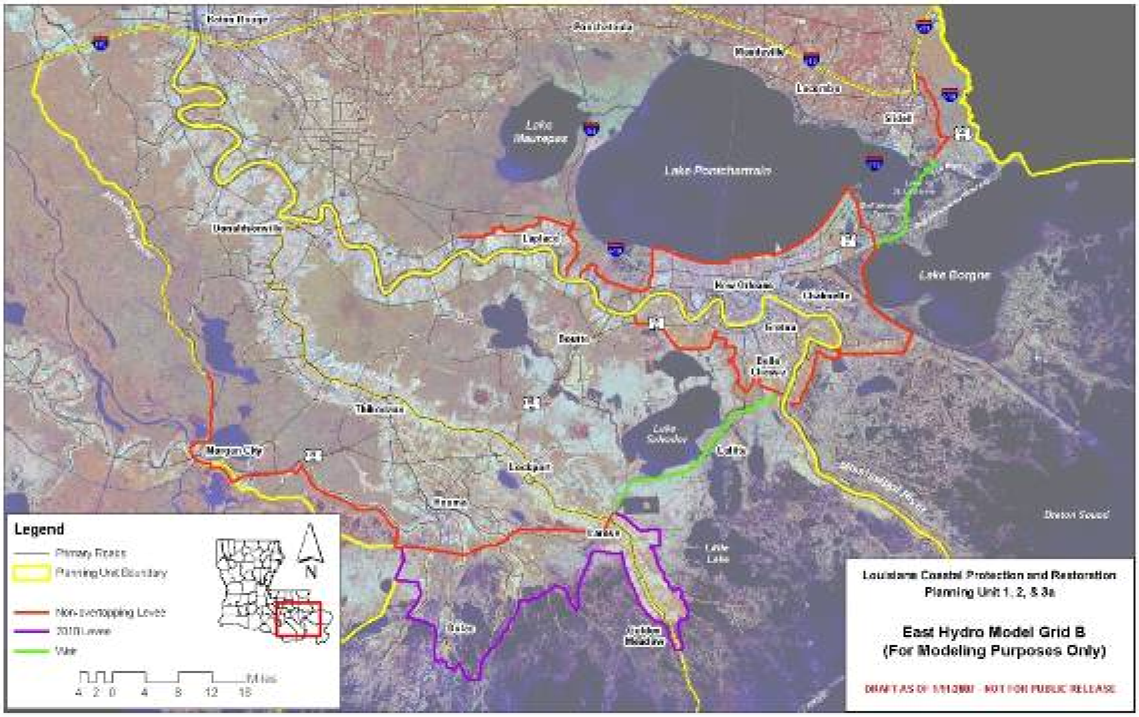


Figure 11.3.4.1-2. LACPR Model Grid B

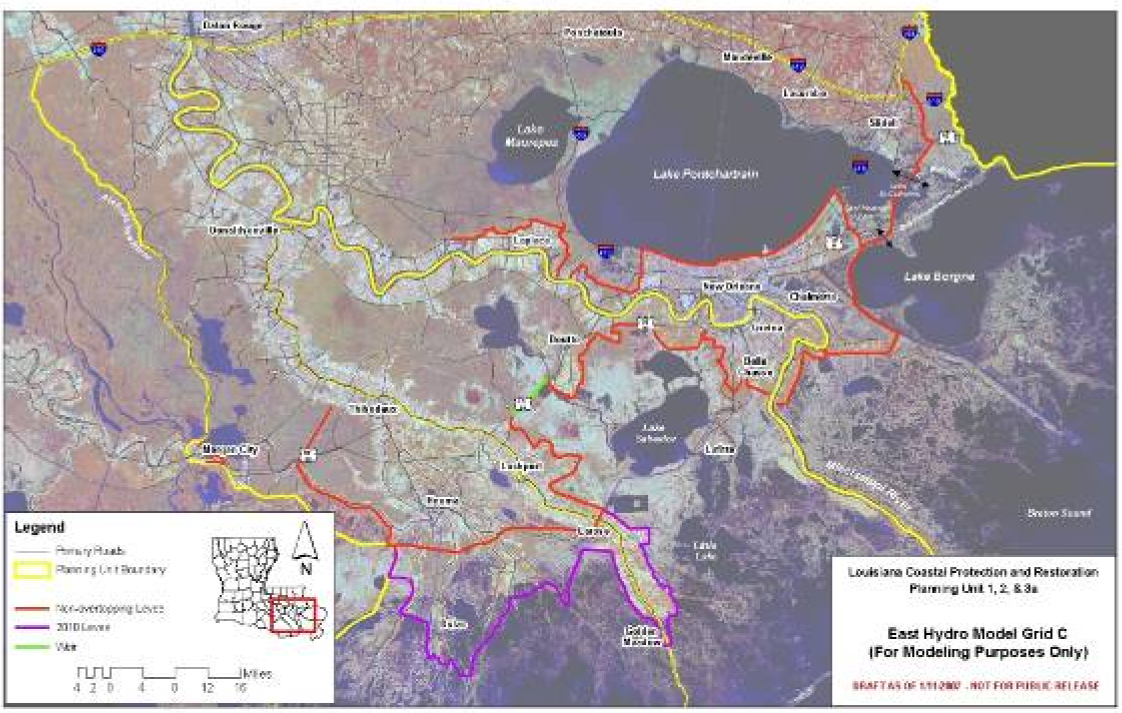


Figure 11.3.4.1-3. LACPR Model Grid C

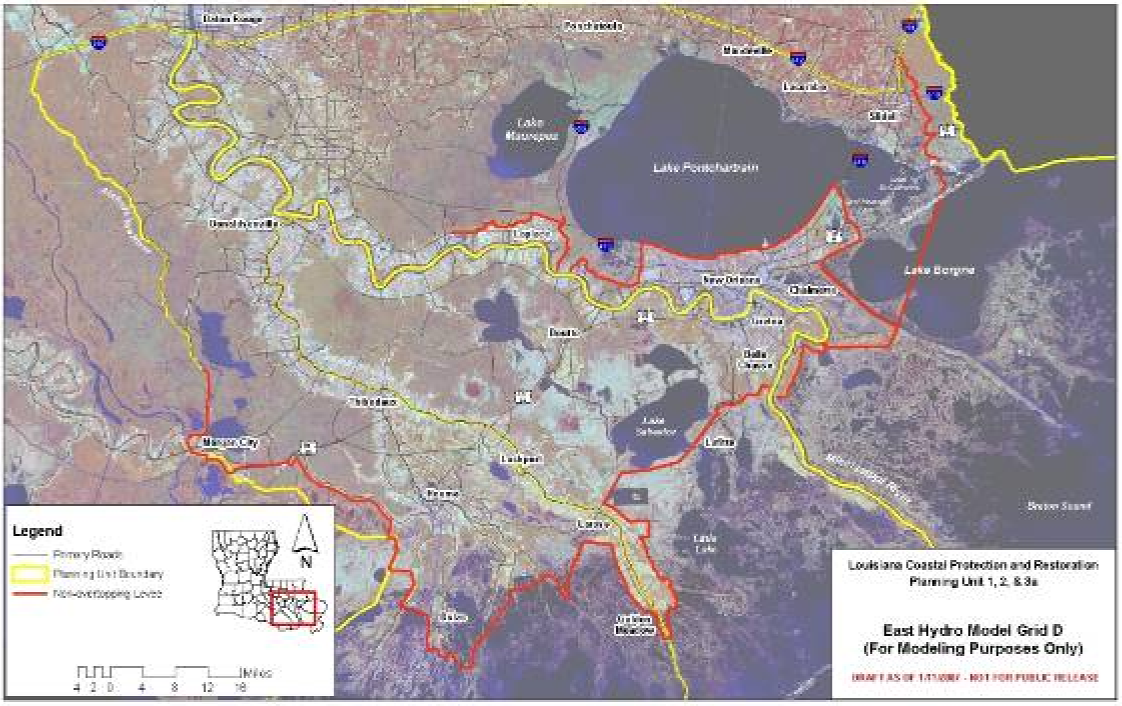


Figure 11.3.4.1-4. LACPR Model Grid D

Note that Grid A was not considered feasible and was eliminated due to the extreme height of the levees required to prevent overflow and the large increases in water levels in Lake Borgne and the Mississippi Sound.

Grid C contained the same non-overtopping levees but the gated control structures proposed for the Chef and Rigolets passes were removed from the grid so that the passes were left open during the hurricane simulation. The plan calling for removal of the control structures was suggested as an environmental plan by the US Fish and Wildlife Service. It was found that the surge responses in and around Lake Pontchartrain for this grid were essentially the same as with the Base 2010 Grid which represents the authorized 100-year hurricane protection system. Therefore the Grid C plan was eliminated as not being effective.

Grid D involved a barrier at a different location compared to the other barrier plans. Results for Grid D were similar to those for Grid A in that there were significant lowering of water levels in Lake Pontchartrain but outside stages were increased due to the Grid D levee alignment having closer proximity to the Mississippi Gulf Coast. Therefore the Grid D plan was eliminated from further consideration. Elimination of the alternatives reflected in Grids A and D were based in part on cross-region influences of these alternatives.

The Grid B, the Lake Pontchartrain surge reduction plan, essentially follows the Grid A alignment and has similar closures at the tidal passes. The connecting levees in grid B were, however, set to a lower elevation so that the levee would function as a weir and the more intense or severe storm surges would overtop this system and enter the Lake Pontchartrain Basin. The Grid B plan also showed substantial reduction in surges in Lake Pontchartrain; however, it caused increases in water levels on the Lake Borgne side of the proposed alignment and the Mississippi Sound. Figures

11.3.4.1-5 through 11.3.4.1-7 show the increase in water levels on the outside of the Grid B Pontchartrain surge barrier structure for the 100, 400 and 1000 year frequency events. It should be noted that due to the limited time for conducting the LACPR work an optimization of the weir height for a proposed surge reduction plan was not done. However, the results suggest that adjustments to the weir height could lead to perhaps a more cost effective plan that maximizes risk reduction and minimizes costs over the entire Louisiana/Mississippi project area. Should a surge reduction plan move to the next phase of planning, then a comprehensive assessment of weir elevations will be performed to evaluate any impacts.

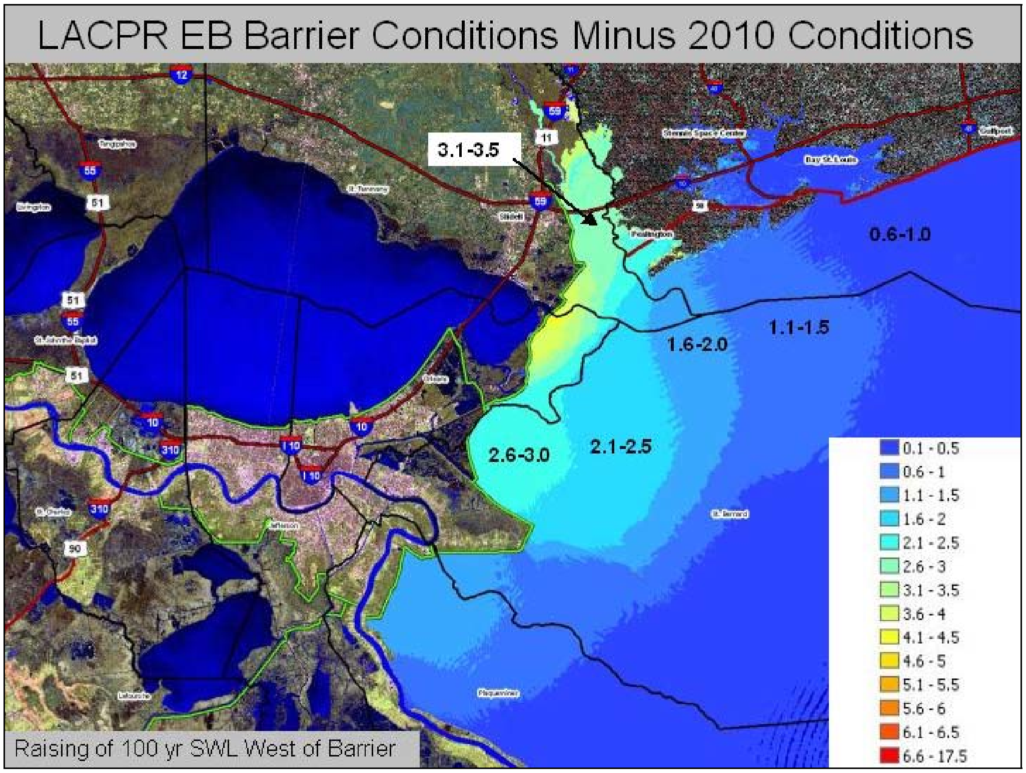


Figure 11.3.4.1-5. Regional-scale changes to 100-yr storm surge levels associated with the Grid B being considered in the LaCPR study

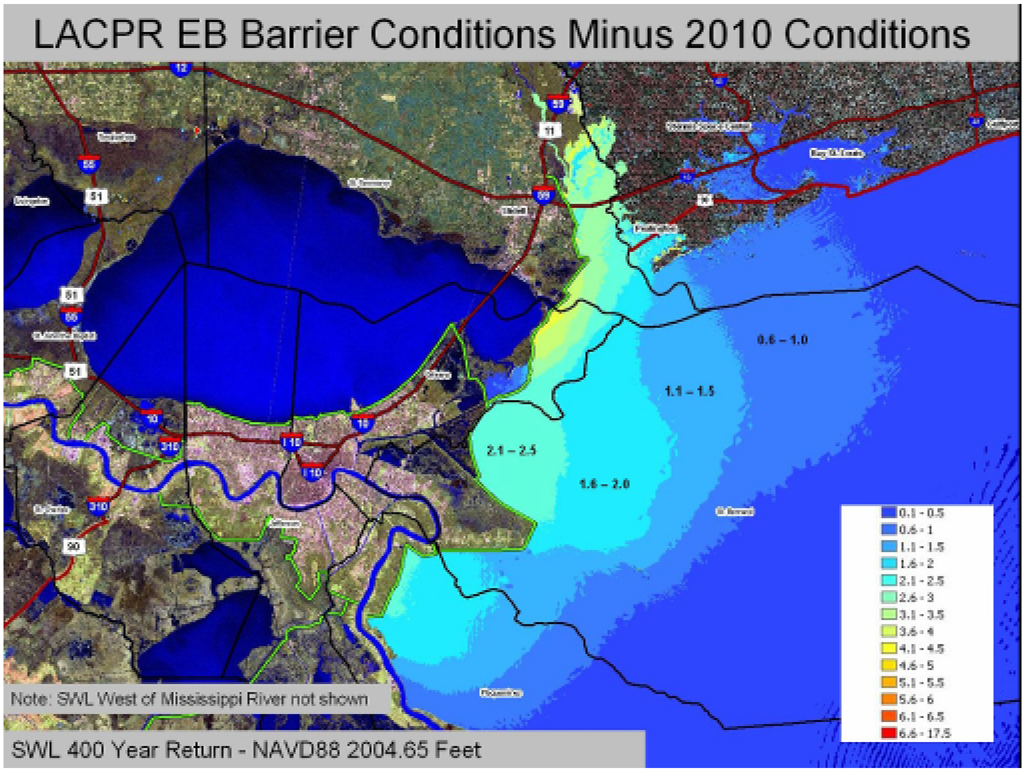


Figure 11.3.4.1-6. Regional-scale changes to 400-yr storm surge levels associated with the Grid B being considered in the LaCPR study.

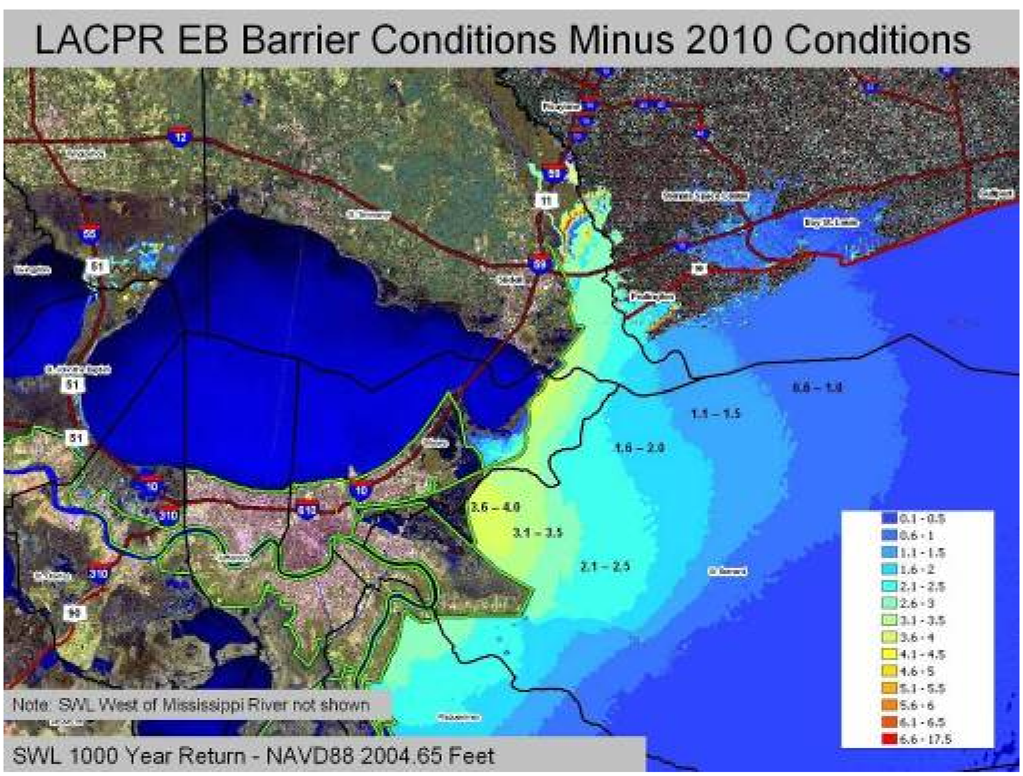


Figure 11.3.4.1-7. Regional-scale changes to 1000-yr storm surge levels associated with the Grid B being considered in the LaCPR study

11.4 Mississippi Barrier Island Restoration

The options being considered for MsCIP include potential projects involving the placement of sand in two of the planning zones, the Offshore Zone which includes the barrier islands of Mississippi, and the Coastal Zone which includes the mainland beaches of Mississippi. The barrier islands are mostly owned by the National Park Service (NPS) and are included in the Gulf Islands National Seashore. The mainland beaches are all man-made and stretch along about 40 miles of Mississippi's coast.

Immediately following Hurricane Katrina, the State of Mississippi proposed restoring the barrier islands back to a pre-Hurricane Camille condition with the concept that this would reduce storm surge on the mainland. Analysis of the land loss among the four islands indicated that from 1917 to 2006 (post-Katrina) over 1600 acres of the islands had been lost. To return the islands back to a 1917 footprint, approximately 66,000,000 cubic yards of sand of a quality similar in color, grain size, and roundness to the sand that currently comprises the barrier islands would be required. The NPS had concerns over the State's proposal because it directly contradicted their policy of letting nature take its course unless it was to restore by mitigating for the activities of man or to protect historical sites within Park boundaries.

Studies by the USGS and ERDC showed a continuing trend in erosion of the islands and that West and East Ship Island would probably be totally lost in the future. Loss of the islands would also be expected to drastically change the ecology of the estuary formed between the islands and the mainland. With all these considerations, the NPS and USACE formulated a plan (referred to as the NPS Plan) for the barrier islands that would help mitigate some of the loss at the islands due to frequent intense storms, relative sea level rise, and anthropogenic activities that may have resulted in a reduction in sand supply and prolong the existence of the islands. This plan includes direct placement of sand to fill a breach in Ship Island, commonly called Camille Cut that has existed since Hurricane Camille, add sand to the littoral zone in two areas, and proposed changes in the disposal practices of littoral zone sediment removed from local navigation channels.

The proposed restoration of barrier islands has regional implications with respect to sediment sources that are required to achieve the restoration and may have impacts on storm surge in Louisiana. Landscape features such as barrier islands have the potential to reduce storm surge elevations. Land elevations greater than the storm surge elevation provide a physical barrier to the surge. Landscape features (e.g., ridges and barrier islands) even when below the surge elevation have the potential to create friction and slow the forward speed of the storm surge. The barrier islands serve as the first line of defense for the Mississippi coast.

The restoration of these islands is a large-scale project and regional influences on storm surge, waves and salinity/water quality should be considered. Any significant lengthening of a barrier island or reductions to the width and cross-section of gaps between barrier islands has potential for altering tidal exchange and the regional salinity and water quality regimes.

11.4.1 Assessment Approach

The impact of barrier island restoration on storm surge at the mainland coast of both Mississippi and Louisiana was assessed with a sensitivity study of various barrier island configurations. Influences on salinity and water quality have not been examined. The sensitivity study is a primarily a qualitative assessment that provides valuable information on trends and relative performance but one should be cautious about making quantitative assessments of surge reduction. The barrier island sensitivity study was conducted on a grid consistent with that applied for the IPET study. It should be noted that the analysis does not consider the morphologic changes to the barrier islands caused by erosion that occur during a storms passage. In these sensitivity tests, the barrier island cross-section was assumed to be invariant, which might be a reasonable assumption for the very high restored barrier island elevation that was considered in the sensitivity tests, but it would not be a good assumption for a low more natural Mississippi barrier island elevation. The analysis also does not consider changes in the structure of the hurricane itself due to landfall infilling phenomenon that may be influenced by landscape features such as barrier islands.

A suite of storms were identified for evaluating storm surge response to changes in barrier island configuration. The suite included two historical storms, Camille and Katrina, because those hurricanes did in fact make landfall on the Mississippi coast in 1969 and 2005, respectively. The storm simulated that would most affect the Louisiana coast was Hurricane Katrina. The barrier island configurations modeled for the historical Katrina were: 1) the existing Post-Katrina degraded condition (elevations ranging from approximately 2 to 6 ft (NAVD88 2004.65)); and 2) a Restored-High barrier island configuration with an extended (pre-Camille) footprint and an elevation of 20 ft NAVD88 2004.65. The Restored-High configuration represents a massive barrier island configuration that would be difficult to achieve; it was modeled for sensitivity purposes. The proposed restoration referred to as the NPS plan above is substantially less than the restoration modeled for sensitivity purposes and thus impacts on regional surges are expected to be much less than those reported below.

11.4.2 Preliminary Results

For the purposes of discussion and comparison, Figure 11.4.2-1 plots the difference in the Post-Katrina and Restored-High peak surge levels for simulations of Hurricane Katrina. There is a reduction in peak storm surge levels of 1.0 to 3.5 ft landward of the barrier islands and an increase in water level of less than 1 ft seaward of the barrier islands. The most significant change in peak storm surge is in the Pascagoula basin where levels are reduced 1 to 3 ft. Note that the impact of the restoration decreases moving east to west and there are smaller changes in the Louisiana area, on the order of tenths of feet. Surge reductions at the Mississippi mainland were approximately 20% in the Pascagoula area, 5 to 10% in the central part of the state, and less than 5% in Waveland. The increase in water level in Louisiana is less than 0.5 ft. The level of restoration recommended in the MsCIP study is much less than the Restored-High configuration and thus the impact on Louisiana is also expected to be less than the results presented in Figure 11.4.2-1. These preliminary results indicate that the restoration of the Mississippi barrier islands, as it is being proposed, is not likely to adversely impact storm surge levels in Louisiana. Once a barrier island restoration level is set, the specifics of the restored barrier island configuration for all islands can be used to modify the regional storm surge and wave model and simulated to more accurately estimate regional impacts. Impacts on waves and salinity should also be evaluated.

11.4.3 Regional Sediment Management Issues

The total quantity of sand required for NPS barrier island plan and mainland beach restoration is considerably less than what would be required for the total restoration of the islands, but still substantial. To fill the breach, the sand would have strict requirements on color, grain size, and roundness. In discussions with the USGS, a potential source of sand was identified at St. Bernard Shoals which is a submerged chain of barrier islands approximately 45 miles south of the Mississippi barrier islands. Both quality and quantity are assumed to be available, but further investigations are required to verify the source. Activity from oil and gas production in the local area must also be considered. Approximately 8,000,000 cubic yards of the high quality sand are needed to fill the breach. An additional 10,000,000 cubic yards of sand is being proposed for placement into the littoral zone east of East Ship Island. This sand would not require the same quality as the direct beach placement, but would still have some physical characteristics that must be considered.

If additional studies are performed on these two measures, another potential source of sand would be investigated that would be much closer to the project site and would allow the beneficial reuse of dredged material. This further study would look at historical disposal areas for the Gulfport navigation channel that crosses through the littoral zone. The sediments that are removed from the channel during routine maintenance dredging have been placed in approved disposal areas that have been used for an extended period of time. While the material placed in these areas was not segregated by grain size, there may be substantial quantities of beach quality material that has potential for use at Ship Island, either for filling Camille Cut, adding to the littoral zone, or both. Reuse of the sediments from the disposal areas would follow Regional Sediment Management practices that promote keeping sediments in the littoral system and/or beneficial use of material that is removed during both new and maintenance dredging.

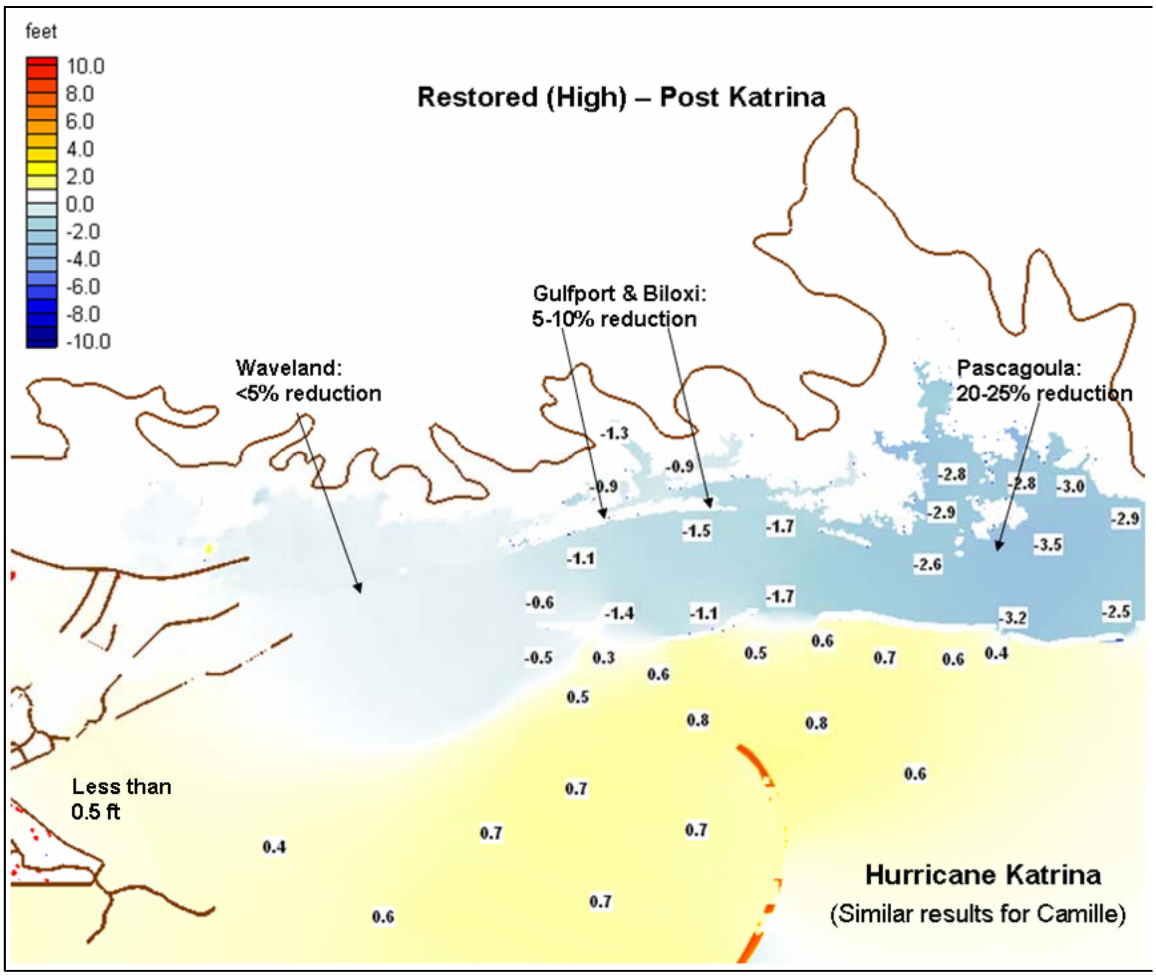


Figure 11.4.2-1. Difference in peak storm surge level (Restored-High – Post Katrina) for Hurricane Katrina

In this same local area, recent sediment transport studies have shown that westward sediment migration has been affected by the southward extension of the Mississippi River delta. This extension has cut off the littoral current and terminated the westward migration of sediments in the pass in the vicinity between Cat and West Ship Island. The fate of these sediments has not been determined, but there may be a large deposit of sand that could be used at Camille Cut or replaced in the littoral system.

Another segment of the Comprehensive Barrier Island Restoration Plan would be to add sand into the littoral zone east of Petit Bois Island. The source of this sand is proposed to be from the inland river system that flows into Mobile Bay provided that the sand is found to be compatible with sediment that exists within the littoral system. Prior to its use, these physical characteristics will be determined by sampling and testing of the inland sand for color, gradation, and particle shape (angularity). To maintain channel depths, sand is dredged from these rivers and placed in numerous upland disposal areas along the river. The lower Tombigbee River has several million cubic yards of sand stored along its banks that could potentially be used for the littoral zone placement based on the compatibility requirements mentioned above. Prior testing, including toxicity studies, has already been conducted on many of the sites. Due to the location of the disposal areas, this sand is being considered for use for the Petit Bois Island littoral zone placement. This source will provide the beneficial use of sand suitable for the littoral placement and at the same time provide additional dredged material storage capacity along the river system.

The placement of sand to fill Camille Cut and the two large littoral zone placements are planned as one-time events to restore some of the islands' land surface that may have been lost to erosion due to man's past activities or from mass erosion during storm events. This decision was based on an agreement with the NPS that allows them to mitigate ay damage from man's activities or to perform necessary means to preserve historic sites. This agreement has a positive aspect to MsCIP with the replacement of sand that has been lost from the littoral system. This sand addition will extend the life of the islands and the closure of Camille Cut will help maintain the boundaries of the estuary. It is understandably difficult to quantify either of these sand loss causes because the barrier islands themselves are dynamic systems that are undergoing constant change. The presence of two deepwater navigation channels that pass through the littoral zone have created artificial boundaries to the westward migration of the islands. The continued maintenance of these channels will require that sand and other sediments be removed, but under the guidelines of the Regional Sediment Management Practices, the sand removed from the channels will be returned to the littoral system.

The continuing study would evaluate future placement of maintenance material dredged from the Pascagoula Harbor Navigation Channel. It has been recommended that sand from the channel be placed down-drift in a newly designated disposal area located in the littoral zone near Sand Island. Much of the sand dredged in the past was placed down-drift, but was formed into a small island commonly called Sand Island. Sand Island has become a prime environmental resource vegetated with dune grasses that provide habitat to many types of shore birds. With no further sand additions, the sand within this island will probably return to the littoral system as wind, waves and currents erode the land mass.

Material removed from the Gulfport Channel has historically been placed in disposal areas south of the littoral zone. In keeping with the guidelines of the Regional Sediment Management Practices, new recommendations have been made to dispose of the material removed from the littoral zone segment of the channel. The channel at the western tip of West Ship Island is a trap for the migrating sand. It has been recommended to place the dredged sand in the littoral zone east of East Ship Island. This practice will allow the sand to nourish Ship Island and slow erosion of the land mass. How to best achieve this will be considered in the continuing study of the islands. Initial ideas include stockpiling the sand in selected areas so the material would be available in the future to relocate it into the littoral zone.

The mainland beaches that are in the Coastal Zone were created in the 1950s to provide protection to the seawalls along beachfront roads. Through time, the beaches have evolved into recreational use and environmental habitat. Some of the beaches have been periodically re-nourished by the local sponsors, primarily the counties. Options that have been studied under MsCIP have included the construction of dunes of various sizes and configurations. The sand for any dune construction will be purchased from any of numerous commercial sources along coastal Mississippi. This sand is typically of good quality and has been used in some of the past nourishments. There is also limited sand reserves available in approved borrow areas just offshore of the mainland beaches. This offshore sand is currently being used for a re-nourishment project in Harrison County.

Many of these same types of issues will be considered for alternatives that involve barrier island restoration in Louisiana. All of the sediment requirements discussed above must be considered in concert with any sand-source requirements that develop from the LaCPR study. Sediment management will be carried our in accordance with Regional Sediment Management practices.

11.5 LaCPR Wetland Restoration Plan

The LaCPR study is considering various restoration alternatives that will provide multiple benefits, particularly ecological benefits. Figure 11.5.1-1 shows an outline of the marsh restoration features being considered for eastern Louisiana. These features have the potential to reduce storm surge and wave action, and the regional implications of these projects will be considered. Landscape features such as wetlands also have the potential to create frictional resistance and affect storm surge even when vegetation is inundated by the storm surge.

11.5.1 Assessment Approach

The impact of wetland restoration on storm surge at the mainland coast of both Louisiana and Mississippi was assessed with a sensitivity study. The sensitivity study was primarily a qualitative assessment that provides valuable information on trends and relative performance but one should be cautious about making quantitative assessments of surge reduction. It should be noted that the analysis does not consider the morphologic and vegetation cover changes to the wetlands caused by erosion and/or damage to vegetation that occurs during a storm's passage. The analysis also does not consider changes in the structure of the hurricane itself due to landfall infilling phenomenon that may be influenced by landscape features such as wetlands.

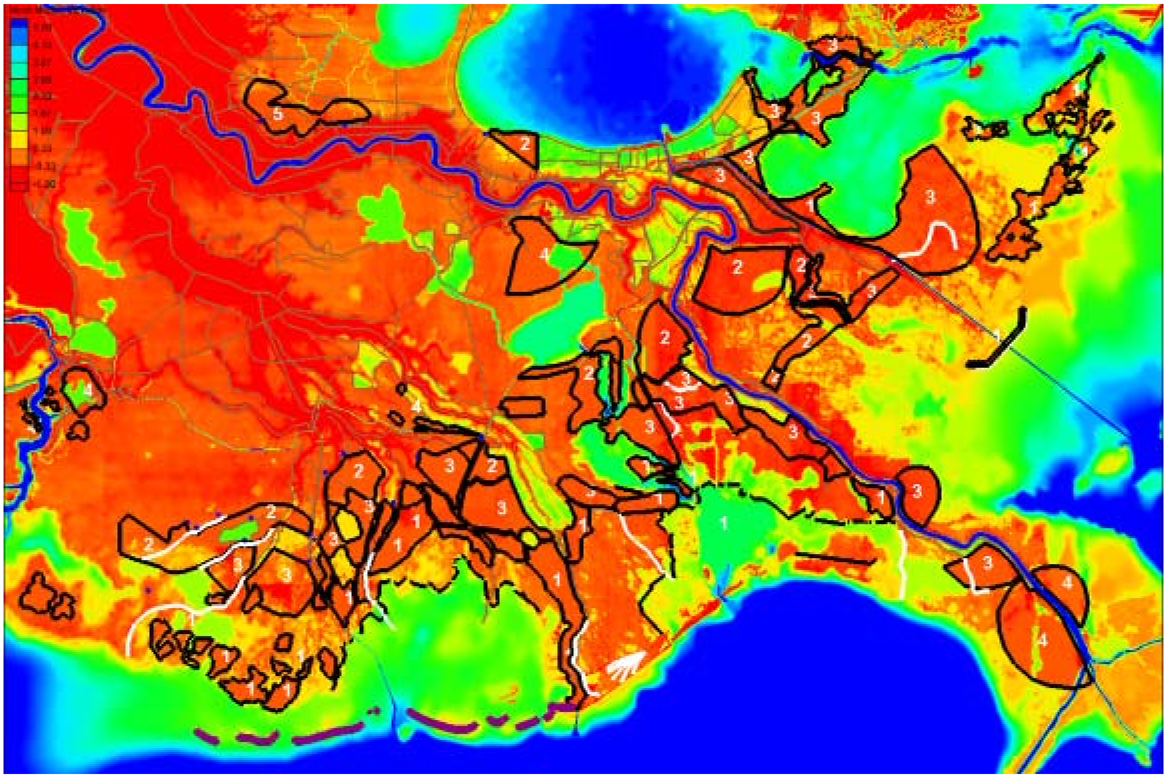


Figure 11.5.1-1. Outline of marsh restoration features. Marsh types are outlined as follows: 1 = saline, 2 = intermediate, 3 = brackish, 4 = fresh, 5 = cypress, white lines = ridges, purple = shrub/scrub for barrier islands. Colors indicate topographic/bathymetric elevation.

The restoration features outlined in Figure 11.5.1-1 were represented in the regional storm surge and wave model through modifications to the bathymetry, Manning's n values, and directional roughness lengths. A suite of 24 hypothetical storms was simulated on the restored condition and maximum water elevations were compared to maximum water elevations for the base condition.

11.5.2 Preliminary Results

Figure 11.5.2-1 presents the difference in maximum water level between the restored marsh configuration and the base case for the suite of 24 storms simulated for the immediate metropolitan New Orleans area. Note that the scale uses the color white to denote areas where changes in peak surge level are between + 1 ft and -1 ft. The wetland restoration has less than 0.5 ft impact on surge levels in both Louisiana and Mississippi. Based on these preliminary results, wetland restoration activities in Louisiana are not expected to adversely affect storm surges in the Mississippi area.

In a general sense, the influence of wetland restoration activities on storm surge and waves will be local in nature and relatively small for the types and spatial-scale of wetland restoration that are being considered and proposed in both the LaCPR and MsCIP studies. Impacts on waves may be greater than impacts on storm surge, but they are expected to be more local and are not expected to have significant regional influences outside the local area. For example, the wetland restoration proposed in the MsCIP study is local, and will not have significant storm surge or wave influences in Louisiana.

Figure 11.5.2-1. Difference in maximum surge level (ft) between the restored marsh configuration and the base case for the restored marsh storm suite

11.6 Mississippi River Diversions

The regional salinity and water quality model, WQM, has been applied to three alternative locations: (1) diversion of freshwater flow from the Mississippi River at Violet Marsh, (2) diversion of all of the Escatawpa River flow into Grand Bay, and (3) diversion of freshwater flow from the Mississippi River at Bonnet Carre' spillway. The purpose of these screening-level simulations was to examine whether or not freshwater diversions at these locations could produce reductions in salinity of a magnitude that are needed to achieve some of the objectives outlined previously for diversions.

11.6.1 Assessment Approach

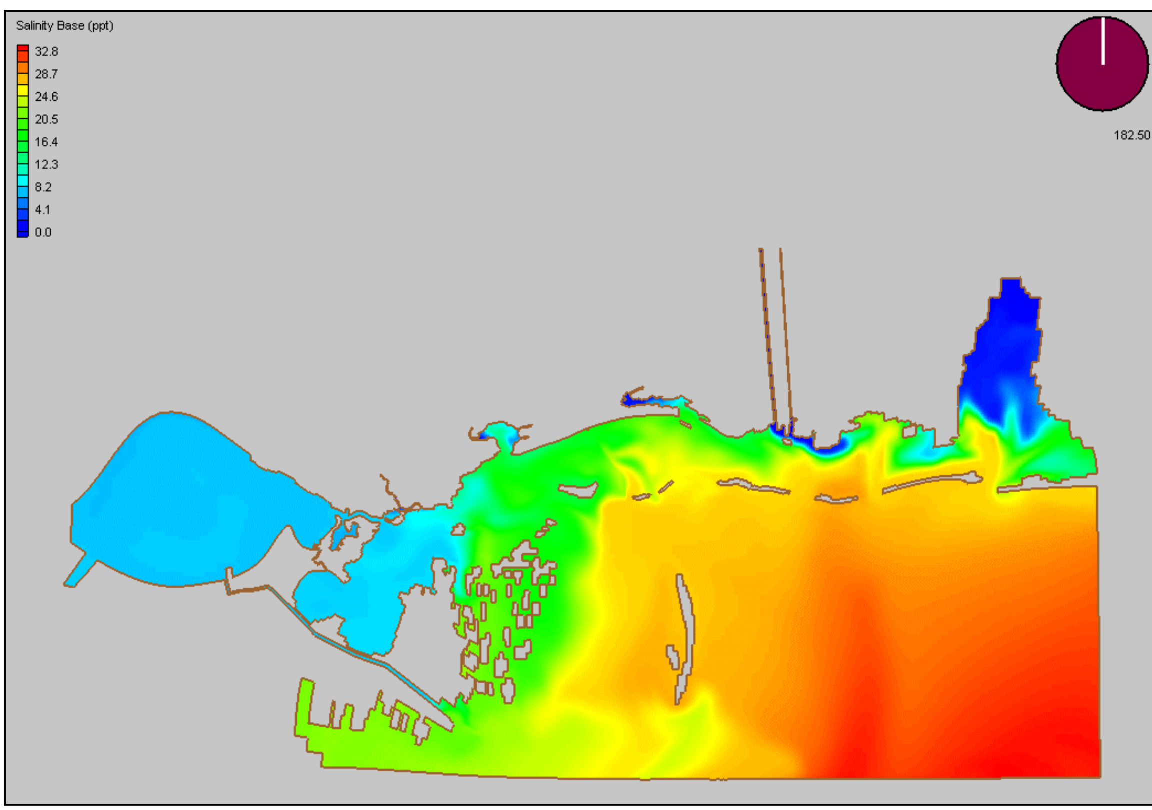
A small range of potential diversion scenarios have been run and are reported in the appendices in the MsCIP report (Dortch et al. 2007). A limited number of operational schedules were considered. For example, the discharge from the Bonnet Carre' diversion was varied by month. The Violet Marsh scenario was a diversion with a constant flow of about 210 cu m/s (7500 cubic feet per second, cfs). The Escatawpa diversion scenario was the flow that occurred in the entire Escatawpa River during 1998. The hydrodynamic model was run with the same conditions as used for the base conditions used in the WQM calibrations for 1998 except that the additional freshwater flows were introduced. The WQM was applied for the period April through September 1998 using the same inputs as the final calibration run except for different hydrodynamic input and different boundary conditions for the diverted flow and associated concentrations of the flow.

11.6.2 Preliminary Results

As an example, the results from a simulated diversion of 7,500 cfs of Mississippi River water near Violet, Louisiana, are presented in Figure 11.6.2-1. The top panel of Figure 11.6.2-1 presents salinity results after 180 days for the baseline condition without a diversion; the bottom panel shows results after 180 days for the simulated Violet diversion. The results suggest that 180 days after initiation of the diversion, salinities were lowered in western Mississippi Sound sufficiently to warrant additional examination. However, at present, absolute salinity values predicted by the regional salinity/water quality model need to be improved to match calibration data. Further refinement of the model should correct this limitation and must be made to improve its potential to quantify the potential beneficial or deleterious effects on oysters and other coastal resources.

Preliminary efforts were made to relate the WQM model results to ecological communities by utilizing oysters as a "target species." Oysters not only support a commercial fishery but interact directly with local hydrodynamic conditions, affecting currents, flow conditions, and sedimentation patterns (Lenihan 1999). They filter large amounts of phytoplankton and detritus exerting a powerful influence on water quality, phytoplankton productivity, and nutrient cycling of estuaries (Dame 1996). Oyster reefs provide habitat for a wide range of other invertebrates present either on the oyster shell itself or in the interstices between shells. Oyster reefs also support numerous resident, transient, and juvenile fish and decapod species and may provide a refuge from predation and poor water quality conditions.

Oysters are sensitive to specific ranges of salinity; therefore, freshwater diversions have the potential to either enhance or threaten the resource. For instance, where the average salinity exceeds 15 ppt oysters often experience increased predation rates by oyster drills whereas young oysters are more susceptible to certain diseases at salinities greater than 9 ppt (Cake 1983; Chatry et al. 1983). Similarly, salinities averaging below 7.5 ppt can inhibit oyster growth and sexual maturation while salinities that persist for extended periods of time below 2 ppt can result in direct mortality (Sellers and Stanley 1984, 1986). The relationship between oyster productivity and river flow is a complex one and there does not appear to be a close link between oyster harvests and freshwater inflow (Turner 2006).



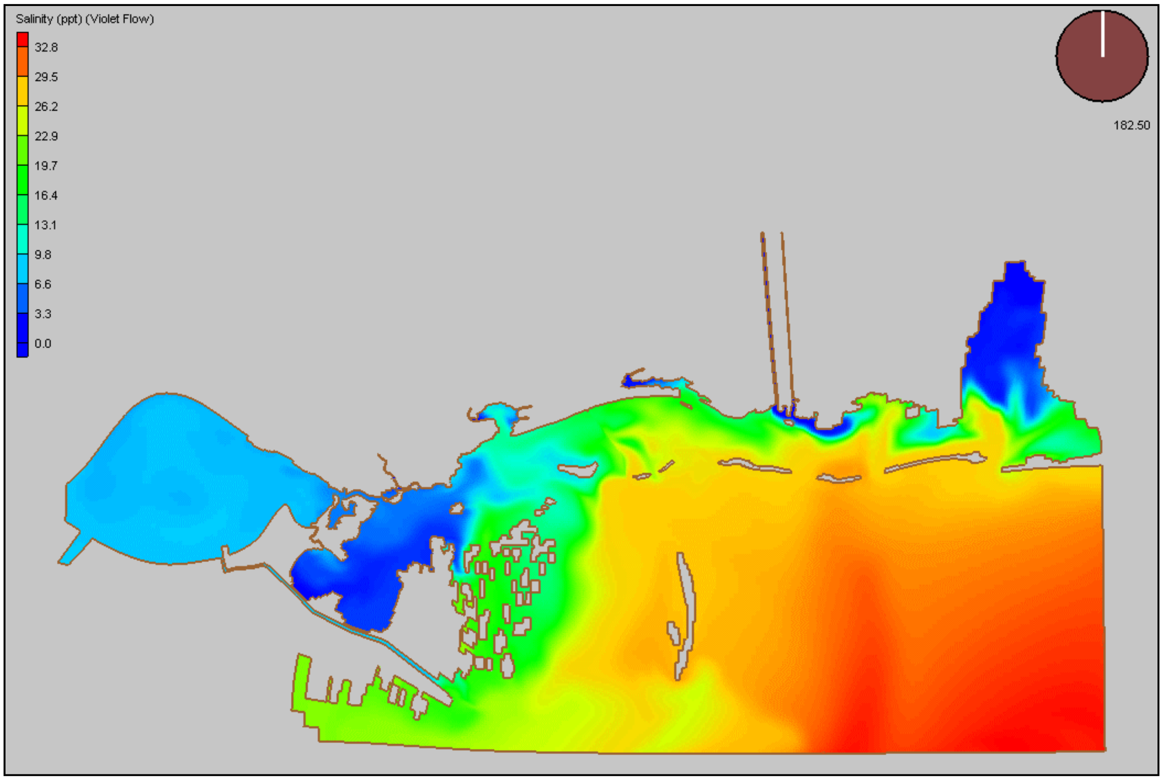


Figure 11.6.2-1. Baseline (upper panel) and projected with-diversion (lower panel) salinity values in parts per thousand (ppt) after 180 days. The royal blue color represents freshwater, while the red indicates sea water with salinity concentrations greater than 30 ppt.

To further refine the ecological concerns, during the summer and fall of 2007, MsCIP and ERDC convened a panel of representatives from the Nature Conservancy, Mississippi Department of Marine Resources, and the University of Southern Mississippi at the Gulf Coast Research Laboratory. The aim of the panel was to suggest simplistic ecological models that can be informed by results from the regional salinity/water quality model to identify diversion actions which might result in an improvement in oyster habitat quality. The panel identified several key attributes that need to be incorporated into the evaluation of freshwater diversion options. The first is that salinity averages should be as close as possible to the optimal range for oyster health and productivity. This is clearly of critical importance since the primary purpose for contemplating freshwater diversions is to improve habitat conditions for oysters. Second, a diversion should not result in extended periods of low salinity resulting in mortality or poor growth and reproduction. This consideration is particularly critical during times of high river flow or other extreme conditions. Third, a diversion should not unduly influence habitat conditions for other critical resources. Diversions that result in favorable conditions for oyster health may not be conductive to other equally important resources. For instance, most seagrasses do poorly at salinities less than 20 ppt. A diversion that results in excellent conditions over the prime commercial oyster beds but drives salinities below 20 ppt in the seagrass elsewhere would not be acceptable. Other important habitat requirements that should also be considered for seagrass health include light availability and nutrient concentrations.

During the autumn of 2007, several meetings with representatives from the States of Mississippi and Louisiana, non-governmental organizations such as the Lake Pontchartrain Foundation and the Environmental Defense Fund, various federal agencies, including US Fish and Wildlife Service, and representatives from both Mobile and New Orleans Districts have been held to discuss options, centering on details associated with a Violet Diversion. Additional work will be required to refine the

WQM regional model and apply it to examine the regional influences of proposed freshwater diversion projects on salinity, water quality and habitat.

11.7 PATH AHEAD

11.7.1 Continued LACPR-MSCIP Northern Gulf of Mexico Planning and Analysis

During the next steps in plan development in the LaCPR and MsCIP investigations beyond December 2007, the joint study teams will collaborate at a Northern Gulf of Mexico integrated systems scale. The purpose of this effort will be to identify common stakeholder agreement on the configuration, performance, and cost of alternatives with a goal of achieving no adverse impacts, levels of risk reduction, and coastal restoration in those plans. The LaCPR and MsCIP teams will hold joint meetings with stakeholders of the coastal areas in Louisiana and Mississippi during the winter-spring 2008 timeframe to accomplish this task, as follows:

- Explain the process on how the range of alternatives were initially developed in both projects for coastal restoration and risk reduction, as described in the December 2007 Technical Reports for LaCPR and MsCIP,
- Present the individual elements and integrated system configurations of the array of developed alternatives that were evaluated through these investigations,
- Describe the performance, costs, and unintended adverse consequences found through modeling simulations of these alternatives,
- Solicit the viewpoints of stakeholders for both studies in joint meeting sessions to identify consensus and differences of opinion on the makeup, performance, and costs of these alternatives,
- Interact with the stakeholders of both studies for screening, refinement, and/or re-formulation of alternatives from a Northern Gulf of Mexico integrated systems scale perspective,
- Conduct iterations of planning and analysis for identifying common agreement on the configuration, performance, and cost of alternatives for attaining no adverse impacts, risk reduction, and coastal restoration, and
- Describe requirements for further alternative plan development and analysis.

11.7.2 Regional Assessment Using Surge and Wave Modeling

In its current state, the regional storm surge and wave model is ready for use in examining regional influences and interactions that are created by MsCIP projects which are slated for construction in the near-term, and proposed LaCPR measures that remain in the final array of alternatives after the screening process. The alternatives proposed for construction in the MsCIP study and the most likely LaCPR alternatives will be evaluated using the regional storm surge and wave model to address regional influences of the proposed projects. Alternatives will be evaluated by the teams' storm surge and wave experts for the potential to produce significant regional influences. That evaluation will be reviewed and concurred upon by the external peer reviewers for both projects and those alternatives will be assessed based upon regional storm surge and wave influences. All proposed projects/alternatives will be integrated into the regional storm surge and wave model and compared to results for the 2010 baseline case. By comparing the results to those obtained for the baseline case, the MsCIP and LaCPR study teams can evaluate the regional influence of the proposed alternative(s).

Together, the MsCIP and LaCPR study teams, along with key stakeholder representatives, will evaluate the issue of regional storm surge and wave influences and assess whether or not there is a significant regional influence, and if so jointly decide whether any additional risk is acceptable, whether the project(s) must be modified to lessen the increased risk, or whether the project(s) need to be reformulated.

11.7.3 Regional Impact of the Lake Pontchartrain Surge Barrier

Analysis of storm surge barriers across Lake Pontchartrain indicates that a barrier can lead to significant undesirable increases in storm surge levels along the coast of Mississippi areas of southeast Louisiana. The increased surge levels are of great concern in light of the fact that coastal flood protection levees, revetments, or seawalls are not being pursued for construction in western coastal Mississippi. Therefore, any regional increase in storm surge levels induced by a Lake Pontchartrain barrier place the population at greater risk in an area that is already at relatively high risk of hurricane-induced flooding compared to other regions of the Gulf.

Lake Pontchartrain barriers provide considerable surge reduction benefits to certain communities around Lake Pontchartrain. The design of a storm surge barrier has not been optimized. Additional studies will be undertaken to assess the benefits of a lower surge barrier, which would likely also reduce adverse regional influences of the barrier. The regional influence issue will be addressed in the same manner as outlined above. Any barrier plan which induces adverse impacts must be eliminated from further consideration or its impacts satisfactorily mitigated on a regional basis.

11.7.4 Regional Assessment Using Salinity/Water Quality Modeling

All alternatives that involve barrier island restoration (specifically, those involving significant changes to island footprint or length), large-scale wetland restoration, storm surge barriers, or large-scale levee/floodwall systems will be evaluated for regional influences on salinity, water quality and habitat. The hydrodynamic, water quality, and habitat experts from the MsCIP and LaCPR study teams, plus outside peer reviewers for both projects, will make the assessment of which alternatives should be considered and integrated into the regional WQM model for this assessment. As was the case for the regional storm surge and wave model, the WQM model will be applied to examine regional influences of the alternatives (which fall into the categories outlined above) proposed for construction in the MsCIP study and the most preferable alternatives that surface in the LaCPR study.

The MsCIP study also is recommending construction of a freshwater diversion at Violet, Louisiana. Results achieved to date show that diversion at Violet has potential to achieve the salinity reduction that is sought for the Lake Borgne and Biloxi Marsh region in order to meet some of the objectives for diversions. It is expected that a freshwater diversion into this region will also be among the alternatives that surface in the LaCPR study. The issue of freshwater diversion into this region will be examined further, maintaining a regional perspective and building upon the work done to date to examine the relative benefits of freshwater diversions at Violet and the Escatawpa River, and Bonne Carre’ as another possible diversion. A diversion at Violet was included in the 2007 Water Resources Development Act. In addition, a diversion at Caernarvon, Louisiana also will be examined in this same regional context.

It is proposed that a bi-state group be formed to assess freshwater diversions into this particular region, with support from the Mobile and New Orleans Districts and the Mississippi Valley and South Atlantic Divisions. One of the first activities of this group will be to fully articulate the goals of the potential diversions and to reconcile conflicts between these goals. Subsequent to this, potential, realistic, operational plans will be developed so that they can be evaluated using the regional WQM modeling framework.

Refinements of the WQM model are required and they will be initiated immediately. The existing model will be expanded to the south and refined with additional resolution to include possible diversions at Caernarvon, and be readied for use in making event, seasonal and long-term simulations. Salinity changes at a number of time scales are of interest. The WQM model will be validated through comparisons to existing measured salinity and water quality data in Lake Pontchartrain, Lake Borgne, Biloxi Marsh, and the vicinity of Caernarvon in order to increase confidence in model predictions and to be able to withstand the close technical scrutiny of the modeling that is done to inform decision-making regarding this highly sensitive issue.

These model improvements will allow for more accurately relating the water quality results to ecological concepts and interpretation, and enable questions and issues that have been raised regarding diversions (pros and cons) to be more thoroughly and accurately addressed. The WQM model should be linked to ecological tools to be able to test the impacts of precise operational discharge plans and seasonal influences on key ecological resources. Our current collaboration with Louisiana State University on the ecological integration will be continued and expanded to more fully include representation from Mississippi.

Once recommended diversions and operational plans for those diversions are defined, they will be integrated into the regional WQM model, along with all the other features that are proposed for construction in the MsCIP study and proposed in the LaCPR study which have possible regional influences on salinity water quality and habitat. The modified regional model will be applied and results will be compared to the 2010 baseline condition. Differences will be examined to assess the regional performance of alternatives and to assess regional influences from salinity, water quality and habitat perspectives.

If alternatives emerge in LaCPR for regions west of the Mississippi River that have the potential for regional salinity, water quality and habitat influences, work will commence to expand coverage of the WQM to cover the areas where influences are of concern. This will be a significant effort.

11.7.5 Recommendations for Research to Benefit Regional Modeling

Both the regional storm/surge and WQM models and inferences made using the results from the WQM model to infer ecological response, have a number of areas of technical uncertainty in the model formulation and knowledge base for making interpretation and analysis. This uncertainty can only be reduced through research and development that is focused on improving model capability in the areas having the greatest uncertainty. The LCA Science and Technology program will focus on these areas of technical deficiency via collaborative research conducted by USACE, State of Louisiana, other federal agencies and the academic community.

The greatest uncertainty lies in inferences made regarding ecological response to changes in hydrodynamics, sediment loading, salinity, and water quality and how they contribute to the general process of marsh creation and ecological health. This will be one area of focused research and development. Wetland and barrier island restoration will have to be undertaken accepting the fact that adaptive management will be required. Not everything will respond as originally envisioned and planned. The system is extremely fragile and complex and knowledge and data volume/quality are poor in a number of technical areas. There are ongoing difficult-to-predict-and-quantify long-term processes like subsidence and sea level rise that complicate matters and render accurate long-term predictions to be highly uncertain and suspect. Changes to wetland restoration practices will be required, and constantly improving regional models can help better inform the adaptive management process and more accurately assess regional influences. The goal for the research and development should be reductions in the uncertainties inherit in forecasts and predictions of ecological response.

A second area for focused research will be the area of beneficial use of wetlands for storm surge and wave reduction. Considerable scientific knowledge gaps, and lack of data volume/quantity, exist in this area. Reliable use of wetlands for surge and wave reduction benefits will require increased understanding of the friction resistance and energy dissipation characteristics provided by a wide range of vegetation species, changes of resistance and energy dissipation with increasing degree of inundation, and response of the vegetation and surrounding wetlands to the destructive forces of wind and energetic waves at varying levels of inundation. The goal for the research and development should be reductions in the uncertainties inherit in forecasts and predictions of wetland influence on storm surge and waves.

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