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COMPREHENSIVE PLAN REPORT ON THE MISSISSIPPI COASTAL IMPROVEMENTS PROGRAM (MsCIP)

COMMUNICATION

FROM

THE ASSISTANT SECRETARY OF THE ARMY, THE DEPARTMENT OF DEFENSE

TRANSMITTING

RECOMMENDATION FOR THE AUTHORIZATION OF THE COMPREHENSIVE PLAN REPORT ON THE MISSISSIPPI COASTAL IMPROVEMENTS PROGRAM (MsCIP)

PART 2 OF 3

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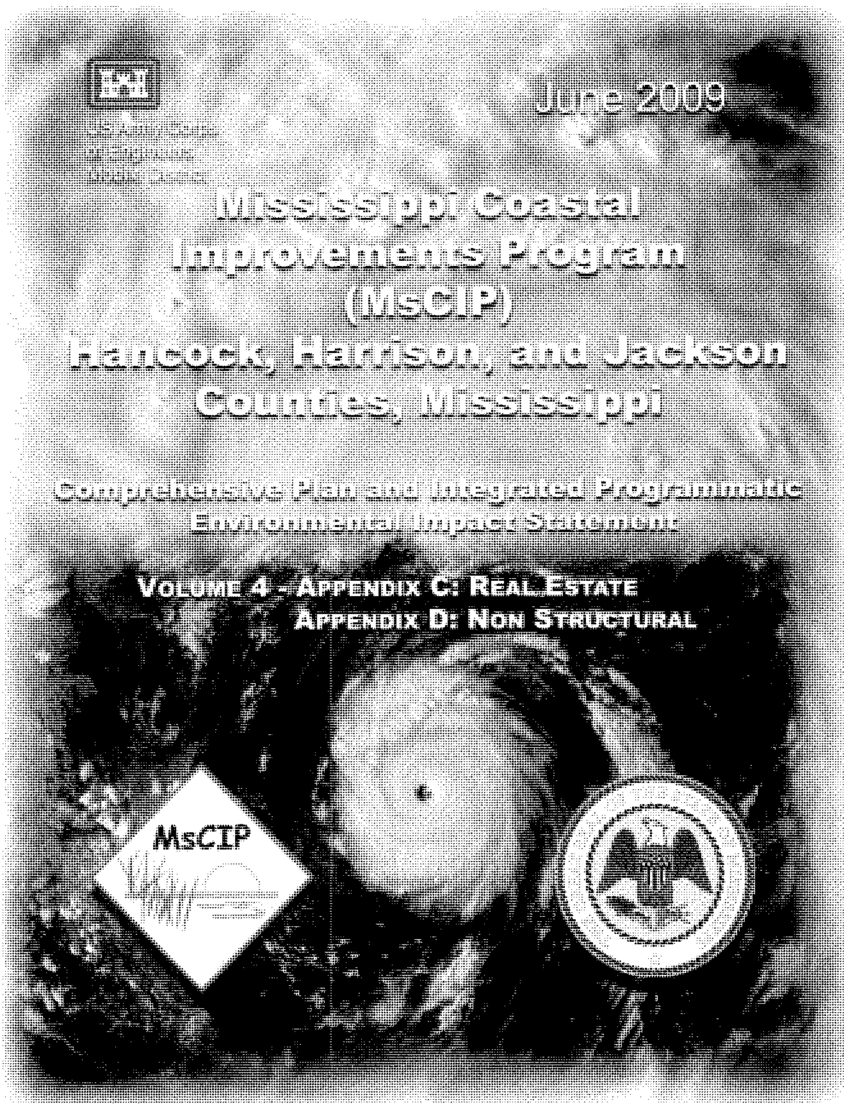
June 2009
Mississippi Coastal
Improvements Program
(MsCIP)
Hancock, Harrison, and Jackson
Counties, Mississippi
Comprehensive Plan and Integrated Programmatic
Environmental Impact Statement
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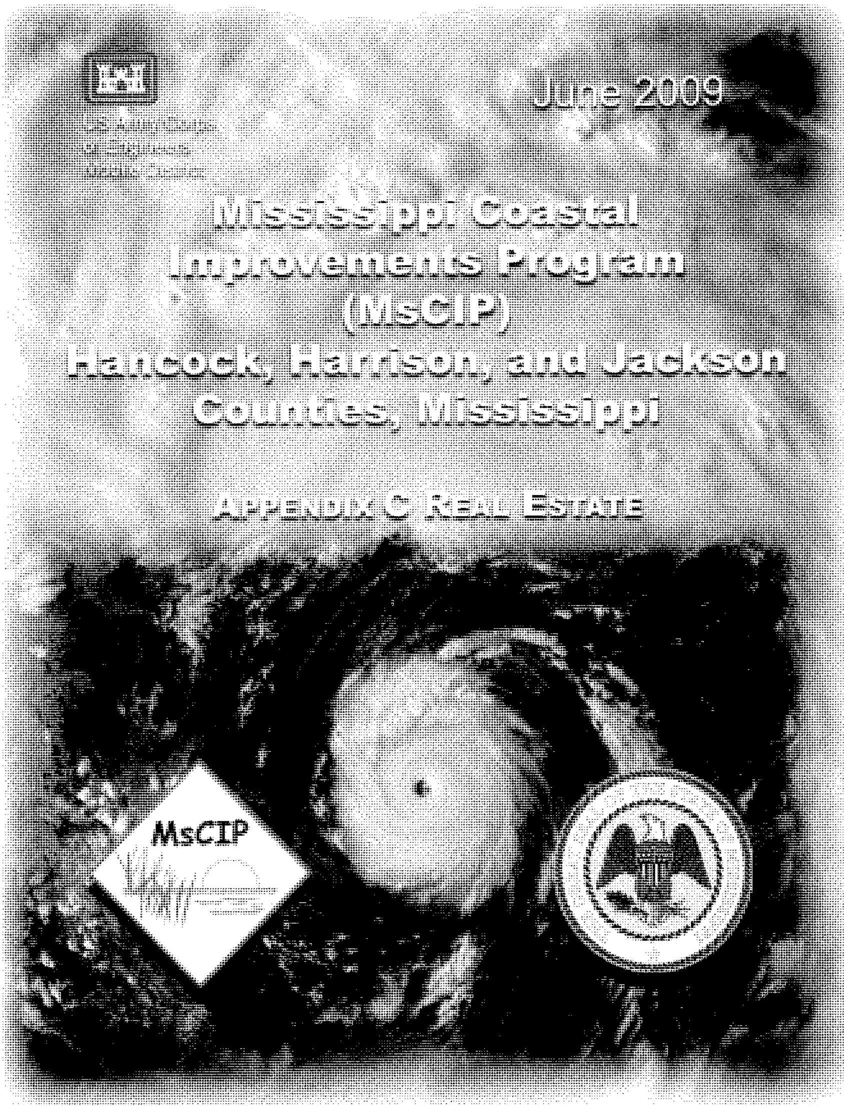
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Hancock, Harrison, and Jackson Counties, Mississippi
APPENDIX C REAL ESTATE
MsCIP

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 that 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.

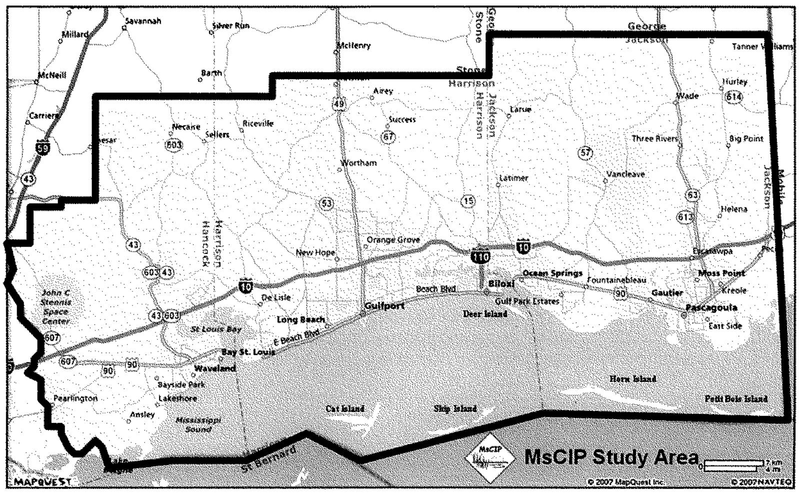

Figure 1.
The MsCIP Study Area

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.

This appendix, the Main Report/EIS, and all other appendices and supporting documentation, were subject to Independent Technical Review (ITR) and 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.

The report presents background on the counties that comprise the Mississippi coastline most severely impacted by the Hurricanes of 2005, their pre-hurricane conditions, a summary of the effects of the 2005 hurricane season, 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.

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, currently presented as tentatively-selected recommendations contained in the Main Report/EIS.

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.

The Real Estate Appendix identifies and describes the lands, easements and rights-of-way (LER) required for construction, operation and maintenance of the proposed projects. Further, the Real Estate Appendix describes the estimated LER value, together with the estimated administrative and incidental costs attributable to providing project LER, and the acquisition process.

The report is not written to the full feasibility level of detail and defers issues pertaining to borrow and disposal sites and facility/utility relocations for further study during Pre-Construction, Engineering and Design (PED) Phase when more specific information is available. At that time those Real Estate Plans for projects recommended for further study will be revised to incorporate new data and information.

REAL ESTATE SUMMARY

The Real Estate Appendix is written to support the Mississippi Coastal Improvements Program (MsCIP) - Comprehensive Report. The Real Estate Appendix discusses the land requirements associated with each of the different alternatives studied for long term protection of the Mississippi Coastline that includes portions of Hancock, Harrison and Jackson counties. The alternatives under consideration which have real estate requirements are identified as Lines of Defense 1, 2, 3, and 4 along with Nonstructural Acquisition and Ecosystem Restoration areas. It is noted that the Bayou Cumbest and Turkey Creek Ecosystem Restoration areas lay completely or partially within the proposed acquisition areas. Although included in the acquisition estimates, a separate real estate cost estimate is provided for each of these alternatives in the event a stand alone ecosystem restoration project is recommended.

Table RES-1 identifies the alternatives evaluated by Real Estate, and provides a cost for real estate acquisition for the given alternative. The total cost for each alternative includes an estimated cost for land/improvements, relocation payments, and administrative costs to acquire lands and provide relocation assistance services. Mobile District obtained land records tax data bases for 2005 from the tax assessors' offices in Jackson, Harrison, and Hancock Counties, and provided the data bases to Savannah District Real Estate. Mobile District also provided digital shape files of the various alternatives included in the study. From the counties' data bases and the digital shape files, the Savannah District Spatial Engineering Section designed a web based GIS program which includes a footprint for each alternative. Spatial Engineering wrote a program to generate a data base that includes the tax information for each parcel impacted by a given alternative.

Due to the magnitude of the project and the vast amount of data considered, a number of assumptions were made in compiling the Real Estate costs. The numbers of impacted parcels for the LOD 4 Option A, B & C alternatives varied. The process began by looking at parcels individually to make a determination of approximately what percentage of the parcel may be impacted by the footprint for construction of the berm or levee. As changes in the alternatives occurred, it became apparent that it was not feasible to continue the analysis on a parcel by parcel basis.

Based on the first parcel by parcel analysis completed on more than 2,000 parcels, a determination was made to estimate subsequent real estate takings based on a percentage factor. The total number of properties impacted for a given alternative was firm. However, an assumption was made that the land/improvements valuation would be based on a take of approximately 65% after allowing for the partial takings for those properties impacted by the alternative. 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 sales used occurred in the first quarter of 2007. From these sales an "adjustment factor" for each county was established. The sales indicated 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".

An assumption was also made that there would be no relocation cost included for those landowners or tenants where there were structures valued at less than $3,000. It was considered likely that in most cases any structure under $3,000 may be an outbuilding or carport so these should not be included. There may be some mobile homes with an assessed valued under $3,000, but this is thought to be a minimal number. For those parcels where the 2005 tax data indicated there was an improvement valued over $3,000, the value of that improvement and a relocation cost for a displacee are included even though the improvement may have been destroyed by Katrina. This was based on the assumption that the improvement would likely be rebuilt by the time acquisition for the project is implemented.

A clear distinction could not be made in all cases as to whether a benefit cost for residential or business relocation may apply, so an average cost of $28,000 is used as a "relocation payment" for parcels that were identified with pre Katrina improvements across all alternatives. There are a number of factors pertaining to relocations that can impact the project both in cost and in schedule. Payments for Housing of Last Resort, which would exceed the standard housing replacement payments, are very likely due to the size of the project and the lack of available decent, safe and sanitary housing in the area. Another factor that could increase cost and impact schedule is the cost of business relocations. Depending on the type of business and the operation, this could involve moving equipment and machinery to new locations. It is necessary to interview each impacted individual and business during Pre-Construction, Engineering and Design Phase to determine the requirements for relocation and to estimate a cost for the relocation.

The Acquisition alternative included 34 separate reaches and a total of 33,191 impacted parcels for all the reaches. The Ecosystem Restoration areas for the Turkey Creek and Bayou Cumbest pilot projects have a total of 74 parcels. For these alternatives no adjustments for partial takings were made. One hundred percent of the adjusted values for the land and improvements was used for estimating cost. Relocation costs were considered for every landowner/tenant where there was a structure valued at $3,000 or greater with the same reasoning as stated above and the average "relocation payment" of $28,000 was used.

Administrative costs for land acquisition are based on a cost of $22,500 per parcel. This includes both Federal and Non-Federal Costs. Administrative cost for relocation assistance under Public Law 91-646 is $7,500 per displaced family/business. Total Real Estate acquisition costs for each measure are rounded to the nearest thousand, and include land costs, relocation costs and administrative costs.

It is likely that costs can be refined during the Pre-Construction, Engineering and Design Phase when plans and specifications are available for a recommended plan. A Real Estate Supplement (RES) will be prepared for each authorized component once the real estate requirements have been sufficiently identified during PED. The RES will be submitted to CESAD-PDS-R for approval. The RES will provide updated information as to final real estate requirements for a particular component and will include updated data on the real estate values and costs since the majority of the costs and values contained herein should not be relied upon beyond calendar year 2008. A Real Estate Relocation Plan should also be prepared during PED for each authorized component requiring relocations or displacement of individuals and/or businesses. The Relocation Plan will investigate the availability of replacement housing within a specified radius and any unique or unusual problems that should be considered.

Table RES-1.
Real Estate Summary of Costs

Alternative	Purpose	County	Impacted Parcels	RE Costs
LOD1 Offshore Barrier Islands Options A-G	Off-shore Breakwater		5	$19,000
LOD2 Beach/Dune Construction	HSDR	Hancock		$19,000
LOD2 Beach/Dune Construction	HSDR	Harrison		$19,000
LOD2 Beach/Dune Construction	HSDR	Jackson		$19,000
LOD3 Pearlington Ring- Option A 20	Flood Damage Reduction	Hancock	111	$8,883,000
LOD3 Pearlington Ring - Option B 30	Flood Damage Reduction	Hancock	120	$9,340,000
LOD3 Bay St. Louis Ring Option A 20	Flood Damage Reduction	Hancock	42	$120,246,000
LOD3 Bay St. Louis Ring Option B 30	Flood Damage Reduction	Hancock	576	$156,364,000
LOD3 Elevated Roadway	Flood Damage Reduction	Hancock	427	$44,939,000
LOD3 Elevated Roadway	Flood Damage Reduction	Harrison	1,031	$502,215,000
LOD3 Forrest Heights Levee Option A 17	HSDR Flood Damage Reduction	Harrison	67	$2,571,000
LOD3 Forrest Heights Levee Option B 21	HSDR Flood Damage Reduction	Harrison	67	$2,649,000
LOD3 Elevated Roadway	Flood Damage Reduction	Jackson	137	$39,005,000
LOD3 Ocean Springs Ring Option A 20	Flood Damage Reduction	Jackson	197	$43,609,000
LOD3 Ocean Springs Ring Option B 30	Flood Damage Reduction	Jackson	576	$119,542,000
LOD3 Gulf Park Estates Ring Option A 20	Flood Damage Reduction	Jackson	354	$31,458,000
LOD3 Gulf Park Estates Ring Option B 30	Flood Damage Reduction	Jackson	399	$34,051,000
LOD3 Gulf Park Estates Ring Option C 20	Flood Damage Reduction	Jackson	521	$55,002,000
LOD3 Gulf Park Estates Ring Option D 30	Flood Damage Reduction	Jackson	561	$58,603,000
LOD3 Belle Fontaine Ring Option A 20	Flood Damage Reduction	Jackson	228	$19,366,000

Alternative	Purpose	County	Impacted Parcels	RE Costs
LOD3 Belle Fontaine Ring Option B 30	Flood Damage Reduction	Jackson	297	$25,774,000
LOD3 Belle Fontaine Ring Option C 20	Flood Damage Reduction	Jackson	286	$26,711,000
LOD3 Belle Fontaine Ring Option D 30	Flood Damage Reduction	Jackson	359	$33,260,000
LOD3 Gautier Ring Option A 20	Flood Damage Reduction	Jackson	313	$56,977,000
LOD3 Gautier Ring Option B 30	Flood Damage Reduction	Jackson	354	$66,585,000
LOD3 Pascagoula Ring Option A 20	Flood Damage Reduction	Jackson	1,075	$237,004,000
LOD3 Pascagoula Ring Option B 30	Flood Damage Reduction	Jackson	1,203	$256,517,000
LOD3 Pascagoula Ring Option C 20	Flood Damage Reduction	Jackson	1,175	$278,147,000
LOD3 Pascagoula Ring Option D 30	Flood Damage Reduction	Jackson	1,321	$297,899,000
LOD3 Pascagoula Ring Option E.20	Flood Damage Reduction	Jackson	2,964	$520,145,000
LOD3 Pascagoula Ring Option F 30	Flood Damage Reduction	Jackson	3,076	$533,059,000
LOD3 Pascagoula Ring Option G 20	Flood Damage Reduction	Jackson	3,138	$574,040,000
LOD3 Pascagoula Ring Option H 30	Flood Damage Reduction	Jackson	3,253	$584,742,000
LOD4 Inland Barrier Option A 20	Flood Damage Reduction	Hancock	426	$66,177,000
LOD4 Inland Barrier Option B 30	Flood Damage Reduction	Hancock	484	$74,262,000
LOD4 Inland Barrier Option C 40	Flood Damage Reduction	Hancock	537	$81,107,000
LOD4 St Louis Bay Surge Barrier Options A-C	Flood Damage Reduction	Hancock & Harrison	8	$1,110,000
LOD4 Inland Barrier Option A 20	Flood Damage Reduction	Harrison	1,512	$253,268,000
LOD4 Inland Barrier Option B 30	Flood Damage Reduction	Harrison	1,688	$271,797,000
LOD4 Inland Barrier Option C 40	Flood Damage Reduction	Harrison	1,927	$300,446,000
LOD4 Inland Barrier Option D 20	Flood Damage Reduction	Harrison	568	$58,266,000
LOD4 Inland Barrier Option E 30	Flood Damage Reduction	Harrison	1,916	$298,748,000
LOD4 Inland Barrier Option F 20	Flood Damage Reduction	Harrison	76	$8,917,000

Alternative	Purpose	County	Impacted Parcels	RE Costs
LOD4 Inland Barrier Option G 30	Flood Damage Reduction	Harrison	189	$20,801,000
LOD4 Inland Barrier Option H 40	Flood Damage Reduction	Harrison	209	$28,271,000
LOD4 Inland Barrier Option I 20	Flood Damage Reduction	Harrison	225	$23,938,000
LOD4 Inland Barrier Option J 30	Flood Damage Reduction	Harrison	171	$25,351,000
LOD4 Back Bay of Biloxi Surge Barrier Options A-C	Flood Damage Reduction	Harrison & Jackson	8	$1,767,000
LOD4 Inland Barrier Option A 20	Flood Damage Reduction	Jackson	323	$58,506,000
LOD4 Inland Barrier Option B 30	Flood Damage Reduction	Jackson	361	$66,571,000
LOD4 Inland Barrier Option C 40	Flood Damage Reduction	Jackson	404	$76,231,000
Nonstructural Acquisition	Flood Damage Reduction	Hancock	17,845	$4,241,808,000
Nonstructural Acquisition	Flood Damage Reduction	Harrison	10,912	$2,722,752,000
Nonstructural Acquisition	Flood Damage Reduction	Jackson	4,434	$775,345,000
Ecosystem Turkey Creek Option A	Ecosystem Restoration	Harrison	13	$1,101,000
Ecosystem Turkey Creek Option B	Ecosystem Restoration	Harrison	8	$752,000
Ecosystem Turkey Creek Option C	Ecosystem Restoration	Harrison	5	$350,000
Ecosystem Bayou Cumbest	Ecosystem Restoration	Jackson	61	$4,807,000

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FIGURES

TABLES

CHAPTER 1. GENERAL

1.1 Guidance

1.1.1 Engineer Regulations

1. ER 405-1-12, Chapter 5 - Acquisition, 5 September 1978, Draft Revision, 9 June 2003
2. ER 405-1-12, Chapter 6 - Relocation Assistance Program, 23 March 1979, Draft Revision, 2 May 2003
3. ER 405-1-12, Chapter 12 - Real Estate Roles and Responsibilities for Civil Works: Cost Shared and Full Federal Projects, 1 May 1998, Draft Revision, 8 March 2003

1.1.2 Engineer Circulars

1. EC 405-1-11, Real Estate Acquisition, 30 December 2003

1.1.3 United States Code

1. Robert T Stafford Disaster Relief and Emergency Assistance Act, as amended, 42 USC § 5121et seq. (Stafford Act)
2. 42 USC, Chapter 61 - Uniform Relocation Assistance and Real Property Acquisition Policies for Federal and Federally Assisted Programs

1.1.4 Code of Federal Regulations

1. Code of Federal Regulations, Title 49, Part 24 - Uniform Relocation Assistance and Real Property Acquisition for Federal and Federally-Assisted Programs

CHAPTER 2. THE REAL ESTATE REPORT

2.1 Statement of Purpose

This report is tentative in nature and is to be used for planning purposes only. The report is written based on specific data from Mobile District and the tax assessors' offices in Hancock, Harrison and Jackson Counties, MS. There may be modifications to the plans that occur during Pre-Construction, Engineering and Design phase, thus changing the final acquisition area(s) and/or administrative and land cost. The Real Estate Appendix is intended to support the Comprehensive Report for the Mississippi Coastal Improvements Program. Due to the scale of the project, the Real Estate Appendix is formatted to include a separate Real Estate Plan (REP) for each of the different measures that are formulated. The Statement of Purpose will not be repeated in each REP. The author of this report has viewed the general Project areas. The State of Mississippi is the non-Federal sponsor for the project. Date of this report is November 2007.

2.2 Study Authority

The Coastal Mississippi Comprehensive Study was authorized by the Department of Defense Appropriations Act, 2006 (P.L. 109-148) 30 December 2005, which states: "For an additional amount for "Investigations" to expedite studies of flood and storm damage reduction related to the consequences of hurricanes in the Gulf of Mexico and Atlantic Ocean in 2005, $37,300,000 to remain available until expended: ***Provided,*** **That using $10,000,000 of the funds provided, the Secretary shall conduct an analysis and design for comprehensive improvements or modifications to existing improvements in the coastal area of Mississippi in the interest of hurricane and storm damage reduction, prevention of saltwater intrusion, preservation of fish and wildlife, prevention of erosion, and other related water resource purposes at full Federal expense:** ***Provided further,*** **That the Secretary shall recommend a cost-effective project, but shall not perform an incremental benefit-cost analysis to identify the recommended project, and shall not make project recommendations based upon maximizing net national economic development benefits;** ***Provided further,*** **That interim recommendations for near term improvements shall be provided within 6 months of enactment of this act with final recommendations within 24 months of this enactment:"**

2.3 Authorization for Entry for Construction

After the non-Federal sponsor completes its acquisition effort and prior to issuance of the solicitation for each construction contract, an informed, authorized, and accountable official of the non-Federal sponsor must execute and provide the district a written Authorization for Entry to all land, easements or rights -of-way (LER) that the Government determined the non-Federal sponsor must provide for that contract. The authorization form must also recite that the non-Federal sponsor is vested with sufficient title and interest in such LER. Further, the non-Federal sponsor must also provide the district with a Certificate of Authority that recites that the official signing the Authorization for Entry form on behalf of the non-Federal sponsor has the authority to furnish such authorization to the Government. Again, rather than including the form in each REP, the form will be included in the Real Estate Appendix as Exhibit "A", and the exhibit will be referenced in the REP.

2.4 Assessment of Non-Federal Sponsor's Real Estate Acquisition Capability

For cost shared projects, a thorough assessment of the non-Federal sponsor's legal and professional capability and experience to acquire and provide the LER for the construction, operations and maintenance of the project, including its condemnation authority and quick-take capability is required. The Capability Assessment checklist must be completed and included as part of the REP. Rather than including the checklist in each REP, the checklist will be included in the Real Estate Appendix as Exhibit "B", and the exhibit will be referenced in the REP. For this study, this assessment will be made during PED.

2.5 Acquisition Schedule and Management Plan

2.5.1 Acquisition Implementation/Management Plan

The acquisition of lands required for a cost shared project is the responsibility of the Non-Federal Sponsor. It is recommended that an Acquisition Implementation and Management Plan (AIMP) be prepared. This plan should outline the necessary steps required to successfully implement and execute the acquisitions. It should include staffing requirements, field office requirements, contracting requirements and schedules identifying milestones to meet completion dates. This plan should be developed jointly with participation from real estate division, the non-federal sponsor and the project manager to ensure adequate time for acquisition and to meet the schedule for advertisement for construction. A lead time of at least six to nine months prior to the estimated date for the availability of the appropriations should be allowed for preparation of the AIMP. It should be noted that on fast track acquisitions, there are several preliminary acquisition activities that can be accomplished during the PED phase such as surveys, title and appraisal requirements. If these activities are scheduled correctly, the acquisitions can be initiated as soon as the appropriations are made available thus saving 6 – 12 months from the acquisition schedule.

2.5.2 Title/Ownership of Lands Acquired

In cost shared projects, the project sponsor is responsible for acquiring real estate required for the project. Since the Non-Federal Sponsor would be required to operate and manage all lands acquired for the project, title to these lands would be acquired in the named of the sponsor. In the event the Federal Government performs the acquisition of lands, the lands would be acquired in the name of the sponsor. In this instance acquisition of LER by the Government on behalf of the sponsor will be by written agreement between the Government and the non-Federal sponsor.

2.6 Mitigation Lands

Implementation of structural plans would require placement of fill within parts of wetlands in Coastal Mississippi. Overall, structural measures have been developed in ways that avoid or minimize wetland impacts. See section 4.1.7, Mitigation Measures in the Environmental Appendix for a discussion on project impacts and measures for mitigation. Land costs for mitigation are not reflected in the Real Estate Appendix as the plan is to purchase credits from a mitigation bank. the cost of the mitigation credits is included in the Environmental Appendix. The cost presented in the Environmental Appendix does not include real estate administrative costs; these costs would be minimal since the purchase of credits from mitigation banks does not involve acquiring a real interest in land. There could be administrative costs incurred for document preparation. Although specific mitigation sites have not been selected, for estimation purposes a cost of $5,500 per acre is based on costs to buy credits from established mitigation banks in the Mississippi coastal area. It is noted that LERRD credit is not given for mitigation credits that may be purchased for a project. The cost to purchase mitigation credits is considered as a construction cost.

2.7 Zoning

Title 17 of the Mississippi Code is legislation that enables the counties and municipalities within the proposed project area to establish land use zoning ordinances for their jurisdictions to fulfill the goals and objectives of their comprehensive plans. Potential relocations and redevelopment being considered in the project may affect some current residential and commercial zoning in the counties and may require variances or re-zoning of those areas for project implementation. Zoning ordinances can be used to limit development in certain high-hazard areas or areas with sensitive environmental resources. In areas where no development has taken place (vacant land) or where development has been largely removed (total loss areas), zoning or rezoning of the property could accomplish project objectives by limiting or prohibiting future development. Property devoid of structures only retains its basic land value as dictated by market forces. That land value is influenced to some extent by the natural hazards that may endanger any development that would be constructed on the property. In the case of the study area, there are vast numbers of privately-owned tracts where the structure has been totally destroyed leaving only a concrete slab or wood pilings from the previous foundation. In these cases, rezoning the property for other land uses more adaptable to and compatible with the natural hazards may accomplish program objectives. Zoning of high-risk properties bordering the coast and some of the inlet areas could be used to reduce the incidence of damages to certain types of development or all development.

Any rezoning of vacant land after purchase of at-risk properties for the project would be entirely up to the local jurisdictions in accordance with the floodplain ordinances and any executed agreements for project cooperation. Section 4.5.4 in the Nonstructural Appendix provides an in-depth discussion on Land Use Regulation and Zoning for those counties and municipalities in the project areas.

2.8 Borrow Areas

Section 1.5 in the Engineering Appendix gives detailed information on the borrow sites being considered for use in construction of the project. Section 1.5.5 discusses the on-shore borrow areas which are permitted sites. A table is given for each county that lists the sites and type materials available. A map shows the general location of the sites. Section 1.5.6 describes the offshore borrow areas proposed for use. Section 1.5.7 describes the inland river system sand (dredged material) that is in disposal areas. Diked disposal areas along the Black Warrior - Tombigbee River system and the Tennessee-Tombigbee Waterway are available for use. A map of the disposal areas and tables listing the sites and type real estate interest acquired in the sites are included. In summary the proposed borrow sites are a mix of permitted commercial sites and disposal sites for which the Government either owns or holds an easement interest. Current estimates for borrow material indicate that sufficient sources are available for construction without having to acquire additional sites from private landowners. However should any requirements be identified for acquisition of additional borrow or disposal sites from private landowners, they would be considered part of the LER, and the responsibility of the non-federal sponsor to acquire. The sponsor would have to comply with any approval processes required by the respective county governments for using lands for new borrow or disposal sites.

2.9 Induced Flooding

Lines of Defense 3 and 4 incorporate the use of levees and barriers in the structural measures proposed for storm damage reduction. When it rains, excess rainfall can be trapped behind the levees and can induce flooding even in the absence of a hurricane. 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. The design of the levees includes flap gates, culverts, pumping stations and drainage ditches to aid in water drainage and to channel excess runoff to either gated culverts or pumping stations which will transfer the excess flow to the outside of the levee thereby minimizing induced damages. 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. However, in some of the areas, existing storage could be adequate to pond water without causing damage, even without pumps. In other areas that do have pumps, some rise in interior water during interior events greater than the 10-yr rain could occur, but may not cause damage. 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. No induced flooding is anticipated as a result of any of the tentatively selected plans. However, should there be a later determination that there will be induced damages for a given measure, a takings analysis will be prepared, the appropriate real estate interest to be acquired will be identified and the real estate estimate will be revised accordingly.

2.10 Utility/Facility Relocations

The term "relocation" shall mean providing a functionally equivalent facility to the owner of an existing utility, cemetery, highway or other public facility or town when such action is authorized in accordance with applicable legal principles of just compensation or as otherwise provided by Federal statute or any project report or House or Senate document referenced therein. Providing a functionally equivalent facility may take the form of adjusting, altering, lowering, raising, or replacement and attendant removal of the affected facility or part thereof. It is important to note that relocation assistance under Public Law 91-646 relates specifically to displaced persons, and should be distinguished from the separate concept of facility or utility relocations

The REP normally contains a description of the facility or utility relocations that must be performed including information regarding the general nature of the impact to each facility or utility; the identity of the owners of the affected facilities and utilities; the purpose of the affected facilities and utilities; whether the owners have compensable real property interests in the land on which the impacted portion of the facility or utility is located; the conclusions reached in an identified Preliminary or Final Attorney's Opinion of Compensability prepared in support of the relocations determinations; whether special legal authority or direction affects relocation classification [for example, the project's authorizing legislation or reports referenced therein; Section 111 of the River and Harbor and Flood Control Act of 1958 (33 U.S.C. §633)]; and other information relevant to the proper identification and performance of relocations necessitated by construction, operation, or maintenance of the project.

Due to level of study in this project, information about specific "relocations" is unknown. In general, it is known that roads would have to be ramped up at intersections for the proposed ring levee projects and that some public utility lines will have to be relocated. The Town of Moss Point in Jackson County has some municipal facilities that would need to be relocated. Each potential utility/facility relocation will be evaluated to determine relocation requirements and possible problems associated with the relocation. Once this assessment is made, the LERRD cost can be adjusted to reflect addition of the utility/faculty relocation cost which are currently included as a construction cost. Any relocation requirements will be identified during PED along with the required supporting documentation and estimated cost. Utility/facility relocations can add cost to the project and need to be factored into the acquisition schedule timeline.

2.11 Navigation Servitude

For those lands required for construction that lay below the mean high water mark, navigation servitude will apply. Navigation servitude is the dominant right of the Government under the Commerce Clause of the U.S. Constitution (U.S. CONST. Art.I,§8,cl.3) to use, control and regulate the navigable waters of the United States and the submerged lands hereunder for various commerce-related purposes including navigation and flood control. In tidal areas, the servitude extends to all lands below the, mean high water mark. In non-tidal areas, the servitude extends to all lands within the bed and banks of a navigable stream that lie below the ordinary high water mark. The determination of the availability of the navigation servitude should be made on a case by case basis and consists of a two -step process. First the government must determine whether the project serves a purpose that has a nexus to navigation. Purposes recognized by the courts to have the nexus include navigation, flood control and hydroelectric power. If determined that such a nexus exists, then the second step is to determine whether the land at issue is located below the mean or ordinary high water mark of a navigable watercourse. As a general rule, the Government does not acquire interests in real property that it already possesses or over which its use or control is or can be legally exercised. Therefore, if the navigation servitude is found to be available as a result of application of the process described in subparagraph b of this paragraph, then the Government will generally exercise its rights hereunder and, to the extent of such rights, will not acquire a real property interest in the land to which the navigation servitude applies. Generally, it is the policy of the U.S. Army Corps of Engineers (USACE) to utilize the navigation servitude in all situations where available, for cost shared and full Federal projects. The determination of availability will be made during PED.

CHAPTER 3. LINES OF DEFENSE (LOD)

3.1 Line of Defense 1 - Offshore Barrier Islands

3.1.1 Project Description

The barrier islands of Mississippi are located 10 to 15 miles south of the mainland. Currently, there are five islands in the chain that extends for 45 miles west from a point south of the Alabama – Mississippi state line along the coast as shown in Figure 3.1.1-1. Currently, Ship Island exists as two islands separated by a shallow sand bar. It was breached during Hurricane Camille in 1969 and remains today as West and East Ship Island. Two maintained navigation channels pass through the chain of islands. The Gulfport channel passes near the west end of West Ship Island and the Pascagoula channel passes near the west end of Petit Bois Island. The present day location of the channels prevents any further westward migration of either island. All of Petit Bois, Horn, and Ship Islands and part of Cat Island are within the boundaries of the Gulf Islands National Seashore under jurisdiction of the National Park Service (NPS) as shown in Figure 3.1.1-2. The approximate western two thirds of the island is owned by the United Sates of America. The remaining portion of the island is in private ownership among multiple owners of record. In most cases, the boundary extends one mile from the shore of the island. Petit Bois and Horn Islands have also been designated as Wilderness Areas by the U.S. Department of the Interior and have a higher degree of protection than the other islands. Project construction will be on those lands within the boundaries of the Gulf Islands National Seashore and will not impact private lands.

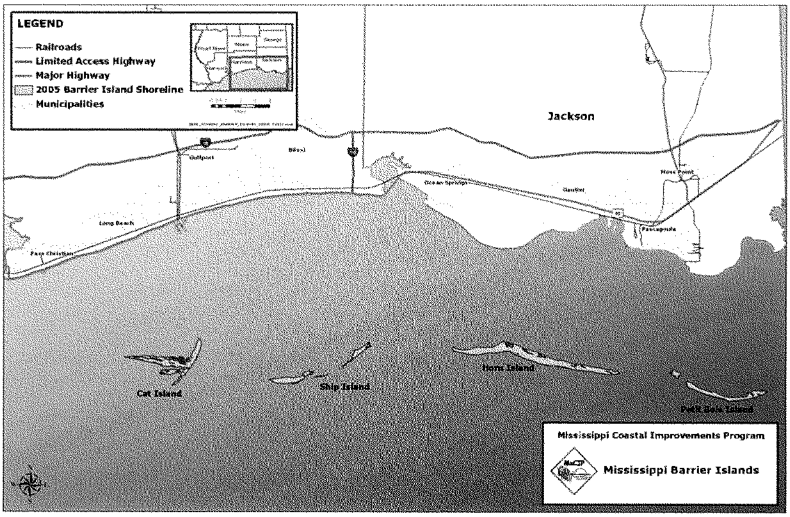

Figure 3.1.1-1.
Location of the Mississippi Barrier Islands

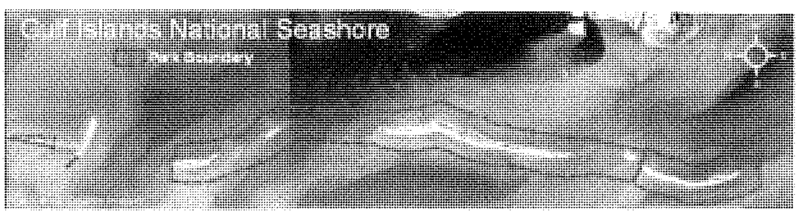

Figure 3.1.1-2.
Boundaries of the Gulf Islands National Seashore

Data shows that the islands have lost approximately 20 to 25 percent of their land mass since pre-Camille times. Figures 3.1.2.1-1 through 3.1.2.1-4 in the Engineering Appendix illustrate the changes in the footprints of the islands from pre-Camille to post-Katrina. The islands have been heavily influenced by the various hurricanes including even the lower intensity ones. Hurricane George, in 1998, even though a small hurricane, proved to be devastating to the islands due to heavy erosion from waves. Many of the higher dune systems on the islands were destroyed and much of the elevation the islands once had is gone. Most of the islands are now very susceptible to over-wash during storms. Another result of being submerged during Hurricane Katrina was the loss of much of the maritime pine forest that existed on the islands. The trees, mostly now dead from the salt water submergence, played a major role in preventing erosion both from wind and any surges against the islands. Modeling efforts have concluded that over a wide range of storms, there would be some protection provided to the eastern coast of Mississippi along the Jackson County shoreline if the islands are in the pre-Camille condition. The options considered for restoration of the offshore barrier islands are listed in Table 3.1.1-1.

Table 3.1.1-1.
Options for Offshore Barrier Islands

Option	Measure
Option A	Restore Island Footprint
Option B	Replenish Sand in Littoral Zone, Inland Source
Option C	Replenish Sand in Littoral Zone, Inland & Offshore Sources
Option D	Environmental Restoration w/2-foot Dune
Option E	Environmental Restoration w/6-foot dune
Option F	Environmental Restoration of Sea Grass Beds
Option G	Restoration of Ship Island Breach

Several approaches to restoration of the islands were considered. Option A proposes to add new land mass to the islands by using sand dredged and transported from an off-shore location. This sand would come from the St. Bernard Shoals located about 45 miles south of the barrier islands. The shaping of the sand into beaches, dunes and marsh areas will not affect the existing islands other than that narrow strip of land that will form the boundary between the existing island and the new land mass. This option can be used in combination with other options under this line of defense should it be desired to restore habitat on the existing islands. Restoration of Ship Island to a pre-Camille configuration includes closing the post-Katrina, 4-mile long breach to a 2000-foot width and with elevation 20.0 dunes, along with some rebuilding of the other islands to a larger land area. As the new land mass is added to the existing islands, portions of the new island will be planted with various types of vegetation to provide habitat and to aid against erosion.

To increase the size of the footprint of each island and restore them back to a pre-Camille footprint will involve several different operations, some of which can take place concurrently. The source of sand that has been designated as the potential borrow area will require additional investigation using both geophysical techniques and physical sampling. The sand is expected to be in submerged shoals that will have to be located and mapped prior to any removal of the sand. This will be completed during design and before the construction begins.

Each of the islands will require that a "dump basin" be excavated by dredging before any sand is transported from the borrow areas which are located offshore about 45 miles south of the islands. These basins are required due to the depth of the water which is too shallow for the dredges to approach the islands. The basins will typically be located about one mile from the beach of the respective island where sand is being added to surrounding waters. These basins will be of sufficient size to allow a large quantity of sand to be stored after being bottom dumped from a hopper dredge. The material dredged from these basins is anticipated to be unsuitable for placement on the islands and is expected to be transported to permitted disposal areas. As each basin is completed, a hopper dredge can begin to remove sand from the borrow area and transport it to the basin where it can be quickly dumped, allowing the dredge to have minimal delays between trips. When the sand in a basin reaches a set capacity, a cutter head, suction dredge will move the sand from the basin to the area where the sand is needed. Where needed, booster pumps will be utilized. The discharge from the suction dredge will be moved over the areas where the size of the island is being increased. As an area is filled to the desired grade, the sand will be shaped into dunes, basins and beaches. As this earthwork is completed for a given area, planting can begin. The suction dredge will be moved as needed to accommodate the excavation of the basins and the transfer of the sand from the basins to the islands. It is anticipated that the suction dredge will be moved, and then remobilized several times during the entire process for completing an islands enlargement.

Option B and Option C propose to restore the islands by supplementing the sand in the littoral system through the use of inland and off-shore sand sources. This could be accomplished by adding sand in specific locations based on sediment transport modeling. This would allow the littoral currents to move the sand onto the islands where the natural process of island building could take place. This would not directly affect the present-day islands and would help mitigate any effects of dredging the ship channels that pass through the chain of islands where sand may have been lost from the system. The construction of inland waterways in Alabama and Mississippi has resulted in continuing maintenance dredging to maintain the channel depths and alignments. This dredged material is now accumulated in disposal areas along the banks of the river. Dredging of some of the areas along the river has produced large quantities of sand that have potential use for replenishment of littoral zones such as are found along the Mississippi Barrier Islands. An inventory of current disposal sites indicates that approximately 30,000,000 cubic yards of sand is available. Only disposal sites that contain a minimum of 100,000 cubic yards of sand were included in the inventory. Of interest to this study are disposal sites that are located along the Black Warrior – Tombigbee River system and the Tennessee – Tombigbee Waterway. Material from these sites could easily be transported by barge down the river system for use among the islands littoral zone. To add off-site sand into the littoral system under Option B, material from inland dredged material disposal sites would be transported by barge down the river system for use among the islands littoral zones.

Each of the areas designated for adding sand will require that a staging area where barges could be unloaded and the sand spread over the selected area. The sand would be transported from each of numerous disposal sites located up the river systems. The size of the locks on the river systems and the depth of associated channels will dictate the size of barges that can be used. As the barges are unloaded at each site, the sand would be pumped to spreader barges that would be able to cover an area sufficient to control the depth of sand placement.

Option C would help restore the islands by supplementing the sand in select littoral system zones with sand obtained from both inland river and offshore borrow areas. Like Option B, this could be accomplished by adding sand in specific locations based on sediment transport modeling. This option would limit addition of sand to the areas east of Ship Island and Petit Bois Island. These two areas were selected based on cooperation between the National Park Service (NPS, 2007) and the Corps of Engineers and is based on restoration policy of natural resources with the NPS. Both of these islands are affected by the presence of navigation channels that limit westward migration. Placement of sand into these two areas would add sediment into the system and would allow the littoral currents to move the sand onto the islands where the natural process of island building could take place. The sand that could be used in this option may come from the same offshore borrow area as Option A, the St. Bernard Shoals located about 45 miles south of the barrier islands and the lower inland river sand described in Option B. The sand from the inland river sources would be from the lower-most areas.

Options D and E involve environmental restoration of the islands consisting of shaping existing sand into dunes on the beaches with planted vegetation and planting of maritime forests on the existing islands where they were mostly destroyed by Hurricane Katrina. For Option D the dune would be shaped from sand that would be removed from the surface between the constructed dune and the edge of the vegetation north of the dune. The dune would have height of 2-feet with a 1v to 3h slopes and a crest width of 6 feet. The dune would be continuous for the length of the gulf-side, south beach. While not designed as a structural defense against storms, the dune would be used as a platform to establish a line of sea oats that in turn would help in the natural process of creating larger and more pronounced sand dunes. The dunes would build with time as wind driven deposits of sand become trapped by the vegetation. For Option E, the dune would have height of 6-feet with a 1v to 3h slopes and a crest width of 6 feet. The sand required to construct a dune of this size would be more than could be removed from the existing beach berm and would come from the same offshore borrow area as the sand used in Option A. Placement of the sand would require moving the sand from a hopper dredge to a staging area on the beach, then moving the sand to the area of placement along the beach.

Option F involves environmental restoration of the sea grass beds that have historically existed on the north side of the islands in the Mississippi Sound. Despite continual changes that occur, the barrier islands remain to buffer the mainland from storms and provide habitat for the rich, diverse wildlife residing within the area. The amount of acres of sea grasses to be planted at each island, based on 50 percent of pre-Camille acreage, is as follows: Cat – 210 acres, Ship – 760 acres, Horn – 2,650 acres, and Petit Bois – 780 acres. This option will involve only the planting of various types of marine aquatic vegetation in selected areas around the islands. No actual construction activities will take place.

Option G proposes to the fill the Ship Island breach. The pre-Camille footprint of Ship Island was obtained from historical records, and showed the area that was breached during Hurricane Camille forming two separate islands. West and East Ship Island has two major historic sites that are in danger from the continuing erosion of the barrier islands. Current studies by the Corps indicate that restoring the two islands to a single island, pre-Camille condition may prevent the rapid erosion of the beaches that is now occurring as well as helping to provide wave erosion on the mainland. Estimates indicated that the restoration of Ship Island to a single land mass off the Mississippi coast will involve approximately 21 million cubic yards of sand. Fort Massachusetts was originally built on the western tip of Ship Island. The westward migration of sand along the southern shore and erosion of the northern shore now has put the fort almost a mile from the western tip of the island, but dangerously close to being in the Sound. Several emergency beach re-nourishments have taken place over the last 35 years through use of operations and maintenance material from the federally authorized Gulfport Harbor Navigation Project to protect the fort from wave action during winter storms. At present, the NPS is again requesting that the Corps place sand along the shore near the fort in conjunction with dredging operations at the Federal Gulfport Harbor navigation channel. This emergency placement of sand is being repeated about every five to six years. The immediate erosion problem will require re-nourishment of the beach adjacent to the fort similar to the past protection projects. The problem of a long-term fix may be tied to closing the three mile wide breach known as Camille Pass between West and East Ship Island. As well as the sand placement, the plan would include sculpting the sand into beaches, dunes, swales, and marshes. Different types of vegetation planting would also be included to restore habitat on the newly created land. The filling of Camille Pass will also provide a designation of a Federal Beach that would be subject to long term maintenance if needed.

Review of literature indicates that suitable sand can be obtained from St. Bernard Shoals which is located about 45 miles south of Ship Island. This sand should be very high quality material and could be used in the island reconstruction. If this offshore sand source is used, a basin would be dredged near each of the islands to discharge the sand being transported from the borrow area. Using this procedure, the hopper dredge could enter the basin and bottom dump the sand. This would be much faster than pumping off the sand. Doing this would also allow the basin to be placed outside the boundaries of the National Seashore. As the basin is filled, a suction dredge would be mobilized to the site and using this type of the equipment, the sand could be moved to the area where the material is needed to create additional land mass. As the sand is placed on the new land mass, it would be sculpted into dunes and swales which would vary from sea level up to heights of 20 feet.

Another source of sand could be sand from inland river systems as discussed in Option B. Material from these sites could easily be transported by barge down the river system for use as replacement sand in the littoral system of the barrier islands. The offshore sand source and the sand from the inland river systems sites provide sufficient sand for the project construction. The anticipated amount of sand required for each island is as follows:

Cat Island – 14,600,000 cubic yards

Ship Island – 21,240,000 cubic yards

Horn Island – 21,240,000 cubic yards

Petit Bois Island – 9,300,000 cubic yards

3.1.2 Real Estate Requirements

Real Estate requirements for Line of Defense 1 will include a Permit from DOI/NPS to allow for beach re-nourishment, dune construction and plantings to include submerged aquatic vegetation. It will also be necessary to obtain a license from the Minerals Management Agency for mining of sand from those offshore borrow areas in the outer continental shelf, and also to create the "dump basins" needed at each island during construction. It is noted that the Engineering Appendix suggests the use of "permitted disposal areas" for borrow and disposal activity. An assumption is made that some type of permit will be required for borrow/disposal of materials in these areas. This will be investigated further in the next phase, Pre-Construction, Engineering and Design.

3.1.3 Utility/Facility Relocation

There are no utility or facility relocations in any of the options for the offshore barrier islands.

3.1.4 Existing Projects/Studies

Several emergency beach re-nourishments have taken place over the last 35 years on Ship Island to protect Fort Massachusetts from wave action during winter storms. This emergency placement of sand is being repeated about every five to six years. Sand has come from dredging of the federally authorized Gulfport Harbor Navigation Project. Other relevant projects and studies are found in the main report at Section 1.6, History of the Investigation and Section 1.7, Prior and On-Going Studies, Reports and Programs.

3.1.5 Environmental Impacts

None of the options described for the offshore barrier islands are expected to cause negative impacts to the surrounding environment. See the Main Report, Chapter 6. Environmental Effects of Plans and the Environmental Appendix, for a full discussion on environmental effects.

3.1.6 Project Sponsor Responsibilities and Capabilities

The State of Mississippi will be the non-Federal Project Sponsor (NFS). The NFS has the responsibility to acquire all real estate interests required for the Project. The NFS shall accomplish all alterations and relocations of facilities, structures and improvements determined by the government to be necessary for construction of the Project.

Since the project will be constructed on lands in the Outer Continental Shelf, any new lands created as a result of the project will be considered lands of the United States of America. Prior to advertisement of any construction contract, the NFS shall furnish to the government an Authorization for Entry for Construction (Exhibit "A" to the Real Estate Appendix) to all lands, easements and rights-of-way, as necessary. The NFS will also furnish to the government evidence supporting their legal authority to grant rights-of-way to such lands. The NFS shall comply with applicable provisions of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970, Public Law 91-646, approved 2 January 1971, and amended by Title IV of the Surface Transportation Uniform Relocation Assistance Act of 1987, Public Law 100-17, effective 2 April 1989, in acquiring real estate interests for the Project, and inform all affected persons of applicable benefits, policies, and procedures in connection with said Act(s). A form for the Assessment of the Non-Federal Sponsor's Capability to Acquire Real Estate is at Exhibit "B" to the Real Estate Appendix. The assessment will be made during PED phase.

The non-Federal sponsor is entitled to receive credit against its share of project costs for the value of lands it provides and the value of the relocations that are required for the project. Generally, for the purpose of determining the amount of credit to be afforded, the value of the LER is the fair market value of the real property interest, plus certain incidental costs of acquiring those interests, that the non-federal sponsor provided for the project as required by the Government. The NFS cannot receive credit for the value of any LER, including incidental costs, which were previously provided as an item of cooperation for another Federal project, including projects that preceded enactment of WRDA 1986.

3.1.7 Government Owned Property

All of Petit Bois, Horn, and Ship Islands and the western two thirds of Cat Island are within the boundaries of the Gulf Islands National Seashore under jurisdiction of the NPS. In most cases, the boundary extends one mile from the shore of the island. The remaining portion of Cat Island is in private ownership held among multiple owners of record.

3.1.8 Historical Significance

The breach of Ship Island has created problems for the National Park Service due to the location of two historically important sites. Fort Massachusetts is located on the northern shore of West Ship and the French Warehouse is located on the northern shore of East Ship Island. Both of these sites are endangered by on-going erosion of the shoreline with Mississippi Sound. Another site, known as the Quarantine Station, has already been lost to erosion. These sites are shown in Figure 3.1.8-1. See the Main Report, Section 3.2.9 Cultural and Archaeological Resources, for a general discussion on cultural and archaeological resources.

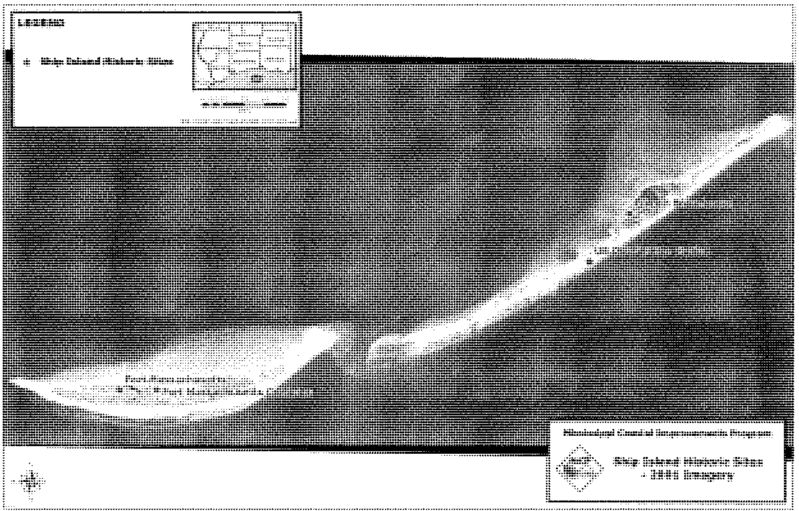

Figure 3.1.8-1.
Aerial photo of West and East Ship Island taken in 2001 showing historic sites

3.1.9 Mineral Rights

There are no known mineral activities within the scope of the proposed project.

3.1.10 Hazardous, Toxic, and Radioactive Waste (HTRW)

Due to the extent of the islands and lack of prior development, no preliminary assessment was performed to identify the possibility of hazardous waste on the sites. These studies will be conducted during the next phase of work. See Sections 3.2.8 and 6.16 of the Main Report for a discussion on HTRW.

3.1.11 Public Law 91-646, Relocation Assistance Benefits

Not Applicable

3.1.12 Attitude of Property Owners

There are no known objections to the proposed project.

3.1.13 Acquisition Schedule

All permits must be obtained prior to advertisement for construction. This could be accomplished in 90 - 120 days. An acquisition schedule will be made during PED and will be a joint effort of the NFS, the project manager and Real Estate.

3.1.14 Estates for Proposed Project

No estates are required for the project. All work will be done by permit from the appropriate agency.

3.1.15 Real Estate Estimate

The real estate cost estimate at Table 3.1.15-1 includes a cost for Federal and non-Federal administrative costs. Administrative costs are those costs incurred for verifying ownership of lands, certification of those lands required for project purposes, legal opinions, analysis or other requirements that may be necessary, during PED. With the exception of a portion of Cat Island that is privately owned, the project will be constructed on offshore barrier islands owned by the Federal Government, so no additional land costs are anticipated. That portion of Cat Island that is privately owned will not be impacted by the project. No cost is included for upland borrow sites as sites have been identified where it will be advantageous to remove fill to make room for future disposal. All costs are for obtaining permits. If further real estate requirements are identified during PED or if there is a significant increase in cost, a supplement to the Real Estate Appendix will be prepared. A 25% contingency is applied to the current estimate. Due to the ownership of the islands, the same administrative cost is projected for any individual option or combinations of options.

Table 3.1.15-1.
Offshore Barrier Islands Estimate

a. Lands and Improvements/Permits		0
	Subtotal	0
b. Mineral Rights		0
c. Damages		0
d. P.L. 91-646 Relocation costs		0
e. Administrative Cost		15,000

	Relocation	Acquisition	Total
Federal	0	7,500	7,500
Non-Federal	0	7,500	7,500
	0	15,000	15,000

Subtotal	15,000
Contingencies (25%)	3,750
Totals	**18,750**
Rounded	**19,000**

3.1.16 Summary of Potential Real Estate Issues

The requirement for using borrow material from the "permitted" sites will be further investigated during PED. Typically if borrow sites are required, this would be considered as part of the LERRD requirements. Real estate would provide an analysis during PED to compare the cost of acquiring an upland borrow site with the cost of using a commercial borrow site and make a determination which method is most cost effective. See Section 2.8 Borrow Areas on page 5.

Should an upland borrow site become a necessary real estate acquisition requirement, valuation of lands will be performed. Land costs associated with an upland site and administrative costs will be added to the Real Estate Cost Estimate. If further real estate requirements are identified during PED or if there is a significant increase in cost, a supplement to the Real Estate Appendix will be prepared and provided to CESAD-PDS-R for review and approval.

Requirements for long term O&M and any associated real estate interests will be identified during PED.

3.1.17 Chart of Accounts

The cost estimate for all Federal and non-Federal real estate activities necessary for implementation of the project after completion of the feasibility study for land acquisition, construction, LERRD, and other items are coded as delineated in the Cost Work Breakdown Structure (CWBS). This real estate cost estimate is then incorporated into the Total Current Working Estimate utilizing the Microcomputer Aided Cost Engineering System (MCACES). The Chart of Accounts at Table 3.1.17-1 shows the CWBS for real estate activities.

Table 3.1.17-1.
Chart of Accounts - Offshore Barrier Islands

01B	Lands and Damages / Permits	Federal	Non Federal	Total
01B40	Acquisition/Review of NFS	7,500		7,500
01B20	Acquisition by NFS		7,500	7,500
01BX	Contingencies (25%)	1,875	1,875	3,750
	Subtotal	9,375	9,375	18,750
01F	PL 91-646 Assistance			
01F20	By NFS			
01FX	Contingencies (25%)			
	Subtotal			
01R	Real Estate Land Payments			
01R1B	Land Payments by NFS			
01R2B	PL91-646 Relocation Payment by NFS			
01R2D	Review of NFS			
01RX	Contingencies (25%)			
	Subtotal			
	Totals	**9,375**	**9,375**	**18,750**
	Rounded			**19,000**

3.2 Line of Defense 2 - Beach/Dune Construction

The Mississippi Mainland shoreline extends approximately 68 miles, and is divided into three coastal counties: Jackson, Harrison, and Hancock Counties, Figure 3.2-1. The Mississippi coast beaches are a valuable asset and provide vital environmental, cultural, recreational, and economic resources; they assist in maintaining the health and productivity of adjacent waters and provide for diverse cultural and recreational activities.

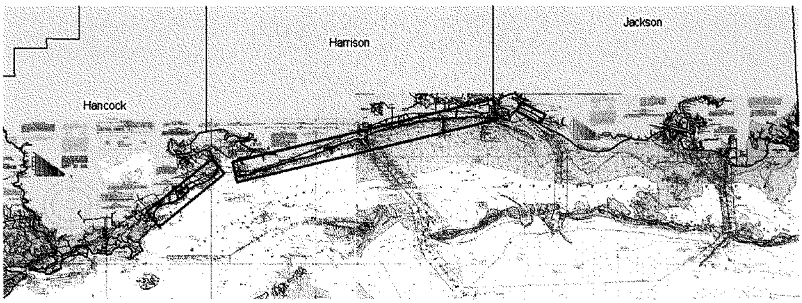

Figure 3.2-1.
Mississippi Beaches

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 provide reduction of damaging wave action from smaller storms. A project to restore the beaches in Harrison County has been funded and is underway. Other projects to construct dunes to a height of 5-feet in Harrison County and to 2-feet in Hancock and Jackson County have been proposed as an interim projects, have been designed and are awaiting funding.

Dunes are consistent with a more natural appearing defense than a hard structure. Construction of dunes will include adding vegetation and sand fencing to help stabilize the dunes. The dunes would be a sacrificial barrier, but could also be important by providing additional protection for the toe of the existing roadway, especially in an elevated seawall or roadway configuration as LOD-3. Placement of the dunes directly against a raised seawall or roadway would also serve aesthetically to mask the appearance of a structural barrier.

3.2.1 Hancock County Beaches

3.2.1.1 Project Description

The purpose of this project is to provide hurricane storm damage reduction and restoration of the shoreline to six miles of public beaches along the Hancock County, MS coastline which was impacted by tidal flooding during Hurricane Katrina in August 2005.

Hancock County is the western-most coastal county in Mississippi and is located approximately 95 miles west of Mobile, Alabama and approximately 40-miles east of New Orleans, Louisiana. Hancock County is bordered to the east by Harrison County, MS, and to the west by the Mississippi-Louisiana state line. The County consists of two municipalities: Bay St. Louis and Waveland. The beaches along the Hancock County shoreline, shown in Figure 3.2.1.1-1, are separated in two sections: the reach extending approximately 6-miles from Grand Bayou in Waveland to the US 90 bridge in Bay St Louis, and the reach extending northeastward approximately 1-mile from Cadet Bayou.

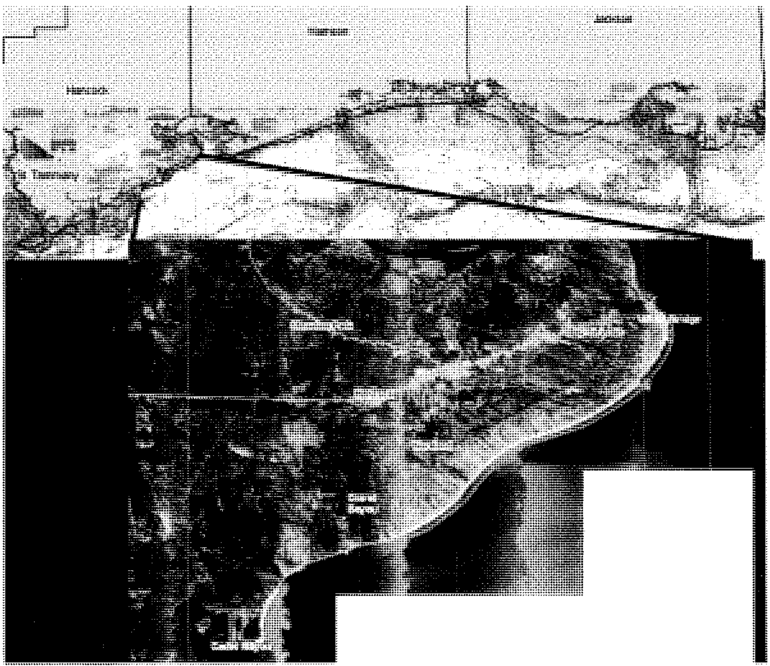

Figure 3.2.1.1-1.
Hancock County Beaches

The Hancock County shoreline south of the US 90 bridge is protected by an 8 mile long seawall extending from the US 90 bridge to Cadet Bayou. The Hancock County beaches were constructed for shore protection; however, the area provides added outdoor recreation and environmental benefits. The project was a local project constructed by Hancock County. The area experiences wave and wind erosion and is therefore periodically maintained or re-nourished with sand. The elevation of the seawall ranges between +3.8 and +5.0 feet National Geodetic Vertical Datum (NGVD). The seawall fronting the downtown Bay St Louis beaches is significantly higher. A sand beach was constructed along approximately 6 miles of the seawall in 1967 as part of the emergency repair and protection following Hurricane Betsy (September 1965). The approximately 1 mile section of beach fronting the downtown Bay St Louis area was constructed during the construction of the US 90 Bridge. The 1 mile section extending from Bayou Cadet was constructed in 2005.

The Hancock County beaches were re-nourished in 1994 with material from a borrow area located approximately 1000 feet offshore. The beaches fronting downtown Bay St Louis, the northeast section of the beaches, were again re-nourished in 1996 with material from a borrow area located on the north side of the US 90 bridge. The existing Hancock County beach profile consists of a berm only feature which extends approximately 150 ft from the seawall to the Mississippi Sound. The berm elevation varies from approximately 5.0 ft at the seawall to 3.5 ft at the slope break to the Mississippi Sound. The downtown Bay St Louis area beaches include a bluff with an elevation of about +12 feet.

The project includes evaluation of eleven options in Hancock County as listed in Table 3.2.1.1-1.

Table 3.2.1.1-1.
Hancock County LOD2 Options

Option	Description					
	Dune			Berm		
	Elevation (ft)	Width (ft)	Side Slope	Width (ft)	Plantings	Sand Fencing
A*	10	40	1:3	80		
B*	8	50	1:3	80		
C*	10	20	1:3	100		
D*	8	30	1:3	80		
E*	10	40	1:3	80	X	X
F*	8	50	1:3	80	X	X
G*	10	20	1:3	100	X	X
H*	8	30	1:3	100	X	X
I**	10	55	1:3	Extend to accommodate		X
J**	10	55	1:3	Extend to accommodate	X	X
K**				Add 2ft, 60 ft width	X	X

* Options are in conjunction with the LOD3 Seawall
** Options are without a seawall

The future with-project evaluations for Hancock County included 11 options which were evaluated for environmental restoration and enhancement of environmental habitat and hurricane storm damage reduction. Options A through D include four design cross-sections with varying dune and berm configurations. The berm and dune options would be constructed adjacent to the seawall along the length of the beach. For environmental and economic purposes, Options E through H further evaluated the four design cross-sections to include sand fencing and plantings on the dune to provide environmental habitat and to reduce sand transport due to the strong winds, which frequently occur during storms. The wider dune features would provide for a larger spatial extent with which to create environmental habitat. Options A through H were evaluated in conjunction with the Line of Defense 3 seawall. Typical cross sections for Options A through D are shown in Figure 3.2.1.1-2. The same cross sections were used for Options E through H. For Options E through H, sea oats would be planted on the seaward dune face in an 18 by 18 inch grid pattern, with a total of three rows of plants starting at the seaward toe of the dune.

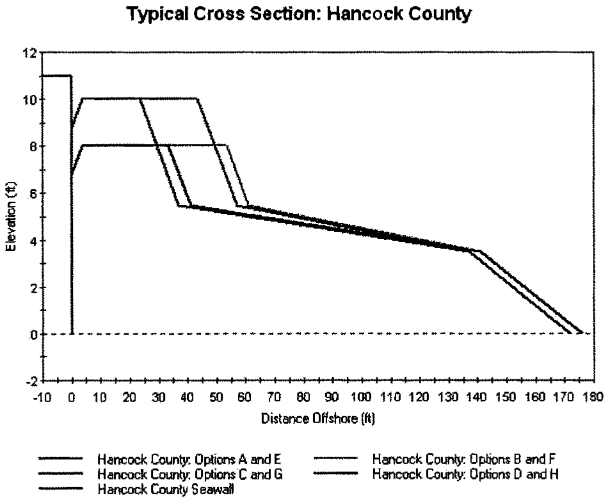

Figure 3.2.1.1-2.
Typical Cross Sections, Hancock County Options A-D and E-H

Options I and J are comparative with-project options, for future evaluation, consisting of a design cross-section which includes a dune and berm constructed as a stand alone project which does not incorporate the Line of Defense 3 seawall. Option I consists of a dune feature constructed approximately 50 ft seaward of the seawall. The berm width would be extended to accommodate the placement of the dune feature. Sand fencing would be placed on the dunes to reduce sand transport due to the strong winds which frequently occur during storms. The cross section for Option J is the same as Option I; however the dune would be planted to provide for additional environmental habitat. For Option J, sea oats would be planted on both the landward and seaward dune face in an 18 by 18 inch grid pattern, with a total of three rows of plants starting at the landward and seaward toes of the dune. The dunes will require initial and continued maintenance of vegetation and sand fencing. A typical cross section for Options I and J is shown in Figure 3.2.1.1-3.

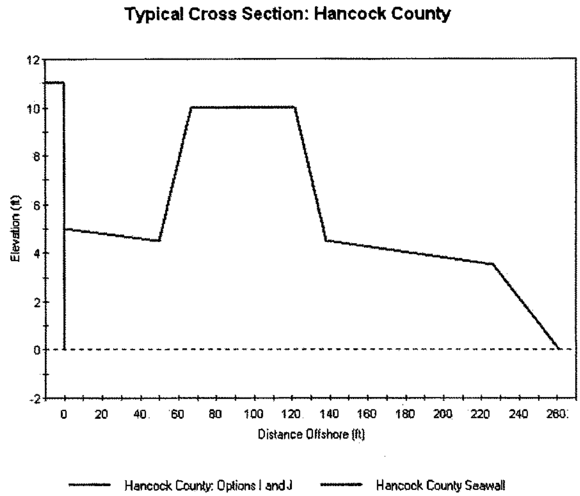

Figure 3.2.1.1-3.
Typical Cross Section, Hancock County Comparative Dune Options I and J

Option K is also an option for future evaluation which consists of an elevated berm section constructed primarily for the creation of environmental habitat. Option K would be constructed as a stand alone option which does not incorporate the Line of Defense 3 seawall. The elevated berm section would be constructed approximately 50 ft seaward of the existing seawall to an elevation 2 ft above the existing berm with a width of approximately 60 ft. The berm width would not be extended to accommodate the placement of the elevated berm feature. The new feature would be vegetated and sand fencing would be placed to create environmental habitat and to reduce sand transport due to the strong winds which frequently occur during storms. For Option K, sea oats would be planted in a 30 by 30 inch grid pattern over the entire elevated berm area. The new feature will require initial and continued maintenance of vegetation and sand fencing. A typical cross section for Option K is shown in Figure 3.2.1.1-4.

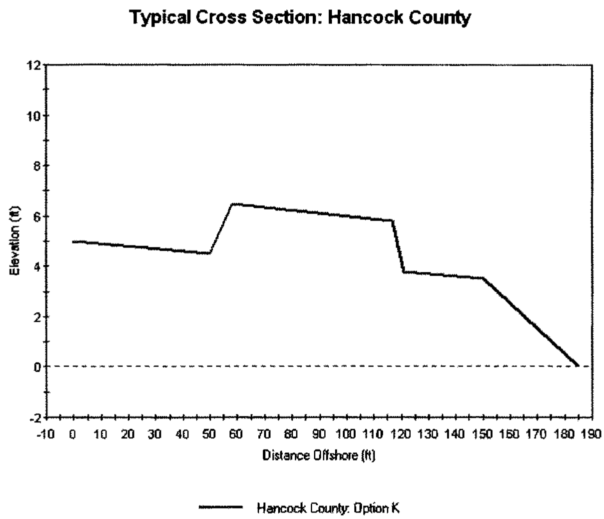

Figure 3.2.1.1-4.
Typical Cross Section, Hancock County Option K

3.2.1.2 Real Estate Requirements

Real Estate requirements for Line of Defense 2 for Hancock County include lands, easements, rights-of-way and relocations, and disposal/borrow areas (LERRD), the right to construct a dune atop the existing beach along with a fence and dune vegetation. Hancock County Tax Maps show parcels under private ownership that are seaward of Beach Boulevard and the seawall. However, under statutory authority, the State claims ownership of all lands seaward of the seawall, and an assumption is made that no further easements will be needed on those lands. An assumption is made that a real estate interest would have been obtained to allow for the original construction of the beaches and subsequent re-nourishment activity. This will be confirmed upon further analysis during PED.

The recommended plan proposes to use material from an inventory of upland borrow sites to construct the dune. See Section 2.8 Borrow Areas on page 5. A specific site has not been identified or confirmed for use at time of this report. Typically if borrow sites are required, this would be considered a part of the LERRD requirement. Real Estate would provide an analysis during PED to compare the cost of acquiring an upland borrow site with the cost of using a commercial borrow site and make a determination which method is most cost effective. Access to the project will be along public roadways and staging is expected to be on sponsor owned lands if required. Addendum C of the Economics Appendix discusses the availability of public parking and access for all three counties. No public access issues have been identified. However, if additional public beach access or parking is required, the sponsor will be responsible for acquiring those real estate interests. Acquisition of additional interests for access and parking are considered as requirements for participation in a Federal project and are not considered as creditable items toward project cost.

3.2.1.3 Utility/Facility Relocation

Some temporary rework of the storm drainage system may be necessary during construction of the project. See Chapter 2 Section 2.10 for more detailed discussion.

3.2.1.4 Existing Projects/Studies

Relevant projects and studies are found in the main report at Section 1.6, History of the Investigation and Section 1.7, Prior and On-Going Studies, Reports and Programs.

3.2.1.5 Environmental Impacts

None of the options described for LOD2 are expected to cause negative impacts to the surrounding environment. See the Main Report, Chapter 6. Environmental Effects of Plans and the Environmental Appendix, for a full discussion on environmental effects.

3.2.1.6 Project Sponsor Responsibilities and Capabilities

The State of Mississippi will be the non-Federal Project Sponsor (NFS). The NFS has the responsibility to acquire all real estate interests required for the Project. The NFS shall accomplish all alterations and relocations of facilities, structures and improvements determined by the government to be necessary for construction of the Project.

Title to any acquired real estate will be retained by the Project Sponsor and will not be conveyed to the United States Government. Prior to advertisement of any construction contract, the NFS shall furnish to the government an Authorization for Entry for Construction (Exhibit "A" to the Real Estate Appendix) to all lands, easements and rights-of-way, as necessary. The NFS will also furnish to the government evidence supporting their legal authority to grant rights-of-way to such lands. The NFS shall comply with applicable provisions of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970, Public Law 91-646, approved 2 January 1971, and amended by Title IV of the Surface Transportation Uniform Relocation Assistance Act of 1987, Public Law 100-17, effective 2 April 1989, in acquiring real estate interests for the Project, and inform all affected persons of applicable benefits, policies, and procedures in connection with said Act(s). A form for the Assessment of the Non-Federal Sponsor's Capability to Acquire Real Estate is at Exhibit "B" to the Real Estate Appendix. The assessment will be made during PED phase.

The non-Federal sponsor is entitled to receive credit against its share of project costs for the value of lands it provides and the value of the relocations that are required for the project. Generally, for the purpose of determining the amount of credit to be afforded, the value of the LER is the fair market value of the real property interest, plus certain incidental costs of acquiring those interests, that the non-federal sponsor provided for the project as required by the Government. The NFS cannot receive credit for the value of any LER, including incidental costs, which were previously provided as an item of cooperation for another Federal project, including projects that preceded enactment of WRDA 1986.

3.2.1.7 Government Owned Property

There are no known Government owned lands within the proposed project.

3.2.1.8 Historical Significance

See the Main Report, Section 3.2.9 Cultural and Archaeological Resources, for a general discussion on cultural and archaeological resources.

3.2.1.9 Mineral Rights

There are no known mineral activities within the scope of the proposed project.

3.2.1.10 Hazardous, Toxic, and Radioactive Waste (HTRW)

Due to the extent of the project, no preliminary assessment was performed to identify the possibility of hazardous waste on the sites. These studies will be conducted during the next phase of work. See Sections 3.2.8 and 6.16 of the Main Report for a discussion on HTRW.

3.2.1.11 Public Law 91-646, Relocation Assistance Benefits

Not Applicable.

3.2.1.12 Attitude of Property Owners

Real Estate has not interviewed property owners or tenants during the study phase for the MsCIP. However, numerous public meetings have been held at different locations throughout the study area to inform stakeholders and property owners about the study and the protective measures under consideration for the Mississippi coastal area. A number of local newspapers have published articles that discuss the MsCIP study and the perceived positive effects as well as the negative impacts that may occur as a result of the project. Some of these articles can be found on web sites. While many of the locals may welcome the benefits of the proposed project, there are some who oppose the project.

3.2.1.13 Acquisition Schedule

An assumption is made that the sponsor holds an interest in all lands required for the project. Certification of lands acquired/owned by the sponsor will be necessary prior to advertisement for construction. This can be accomplished within 30 days. However, if a borrow area or temporary work area easements become a requirement, 6-12 months should be allowed for easement acquisition of the sites. An acquisition schedule will be made during PED and will be a joint effort of the NFS, the project manager and Real Estate.

3.2.1.14 Estates for Proposed Project

An assumption is made that no easements will be required on lands seaward of the seawall. Should a borrow site be required, the Borrow Easement should be used. The Temporary Work Area Easement will be used for any staging or temporary work areas if required. The estates recommended are standard estates.

BORROW EASEMENT.

A (temporary) (perpetual and assignable) right and easement to clear, borrow, excavate and remove sand, soil, dirt, and other materials from (the land described in Schedule A) (Tracts Nos. _____, _____ and _____); subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines; reserving, however, to the landowners, their heirs and assigns, all such rights and privileges in said land as may be used without interfering with or abridging the rights and easement hereby acquired.

TEMPORARY WORK AREA EASEMENT.

A temporary easement and right-of-way in, on, over and across (the land described in Schedule A) (Tracts Nos. _____, _____ and _____), for a period not to exceed ____________________, beginning with date possession of the land is granted to the Project Sponsor, for use by the Project Sponsor, its representatives, agents, and contractors as a work area, including the right to deposit backfill, move, store and remove equipment and supplies, and erect and remove temporary structures on the land and to perform any other work necessary and incident to the construction of the ____________________ Project, together with the right to trim, cut, fell and remove there from all trees, underbrush, obstructions, and any other vegetation, structures, or obstacles within the limits of the right-of-way; reserving, however, to the landowners, their heirs and assigns, all such rights and privileges as may be used without interfering with or abridging the rights and easement hereby acquired; subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

3.2.1.15 Real Estate Estimate

The real estate cost estimate at Table 3.2.1.15-1 includes a cost for Federal and non-Federal administrative costs. Administrative costs are those costs incurred for verifying ownership of lands, certification of those lands required for project purposes, legal opinions, analysis or other requirements that may be necessary, during PED. The State claims ownership of those lands seaward of the seawall, so no additional land costs are anticipated. No cost is included for an upland borrow site. The requirement, if any, for an upland borrow site will be identified during PED. If further real estate requirements are identified during PED or if there is a significant increase in cost, a supplement to the Real Estate Appendix will be prepared. A 25% contingency is applied to the current estimate. The same administrative cost is projected for any individual option or combinations of options.

Table 3.2.1.15-1.
LOD2 Hancock County Estimate

a. Lands and Improvements/Permits					0
				Subtotal	0
b. Mineral Rights					0
c. Damages					0
d. P.L. 91-646 Relocation costs					0
e. Administrative Cost					15,000
		Relocation	Acquisition	Total	
	Federal	0	7,500	7,500	
	Non-Federal	0	7,500	7,500	
		0	15,000	15,000	
Subtotal					15,000
Contingencies (25%)					3,750
	Totals				**18,750**
	Rounded				**19,000**

3.2.1.16 Summary of Potential Real Estate Issues

The requirement for borrow areas or temporary work areas has not been identified. Should these areas be required, these would be considered as part of the LERRD requirements. Typically if borrow sites are required, Real estate would provide an analysis during PED to compare the cost of acquiring an upland borrow site with the cost of using a commercial borrow site and make a determination which method is most cost effective. See Section 2.8 Borrow Areas on page 5.

Should borrow areas or temporary work areas become a necessary real estate acquisition requirement, valuation of lands will be performed. Land costs associated with these areas, and administrative costs will be added to the Real Estate Cost Estimate. If further real estate requirements are identified during PED or if there is a significant increase in cost, a supplement to the Real Estate Appendix will be prepared.

Any requirements for relocation contracts pertaining to facilities/utilities will be identified and completed during PED.

Specific requirements for long term O&M and any associated real estate interests will be identified during PED.

Should condemnation of any required real estate interest be necessary, it is the responsibility of the NFS. This issue is addressed during the Assessment of the Non-Federal Sponsor's Real Estate Acquisition Capability. However, if the real estate interest is one that the NFS does not have authority to condemn, the Federal Government can perform the condemnation on behalf of the NFS.

3.2.1.17 Chart of Accounts

The cost estimate for all Federal and non-Federal real estate activities necessary for implementation of the project after completion of the feasibility study for land acquisition, construction, LERRD, and other items are coded as delineated in the Cost Work Breakdown Structure (CWBS). This real estate cost estimate is then incorporated into the Total Current Working Estimate utilizing the Microcomputer Aided Cost Engineering System (MCACES). The Chart of Accounts at Table 3.2.1.17-1 shows the CWBS for real estate activities.

Table 3.2.1.17-1.
Chart of Accounts - LOD2 Hancock County

01A	Project Planning	Federal	Non-Federal	Totals
	Other			
	Project Cooperation Agreement			
01AX	Contingencies (25%)			
	Subtotal			
01B	Lands and Damages / Permits			
01B40	Acquisition/Review of NFS	7,500		7,500
01B20	Acquisition by NFS		7,500	7,500
01BX	Contingencies (25%)	1,875	1,875	3,750
	Subtotal	9,375	9,375	18,750
01F	PL 91-646 Assistance			
01F20	By NFS			
01FX	Contingencies (25%)			
	Subtotal			

01A	Project Planning	Federal	Non-Federal	Totals
01R	Real Estate Land Payments			
01R1B	Land Payments by NFS			
01R2B	PL91-646 Relocation Payment by NFS			
01R2D	Review of NFS			
01RX	Contingencies (25%)			
	Subtotal			
	Totals	**9,375**	**9,375**	**18,750**
	Rounded			**19,000**

3.2.2 Harrison County Beaches

3.2.2.1 Project Description

The purpose of this project is to provide hurricane storm damage reduction and restoration of the shoreline to 26 miles of public beaches along Harrison County, MS coastline which was impacted by tidal flooding during Hurricane Katrina in August 2005.

The Mississippi mainland shoreline is divided into three coastal counties: Jackson, Harrison, and Hancock Counties. Harrison County, extends approximately 26-miles, has the largest population, and the greatest number of municipalities. It is bordered on the east by industrialized Jackson County, on the west by Hancock County and the John C. Stennis Space Center and to the north by primarily rural Stone County. The County consists of five municipalities: Biloxi, D'Iberville, Gulfport, Long Beach, and Pass Christian. The Harrison County Federal Shore Protection Project shown in Figure 3.2.2.1-1 extends approximately 26-miles from Biloxi on the east to Henderson Point on the west.

As a result of the 1915 hurricane which destroyed half of U.S. 90, a seawall was constructed to protect the roadway and beach front property. After the hurricane in 1947 and due to ongoing loss of sediment, the Harrison County, Mississippi Federal Beach Erosion Control Project was constructed in 1952 under the Section 2 authority of the River and Harbor Act .The project was constructed to protect the seawall and US 90, which provides an evacuation route for residents. The non-federal sponsor was Harrison County.

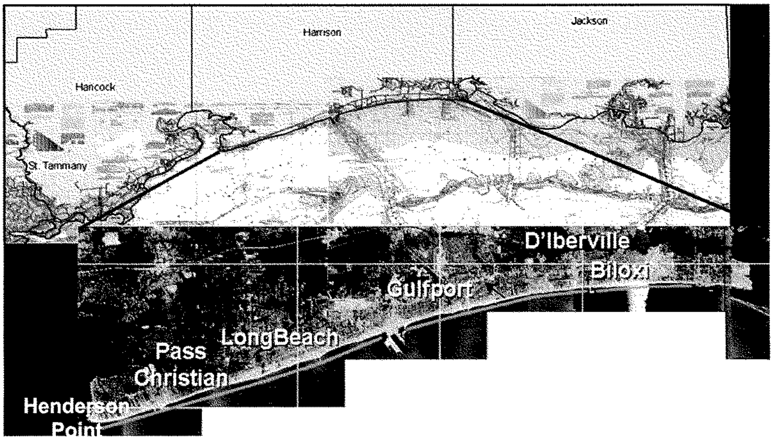

Figure 3.2.2.1-1. Project Location, Harrison County Beaches

The authorized Harrison County project provides for a beach profile consisting of a berm only feature which extends approximately 265 ft from the seawall to mean sea level (MSL). The berm elevation varies from an elevation of approximately 7.2 ft (NAVD 88) at the seawall to 3.5 ft at the slope break to the Mississippi Sound. Storm water culverts pass beneath US 90 to the shoreline to drain sections of Biloxi, Long Beach, and Pass Christian. The Harrison County beaches were last re-nourished in 2001, which placed approximately 1.1 million CY of beach quality sand obtained from borrows sites located about 1,500 ft offshore of the Harrison County shoreline. During Hurricane Katrina on 29 August 2005, the project experienced erosional damage due to wind driven waves, debris scour, storm surge and subsequent return flow after the hurricane.

The project includes the evaluation of eleven options in Harrison County as listed in Table 3.2.2.1-1.

Table 3.2.2.1-1.
Harrison County LOD2 Options

Option	Dune Elevation (ft)	Dune Width (ft)	Dune Side Slope	Berm Width (ft)	Plantings	Sand Fencing
A*	15	35	1:3	160		
B*	13	45	1:3	160		
C*	15	25	1:3	170		
D*	13	15	1:3	160		
E*	15	35	1:3	160	X	X
F*	13	45	1:3	80	X	X
G*	15	25	1:3	170	X	X
H*	13	15	1:3	160	X	X
I**	15	55	1:3	Extend to accommodate		X
J**	15	55	1:3	Extend to accommodate	X	X
K**				Add 2ft, 60 ft width	X	X

* Options are in conjunction with the LOD3 Seawall
** Options are without a seawall

The future with-project evaluations for Harrison County included 11 options which were evaluated for environmental restoration and enhancement of environmental habitat and for hurricane and storm damage reduction. Options A through D included four design cross-sections with varying dune and berm configurations. The berm and dune options would be constructed adjacent to the seawall along the length of the beach. For environmental and economic purposes, Options E through H further evaluated the four design cross-sections to include sand fencing and plantings on the dune to provide environmental habitat and to reduce sand transport due to the strong winds, which frequently occur during storms. The wider dune features would provide for a larger spatial extent with which to create environmental habitat. Options A through H were evaluated in conjunction with the Line of Defense 3 seawall. The dunes will be constructed to accommodate the approximately 10 ft wide boardwalk which extends along most of the Harrison County seawall. Typical cross sections for Options A through D are shown in Figure 3.2.2.1-2. The same cross sections were used for Options E through H. For Options E through H, sea oats would be planted on the seaward dune face in an 18 by 18 inch grid pattern, with a total of three rows of plants starting at the seaward toe of the dune.

Options I and J are comparative with-project options, for future evaluation, consisting of a design cross-section which includes a dune and berm constructed as a stand alone project which does not incorporate the Line of Defense 3 seawall. Option I consists of a dune feature constructed approximately 50 ft seaward of the seawall at an elevation of 15 ft (NAVD 88), with a crest width of 55 ft, and a dune slope of 1:3. The berm width would be extended to accommodate the placement of the dune feature. Sand fencing would be placed on the dunes to reduce sand transport due to the strong winds which frequently occur during storms. The cross section for Option J is the same as Option I; however the dune would be planted to provide for additional environmental habitat. For Option J, sea oats would be planted on both the landward and seaward dune face in an 18 by 18 inch grid pattern, with a total of three rows of plants starting at the landward and seaward toes of the dune. The dunes will require initial and continued maintenance of vegetation and sand fencing. A typical cross section for Options I and J is shown in Figure 3.2.2.1-3.

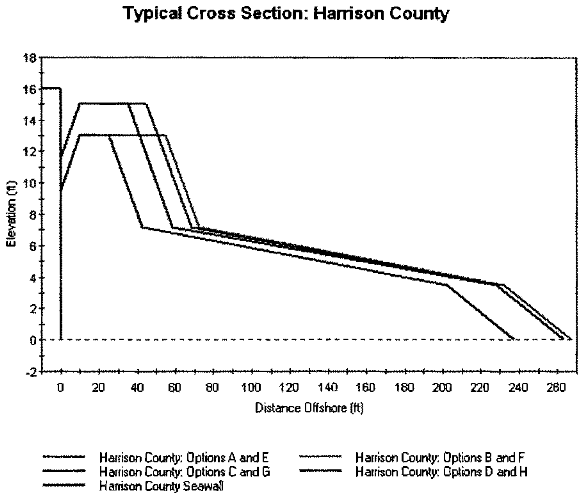

Figure 3.2.2.1-2.
Typical Cross Sections, Harrison County Options A-D and E-H

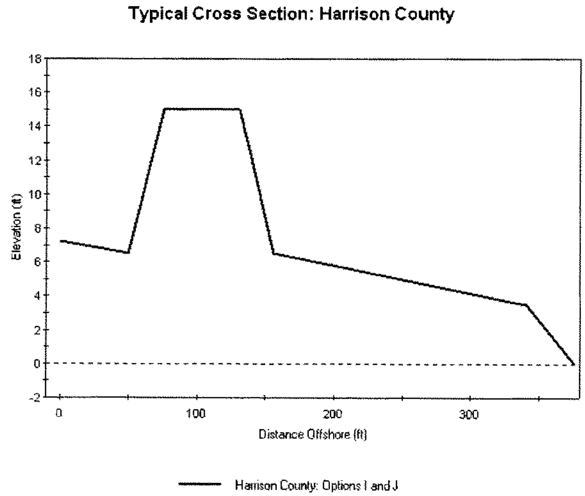

Figure 3.2.3.1-3.
Typical Cross Section, Harrison County Comparative Dune Options I and J

Option K is also an option for future evaluation which consists of an elevated berm section constructed primarily for the creation of environmental habitat. Option K would be constructed as a stand alone option which does not incorporate the Line of Defense 3 seawall. The elevated berm section would be constructed approximately 50 ft seaward of the existing seawall to an elevation 2 ft above the existing berm with a width of approximately 60 ft. The berm width would not be extended to accommodate the placement of the elevated berm feature. The new feature would be vegetated and sand fencing would be placed to create environmental habitat and to reduce sand transport due to the strong winds which frequently occur during storms. For Option K, sea oats would be planted in a 30 by 30 inch grid pattern over the entire elevated berm area. The new feature will require initial and continued maintenance of vegetation and sand fencing. A typical cross section for Option K is shown in Figure 3.2.2.1-4.

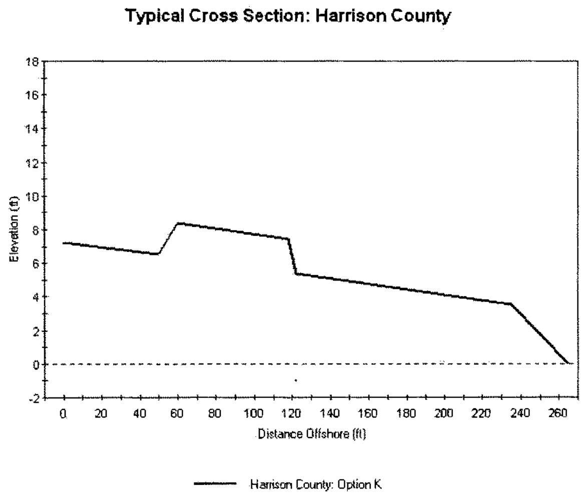

Figure 3.2.2.1-4.
Typical Cross Section, Harrison County Option K

3.2.2.2 Real Estate Requirements

Real Estate requirements for Line of Defense 2 for Harrison County include lands, easements, rights-of-way and relocations, and disposal/borrow areas (LERRD), the right to construct a dune atop the existing beach along with a fence and dune vegetation. Harrison County Tax Maps show parcels under private ownership that are seaward of Beach Boulevard and the seawall. However, the State claims ownership of all lands seaward of the seawall, and an assumption is made that no further easements will be needed on those lands. An assumption is made that a real estate interest would have been obtained to allow for the original construction of the beaches and subsequent re-nourishment activity. This will be confirmed upon further analysis during PED. The sand used for project construction is expected to come from established off shore sources within one mile of the work area. Appropriate permitting will be required to borrow from the off shore sites.

Access to the project will be along public roadways and staging is expected to be on sponsor owned lands if required. Addendum C of the Economics Appendix discusses the availability of public parking and access for all three counties. No public access issues have been identified. However, if additional public beach access or parking is required, the sponsor will be responsible for acquiring those real estate interests. Acquisition of additional interests for access and parking are considered as requirements for participation in a Federal project and are not considered as creditable items toward project cost.

3.2.2.3 Utility/Facility Relocation

There are no known utility or facility relocations in any of the options for the berm and dune construction.

3.2.2.4 Existing Projects/Studies

The Harrison County Shore Protection Project was completed in June 1952 and provided for the repair of the existing 24 mile long Harrison County seawall and its protection by the construction of a beach from Biloxi Lighthouse to Henderson point near Pass Christian. The beach has been maintained by Harrison County since then. During PED a determination will be made of what interest was acquired for the project. Other relevant projects and studies are found in the main report at Section 1.6, History of the Investigation and Section 1.7, Prior and On-Going Studies, Reports and Programs.

3.2.2.5 Environmental Impacts

None of the options described for LOD2 are expected to cause negative impacts to the surrounding environment. See the Main Report, Chapter 6. Environmental Effects of Plans and the Environmental Appendix, for a full discussion on environmental effects.

3.2.2.6 Project Sponsor Responsibilities and Capabilities

The State of Mississippi will be the non-Federal Project Sponsor (NFS). The NFS has the responsibility to acquire all real estate interests required for the Project. The NFS shall accomplish all alterations and relocations of facilities, structures and improvements determined by the government to be necessary for construction of the Project.

Title to any acquired real estate will be retained by the Project Sponsor and will not be conveyed to the United States Government. Prior to advertisement of any construction contract, the NFS shall furnish to the government an Authorization for Entry for Construction (Exhibit "A" to the Real Estate Appendix) to all lands, easements and rights-of-way, as necessary. The NFS will also furnish to the government evidence supporting their legal authority to grant rights-of-way to such lands. The NFS shall comply with applicable provisions of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970, Public Law 91-646, approved 2 January 1971, and amended by Title IV of the Surface Transportation Uniform Relocation Assistance Act of 1987, Public Law 100-17, effective 2 April 1989, in acquiring real estate interests for the Project, and inform all affected persons of applicable benefits, policies, and procedures in connection with said Act(s). A form for the Assessment of the Non-Federal Sponsor's Capability to Acquire Real Estate is at Exhibit "B" to the Real Estate Appendix. The assessment will be made during PED phase.

The non-Federal sponsor is entitled to receive credit against its share of project costs for the value of lands it provides and the value of the relocations that are required for the project. Generally, for the purpose of determining the amount of credit to be afforded, the value of the LER is the fair market value of the real property interest, plus certain incidental costs of acquiring those interests, that the non-federal sponsor provided for the project as required by the Government. The NFS cannot receive credit for the value of any LER, including incidental costs, which were previously provided as an item of cooperation for another Federal project, including projects that preceded enactment of WRDA 1986.

3.2.2.7 Government Owned Property

There are no known Government owned lands within the proposed project.

3.2.2.8 Historical Significance

See the Main Report, Section 3.2.9 Cultural and Archaeological Resources, for a general discussion on cultural and archaeological resources.

3.2.2.9 Mineral Rights

There are no known mineral activities within the scope of the proposed project.

3.2.2.10 Hazardous, Toxic, and Radioactive Waste (HTRW)

Due to the extent of the project, no preliminary assessment was performed to identify the possibility of hazardous waste on the sites. These studies will be conducted during the next phase of work. See Sections 3.2.8 and 6.16 of the Main Report for a discussion on HTRW.

3.2.2.11 Public Law 91-646, Relocation Assistance Benefits

Not Applicable

3.2.2.12 Attitude of Property Owners

Real Estate has not interviewed property owners or tenants during the study phase for the MsCIP. However, numerous public meetings have been held at different locations throughout the study area to inform stakeholders and property owners about the study and the protective measures under consideration for the Mississippi coastal area. A number of local newspapers have published articles that discuss the MsCIP study and the perceived positive effects as well as the negative impacts that may occur as a result of the project. Some of these articles can be found on web sites. While many of the locals may welcome the benefits of the proposed project, there are some who oppose the project.

3.2.2.13 Acquisition Schedule

An assumption is made that the sponsor holds an interest in all lands required for the project. Certification of lands acquired/owned by the sponsor will be necessary prior to advertisement for construction. This can be accomplished within 30 days. However, if temporary work area easements become a requirement, 6-12 months should be allowed for an easement acquisition of the sites. An acquisition schedule will be made during PED and will be a joint effort of the NFS, the project manager and Real Estate.

3.2.2.14 Estates for Proposed Project

An assumption is made that no easements will be required on lands seaward of the seawall. The standard estate Temporary Work Area Easement will be used for any staging or temporary work areas if required.

TEMPORARY WORK AREA EASEMENT.

A temporary easement and right-of-way in, on, over and across (the land described in Schedule A) (Tracts Nos. _____, _____ and _____), for a period not to exceed __________________, beginning with date possession of the land is granted to the Project Sponsor, for use by the Project Sponsor, its representatives, agents, and contractors as a work area, including the right to deposit backfill, move, store and remove equipment and supplies, and erect and remove temporary structures on the land and to perform any other work necessary and incident to the construction of the ____________________ Project, together with the right to trim, cut, fell and remove there from all trees, underbrush, obstructions, and any other vegetation, structures, or obstacles within the limits of the right-of-way; reserving, however, to the landowners, their heirs and assigns, all such rights and privileges as may be used without interfering with or abridging the rights and easement hereby acquired; subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

3.2.2.15 Real Estate Estimate

The real estate cost estimate at Table 3.2.2.15-1 includes a cost for Federal and non-Federal administrative costs. Administrative costs are those costs incurred for verifying ownership of lands, certification of those lands required for project purposes, legal opinions, analysis or other requirements that may be necessary, during PED. The State claims ownership of those lands seaward of the seawall, so no additional land costs are anticipated. If further real estate requirements are identified during PED or if there is a significant increase in cost, a supplement to the Real Estate Appendix will be prepared. A 25% contingency is applied to the current estimate. The same administrative cost is projected for any individual option or combinations of options.

Table 3.2.2.15-1.
LOD2 Harrison County Estimate

a. Lands and Improvements/Permits					0
				Subtotal	0
b. Mineral Rights					0
c. Damages					0
d. P.L. 91-646 Relocation costs					0
e. Administrative Cost					15,000
		Relocation	Acquisition	Total	
	Federal	0	7,500	7,500	
	Non-Federal	0	7,500	7,500	
		0	15,000	15,000	
Subtotal					15,000
Contingencies (25%)					3,750
	Totals				**18,750**
	Rounded				**19,000**

3.2.2.16 Summary of Potential Real Estate Issues

If further real estate requirements are identified during PED or if there is a significant increase in cost, a supplement to the Real Estate Appendix will be prepared.

Should temporary work areas become a necessary real estate acquisition requirement, valuation of lands will be performed. Land costs associated with these areas, and administrative costs will be added to the Real Estate Cost Estimate. If further real estate requirements are identified during PED or if there is a significant increase in cost, a supplement to the Real Estate Appendix will be prepared.

Specific requirements for long term O&M and any associated real estate interests will be identified during PED.

Should condemnation of any required real estate interest be necessary, it is the responsibility of the NFS. This issue is addressed during the Assessment of the Non-Federal Sponsor's Real Estate Acquisition Capability. However, if the real estate interest is one that the NFS does not have authority to condemn, the Federal Government can perform the condemnation on behalf of the NFS.

3.2.2.17 Chart of Accounts

The cost estimate for all Federal and non-Federal real estate activities necessary for implementation of the project after completion of the feasibility study for land acquisition, construction, LERRD, and other items are coded as delineated in the Cost Work Breakdown Structure (CWBS). This real estate cost estimate is then incorporated into the Total Current Working Estimate utilizing the Microcomputer Aided Cost Engineering System (MCACES). The Chart of Accounts at Table 3.2.2.17-1 shows the CWBS for real estate activities.

Table 3.2.2.17-1.
Chart of Accounts - LOD2 Harrison County

01A	Project Planning	Federal	Non-Federal	Totals
	Other			
	Project Cooperation Agreement			
01AX	Contingencies (25%)			
	Subtotal			
01B	Lands and Damages / Permits			
01B40	Acquisition/Review of NFS	7,500		7,500
01B20	Acquisition by NFS		7,500	7,500
01BX	Contingencies (25%)	1,875	1,875	3,750
	Subtotal	9,375	9,375	18,750
01F	PL 91-646 Assistance			
01F20	By NFS			
01FX	Contingencies (25%)			
	Subtotal			
01R	Real Estate Land Payments			
01R1B	Land Payments by NFS			
01R2B	PL91-646 Relocation Payment by NFS			
01R2D	Review of NFS			
01RX	Contingencies (25%)			
	Subtotal			
	Totals	**9,375**	**9,375**	**18,750**
	Rounded			**19,000**

3.2.3 Jackson County Beaches

3.2.3.1 Project Description

The purpose of this project is to provide hurricane storm damage reduction and restoration of the shoreline to 7 miles of public beaches along the Jackson County, MS coastline which was impacted by tidal flooding during Hurricane Katrina in August 2005.

The Mississippi mainland shoreline is divided into three coastal counties: Jackson, Harrison, and Hancock Counties. Jackson County is the eastern-most coastal county in Mississippi and is bordered on the east by the Mississippi-Alabama state line and on the west by Harrison County. Jackson County consists of four municipalities: Pascagoula, Moss Point, Gautier, and Ocean Springs. The beaches along the Ocean Springs shoreline are divided into two reaches: Front Beach extending approximately 1 mile southeastward from US 90 along Front Beach drive to the Ocean Springs Harbor, and East Beach extending approximately 1 mile from the Ocean Springs Harbor to Halstead Road, Figure 3.2.3.1-1.

Seawalls were constructed along the shoreline fronting the developed sections of Ocean Springs in the late 1920s. Two decades later, beach nourishment projects created sand beaches in front of two seawall segments, and the modern shoreline reaches of Front Beach and East Beach became named. Front Beach, more exposed to wave and tidal forces, experienced greater levels of erosion, and re-nourishment with dredged material was conducted in the 1970s. At wave-sheltered East Beach, marsh vegetation colonized the beachfront intertidal zone and thus assisted in the stabilization of the shoreline. Both Front Beach and East Beach systems only consist of a berm with landward elevations ranging from approximately 2.5 to 5 ft and berm widths of about 100 ft.

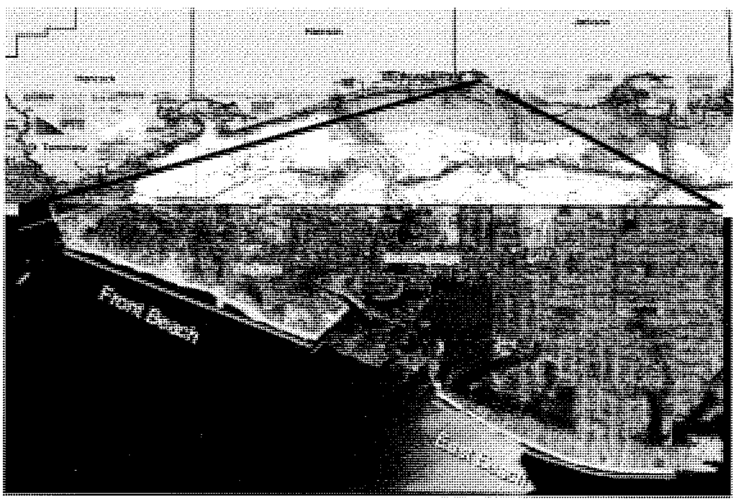

Figure 3.2.3.1-1.
Project Location, Jackson County Beaches

The project includes evaluation of eleven options in Jackson County as listed in Table 3.2.3.1-1. Evaluation of the Jackson County beaches was based on the analysis of the Hancock County beaches. The Jackson County beach options are the same design as the Hancock County beaches; therefore the reader is referred to Section 3.2.1.1 for information regarding the Hancock County future with project options.

Table 3.2.3.1-1.
Jackson County LOD2

Option	Description					
	Dune			Berm		
	Elevation (ft)	Width (ft)	Side Slope	Width (ft)	Plantings	Sand Fencing
A*	10	40	1:3	80		
B*	8	50	1:3	80		
C*	10	20	1:3	100		
D*	8	30	1:3	80		
E*	10	40	1:3	80	X	X
F*	8	50	1:3	80	X	X
G*	10	20	1:3	100	X	X
H*	8	30	1:3	100	X	X
I**	10	55	1:3	Extend to accommodate		X
J**	10	55	1:3	Extend to accommodate	X	X
K**				Add 2ft, 60 ft width	X	X

* Options are in conjunction with the LOD3 Seawall
** Options are without a seawall

3.2.3.2 Real Estate Requirements

Real Estate requirements for Line of Defense 2 for Jackson County include lands, easements, rights-of-way and relocations, and disposal/borrow areas (LERRD), the right to construct a dune atop the existing beach along with a fence and dune vegetation. Jackson County Tax Maps show parcels under private ownership that are seaward of the beach boulevards. However, the State claims ownership of all lands seaward of the seawall, and an assumption is made that no further easements will be needed on those lands. An assumption is made that a real estate interest would have been obtained to allow for the original construction of the beaches and subsequent re-nourishment activity. This will be confirmed upon further analysis during PED.

The recommended plan proposes to use material from an inventory of upland borrow sites to construct the project. The sources are within ten miles of the work area. A specific site has not been identified or confirmed for use at time of this report. Typically if borrow sites are required, this would be considered a part of the LERRD requirement. Real Estate would provide an analysis during PED to compare the cost of acquiring an upland borrow site with the cost of using a commercial borrow site and make a determination which method is most cost effective. Access to the project will be along public roadways and staging is expected to be on sponsor owned lands if required. Addendum C of the Economics Appendix discusses the availability of public parking and access for all three counties. No public access issues have been identified. However, if additional public beach access or parking is required, the sponsor will be responsible for acquiring those real estate interests. Acquisition of additional interests for access and parking are considered as requirements for participation in a Federal project and are not considered as creditable items toward project cost.

3.2.3.3 Utility/Facility Relocation

There are no known utility or facility relocations in any of the options for the berm and dune construction.

3.2.3.4 Existing Projects/Studies

Relevant projects and studies are found in the main report at Section 1.6, History of the Investigation and Section 1.7, Prior and On-Going Studies, Reports and Programs.

3.2.3.5 Environmental Impacts

None of the options described for LOD2 are expected to cause negative impacts to the surrounding environment. See the Main Report, Chapter 6. Environmental Effects of Plans and the Environmental Appendix, for a full discussion on environmental effects.

3.2.3.6 Project Sponsor Responsibilities and Capabilities

The State of Mississippi will be the non-Federal Project Sponsor (NFS). The NFS has the responsibility to acquire all real estate interests required for the Project. The NFS shall accomplish all alterations and relocations of facilities, structures and improvements determined by the government to be necessary for construction of the Project.

Title to any acquired real estate will be retained by the Project Sponsor and will not be conveyed to the United States Government. Prior to advertisement of any construction contract, the NFS shall furnish to the government an Authorization for Entry for Construction (Exhibit "A" to the Real Estate Appendix) to all lands, easements and rights-of-way, as necessary. The NFS will also furnish to the government evidence supporting their legal authority to grant rights-of-way to such lands. The NFS shall comply with applicable provisions of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970, Public Law 91-646, approved 2 January 1971, and amended by Title IV of the Surface Transportation Uniform Relocation Assistance Act of 1987, Public Law 100-17, effective 2 April 1989, in acquiring real estate interests for the Project, and inform all affected persons of applicable benefits, policies, and procedures in connection with said Act(s). A form for the Assessment of the Non-Federal Sponsor's Capability to Acquire Real Estate is at Exhibit "B" to the Real Estate Appendix. The assessment will be made during PED phase.

The non-Federal sponsor is entitled to receive credit against its share of project costs for the value of lands it provides and the value of the relocations that are required for the project. Generally, for the purpose of determining the amount of credit to be afforded, the value of the LER is the fair market value of the real property interest, plus certain incidental costs of acquiring those interests, that the non-federal sponsor provided for the project as required by the Government. The NFS cannot receive credit for the value of any LER, including incidental costs, which were previously provided as an item of cooperation for another Federal project, including projects that preceded enactment of WRDA 1986.

3.2.3.7 Government Owned Property

There are no known Government owned lands within the proposed project.

3.2.3.8 Historical Significance

See the Main Report, Section 3.2.9 Cultural and Archaeological Resources, for a general discussion on cultural and archaeological resources.

3.2.3.9 Mineral Rights

There are no known mineral activities within the scope of the proposed project.

3.2.3.10 Hazardous, Toxic, and Radioactive Waste (HTRW)

Due to the extent of the project, no preliminary assessment was performed to identify the possibility of hazardous waste on the sites. These studies will be conducted during the next phase of work. See Sections 3.2.8 and 6.16 of the Main Report for a discussion on HTRW.

3.2.3.11 Public Law 91-646, Relocation Assistance Benefits

Not Applicable.

3.2.3.12 Attitude of Property Owners

Real Estate has not interviewed property owners or tenants during the study phase for the MsCIP. However, numerous public meetings have been held at different locations throughout the study area to inform stakeholders and property owners about the study and the protective measures under consideration for the Mississippi coastal area. A number of local newspapers have published articles that discuss the MsCIP study and the perceived positive effects as well as the negative impacts that may occur as a result of the project. Some of these articles can be found on web sites. While many of the locals may welcome the benefits of the proposed project, there are some who oppose the project.

3.2.3.13 Acquisition Schedule

An assumption is made that the sponsor holds an interest in all lands required for the project. Certification of lands acquired/owned by the sponsor will be necessary prior to advertisement for construction. This can be accomplished within 30 days. However, if borrow or temporary work area easements become a requirement, 6-12 months should be allowed for an easement acquisition of the sites. An acquisition schedule will be made during PED and will be a joint effort of the NFS, the project manager and Real Estate.

3.2.3.14 Estates for Proposed Project

An assumption is made that no easements will be required on lands seaward of the seawall. Should a borrow site be required, the Borrow Easement should be used. The Temporary Work Area Easement will be used for any staging or temporary work areas if required. The estates recommended are standard estates.

BORROW EASEMENT.

A (temporary) (perpetual and assignable) right and easement to clear, borrow, excavate and remove sand, soil, dirt, and other materials from (the land described in Schedule A) (Tracts Nos. _____, _____ and _____); subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines; reserving, however, to the landowners, their heirs and assigns, all such rights and privileges in said land as may be used without interfering with or abridging the rights and easement hereby acquired.

TEMPORARY WORK AREA EASEMENT.

A temporary easement and right-of-way in, on, over and across (the land described in Schedule A) (Tracts Nos. _____, _____ and _____), for a period not to exceed ____________________, beginning with date possession of the land is granted to the Project Sponsor, for use by the Project Sponsor, its representatives, agents, and contractors as a work area, including the right to deposit backfill, move, store and remove equipment and supplies, and erect and remove temporary structures on the land and to perform any other work necessary and incident to the construction of the ____________________ Project, together with the right to trim, cut, fell and remove there from all trees, underbrush, obstructions, and any other vegetation, structures, or obstacles within the limits of the right-of-way; reserving, however, to the landowners, their heirs and assigns, all such rights and privileges as may be used without interfering with or abridging the rights and easement hereby acquired; subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

3.2.3.15 Real Estate Estimate

The real estate cost estimate at Table 3.2.3.15-1 includes a cost for Federal and non-Federal administrative costs. Administrative costs are those costs incurred for verifying ownership of lands, certification of those lands required for project purposes, legal opinions, analysis or other requirements that may be necessary, during PED. The State claims ownership of those lands seaward of the seawall, so no additional land costs are anticipated. If further real estate requirements are identified during PED or if there is a significant increase in cost, a supplement to the Real Estate Appendix will be prepared. A 25% contingency is applied to the current estimate. The same administrative cost is projected for any individual option or combinations of options.

Table 3.2.3.15-1.
LOD2 Jackson County Estimate

a. Lands and Improvements/Permits					0
				Subtotal	0
b. Mineral Rights					0
c. Damages					0
d. P.L. 91-646 Relocation costs					0
e. Administrative Cost					15,000
		Relocation	Acquisition	Total	
	Federal	0	7,500	7,500	
	Non-Federal	0	7,500	7,500	
		0	15,000	15,000	
Subtotal					15,000
Contingencies (25%)					3,750
	Totals				**18,750**
	Rounded				**19,000**

3.2.3.16 Summary of Potential Real Estate Issues

The requirement for borrow areas or temporary work areas has not been identified. Should these areas be required, these would be considered as part of the LERRD requirements. Typically if borrow sites are required, Real estate would provide an analysis during PED to compare the cost of acquiring an upland borrow site with the cost of using a commercial borrow site and make a determination which method is most cost effective. See Section 2.8 Borrow Areas on page 5.

Should borrow areas or temporary work areas become a necessary real estate acquisition requirement, valuation of lands will be performed. Land costs associated with these areas, and administrative costs will be added to the Real Estate Cost Estimate. If further real estate requirements are identified during PED or if there is a significant increase in cost, a supplement to the Real Estate Appendix will be prepared.

Specific requirements for long term O&M and any associated real estate interests will be identified during PED.

Should condemnation of any required real estate interest be necessary, it is the responsibility of the NFS. This issue is addressed during the Assessment of the Non-Federal Sponsor's Real Estate Acquisition Capability. However, if the real estate interest is one that the NFS does not have authority to condemn, the Federal Government can perform the condemnation on behalf of the NFS.

3.2.3.17 Chart of Accounts

The cost estimate for all Federal and non-Federal real estate activities necessary for implementation of the project after completion of the feasibility study for land acquisition, construction, LERRD, and other items are coded as delineated in the Cost Work Breakdown Structure (CWBS). This real estate cost estimate is then incorporated into the Total Current Working Estimate utilizing the Microcomputer Aided Cost Engineering System (MCACES). The Chart of Accounts at Table 3.2.3.17-1 shows the CWBS for real estate activities.

Table 3.2.3.17-1.
Chart of Accounts - LOD2 Jackson County

01A	Project Planning	Federal	Non-Federal	Totals
	Other			
	Project Cooperation Agreement			
01AX	Contingencies (25%)			
	Subtotal			
01B	Lands and Damages / Permits			
01B40	Acquisition/Review of NFS	7,500		7,500
01B20	Acquisition by NFS		7,500	7,500
01BX	Contingencies (25%)	1,875	1,875	3,750
	Subtotal	9,375	9,375	18,750
01F	PL 91-646 Assistance			
01F20	By NFS			
01FX	Contingencies (25%)			
	Subtotal			
01R	Real Estate Land Payments			
01R1B	Land Payments by NFS			
01R2B	PL91-646 Relocation Payment by NFS			
01R2D	Review of NFS			
01RX	Contingencies (25%)			
	Subtotal			
	Totals	**9,375**	**9,375**	**18,750**
	Rounded			**19,000**

3.3 Line of Defense 3 - Elevated Roadways, Seawall, and Ring Levees

All of the beaches described in the LOD-2 alternative have a roadway landward of the beach. The 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 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 with an associated seawall defines a portion of the 3rd line of defense, LOD-3. This would be the first hard engineered structure that will not be affected by erosion from a storm such as a dune system.

Initial strategy was to study three elevations, 12.0, 18.0 and 24.0 feet. This coastal barrier will coincide with the beaches where they exist. Raising the beach-front road does present some engineering challenges due to the numerous intersections with other streets and roads. With any significant increase in elevation, the intersecting roads would require ramps that would be extremely long to have a reasonable grade. Each of these ramps would also create areas where rainfall would collect and have to be removed during a storm. It also became apparent that public opinion was against any structure that would block the view of the beaches and water from the adjoining properties immediately north of the roads. This was voiced in public meetings and also from agencies that were involved in the study. To maintain some level of support for this defense, it was decided to raise the roadways an average of six feet. This allowed reasonable road intersection construction while maintaining the aesthetic view of the water and would not be perceived as a high seawall along the coast. A review of the typical roadway elevations allowed raising the roadways in Jackson and Hancock County to Elevation 11.0 and Highway 90 in Harrison County to Elevation 16.0. It was decided to study these elevations without other options as the main part of LOD-3 with the understanding that these structures would not provide protection from large storms. As described above, the LOD-2 dunes could also be constructed against the elevated roadway to help protect the toe of the structural wall associated with the road.

This line of defense would be connected to LOD-4, described below, at the mouth of Biloxi Bay and St. Louis Bay. It would also extend northward to higher ground or to LOD- 4 in Jackson County and Hancock County. The bays are an inlet for storm surge that would be controlled by surge gates as part of LOD- 4. It was also recognized that if LOD-3 was constructed without LOD-4, surge gates across the bays would have to be included as part of LOD-3.

As the first structural defense, LOD-3 will exclude some areas that may be considered potential areas of retreat or have other non-structural solutions. This may be due to low population density, ecological sensitivity, areas that contain numerous waterway crossings or areas that could not function with a structural barrier in place. In Jackson County, LOD-3 will encompass the southern portion of Ocean Springs, but due to extended marshes and streams, it will extend northeastward from near the eastern end of East Beach Road to higher ground. Areas east of this location contain numerous marshes, streams, and scattered development. Ring levees will be evaluated for housing developments in some areas. Further east in Jackson County are the cities of Gautier, Pascagoula and Moss Point. The presence of numerous streams and inlets will make a continuous barrier very difficult and these areas are also envisioned to have individual ring levees. While alignments were selected that provided the maximum protection for the most developed areas, some portions could be excluded due to cost and technical issues with closing off drainages. Redrawing the alignments would place some areas into a non-structural solution and could be considered as potential options for further study. These alternate alignments were drawn for Pascagoula/Moss Point, Bell Fontaine, and Gulf Park Estates.

At the western end of LOD-3, the barrier will extend down North Beach Boulevard for several miles to near Bayou Caddy and then turn north to tie in with higher ground. By following this path, the existing roadway will provide an alignment and it will encompass much of the developed waterfront from Bay St. Louis to Waveland, MS. Further west, the town of Pearlington will be evaluated for construction of a ring levee.

As with the main portion of LOD-3, the ring levees were initially considered with the same three elevations of 12.0, 18.0 and 24.0. Closer study revealed that in many cases, the elevation 12.0 was too low based on existing ground surfaces and the elevation 24.0 may not be high enough to be certified by FEMA for a 100-year storm event. The elevations to be studied for the ring levees then was changed to 20.0 and 30.0 with the assumption that the 100-year event would fall between these elevations and that the elevation 30.0 design would be sufficiently high for even a 500-year event. A 100-year minimum event is necessary for levee certification by FEMA.

While many options were reviewed for the type of structure to be used along the roadways, a simple elevated roadway associated with an extension of the existing seawall was chosen for reliability reasons. A structure that did not mainly rely on powered systems or with multiple moving systems was deemed more suitable for the purposes of this line of defense. Numerous conceptual designs were considered including inflatable barriers, concrete sidewalks or roadways that could be hydraulically rotated upwards to form a seawall, sliding panel gates within a seawall, and structural concrete seawalls. The ring levees were all designed as earthen structures. It should be understood that all of these LOD-3 structures would provide less protection than would be required for a Camille or Katrina-like storm. LOD-3 storm damage reduction levels are limited and will be determined based on public and local government acceptance and the amount of risk that Mississippi is willing to accept.

As previously mentioned, this LOD-3 is dependent on having the ability of closure across the two bays to prevent the storm surge from running inside the mouths of the bays. While the plan calls for surge gates to be associated with LOD-4, surge gates would also have to be incorporated with LOD-3 if LOD-4 is not selected as an alternative. The top elevation of surge gates used solely for LOD-3 would be of an elevation that would be compatible with the rest of that barrier.

Interior drainage behind these barriers must be considered. Any large rainfall event would require that the water trapped behind the barrier have a means to drain or even be mechanically pumped. The amount of storage that a given watershed could provide behind a barrier during surge conditions will vary. The means to block surge but allow drainage as the surge passes may include conduits with flap valves or gated culverts up to surge gates across large bodies of water. The areas where pumping is required are numerous, but necessary to prevent residual damages associated with this blockage of normal drainage.

The pumping stations, where required, must survive any storm damage and continue to operate until the storm event has passed. This will require hardened structures to house the pumps and power systems, and be constructed to a height that corresponds to the risk associated with that line of defense.

3.3.1 Hancock County Ring Levees, Pearlington

Pearlington is a small town located in the western part of Hancock County as shown in Figure 3.3.1-1. The town lies on the bank of the Pearl River about 5 miles from the Mississippi Sound. Ground elevations over most of the residential and business areas are very low between elevations 6-10 ft NAVD88. Pearlington was an extremely hard hit area during the 2005 hurricane season. Water reached a depth of 10-14 feet over the whole community. For purposes of providing protection for future storm events, the construction of an earthen ring levee is evaluated. The options in this study are identified as Option A and Option B.

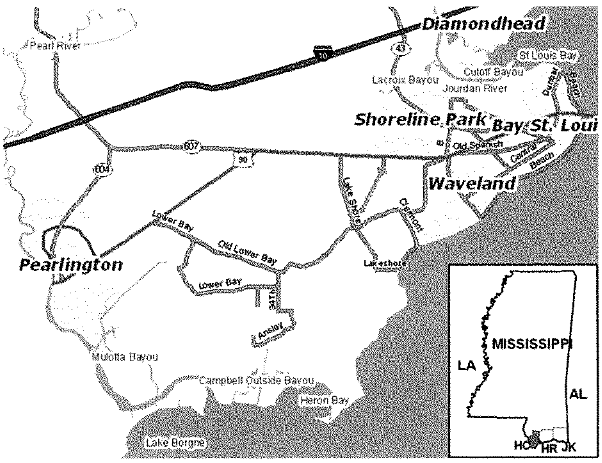

Figure 3.3.1-1.
Vicinity Map, Pearlington

3.3.1.1 Option A - Elevation 20.0 ft NAVD88

This option consists of an earthen dike around the most densely populated areas of Pearlington along with the internal sub-basins and levee culvert/pump locations. The levee would have an elevation of 20.0 ft NAVD88 with a top width of 15 ft and slopes of 1 vertical to 3 horizontal.

3.3.1.2 Option B - elevation 30.0 ft NAVD88

The alignment of the levee is the same as Option A, above but with an elevation of 30.0 ft NAVD88. The difference between the description of this option and the preceding description of Option A is the height of the levee, pumping facilities, number of roadway and railroad intersections, and the length of the levee culverts.

3.3.1.3 Project Description

Figure 3.3.1.3-1 shows the location of the proposed project alternatives. As described above, the levee will be an earthen berm constructed either at elevation 20.0 feet or 30.0 feet along with the internal sub-basins and levee culvert/pump locations. Drainage on the interior of the ring levee would be collected at the levee and channeled to culverts placed in the levee. 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. In addition, pumps would be constructed near the outflow points to remove water from the interior during storm events occurring when the culverts are closed because of high water in the sound. Drainage ditches along the toe of the levee will be required to assure that smaller basins can be drained to a culvert/pump site. Figure 3.3.1.3-2 shows the proposed location of the pump/culvert sites. 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. Further studies will detail the requirement for the appropriate ponding areas, pump sizes, or buyouts in the affected areas.

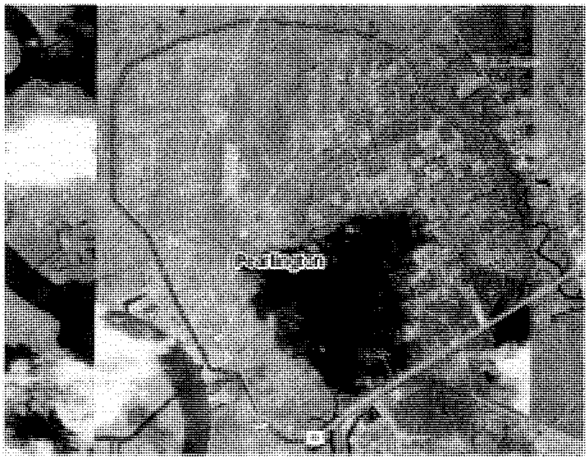

Figure 3.3.1.3-1.
Pearlington Ring Levee

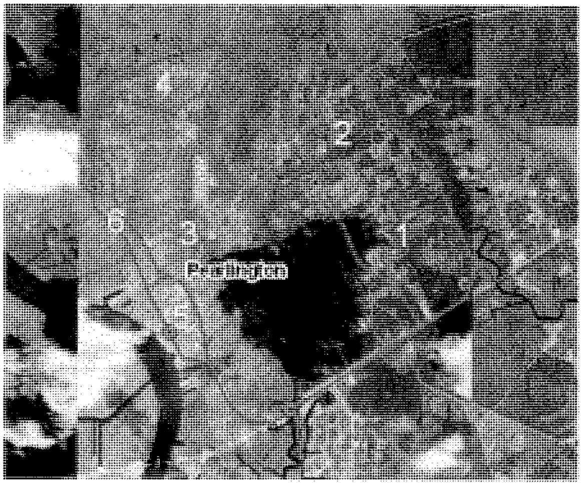

Figure 3.3.1.3-2.
Pump/Culvert/Sub-basin Site Locations

The inland barrier earthen levee section will have one vertical to three horizontal side slopes with a fifteen foot crest width. All work areas to receive fill shall be cleared and grubbed of all trees and surface organics and all existing foundations, streets, utilities, etc. will be removed and the subsequent cavities backfilled and compacted. The levee will be constructed of sand clay materials obtained from off site borrow sources, and trucked to the work area. The final surface will be armored by the placement of 24 inch thick gabion mattress filled with small stone for erosion protection during an event that overtops the levee. The armoring will be anchored on the front face by trenching and extend across the downstream slope and a 25 foot area beyond the toe. The front side of the levee and all non critical surface areas will be subsequently covered by grassing. In order to maintain the natural runoff patterns culverts would be inserted through the protection line at appropriate locations. For this study these were configured as cast-in-place reinforced concrete box structures fitted with flap gates to minimize normal backflows and sluice gates to provide storm closure when needed. Pump facilities will be required at 6 locations.

Road crossings will incorporate small gate structures or ramping over the embankment where the surface elevation is near that of the crest elevation. The elevation relationship of the crest and the adjacent railroad will be a governing factor. At each point where a roadway crosses the protection line the decision must be made whether to maintain this artery and adapt the protection line to accommodate it, or to terminate the artery at the protection line and divert traffic to cross the protection line at another location. For this study it was assumed that all roadways and railways crossing the levee alignment would be retained except where it was very evident that traffic could be combined without undue congestion. Once the decision has been made to retain a particular roadway, it must then be determined how best to configure the artery to conduct traffic across the protection line. The simplest means of passing roadway traffic is to ramp the roadway over the protection line. This alternative is not always viable because of severe right-of-way restraints caused

by extreme levee height, urban congestion, etc. In such instances other methods can be used including partial ramping in combination with low profile roller gates. In more restricted areas full height gates which would leave the roadway virtually unaltered might be preferable, even though this alternative would usually be more costly than ramping. In some extreme circumstances where high levees are required to pass through very congested areas, installation of tunnels with closure gates may be required.

Because of the extreme gradient restrictions necessarily placed on railway construction, it is practically never acceptable to elevate a railway up and over a levee. Therefore, the available alternatives would include gated pass through structures. Because of the vertical clearance requirements of railroad traffic all railroad pass through structures for this study were configured having vertical walls on either side of the railway with double swing gates extending to the full height of the levee.

With the installation of a ring levee around the Pearlington area, 18 roadway intersections would have to be accommodated. For this study it was estimated that all 18 would require swing gate structures.

Operation and maintenance activities for this project will be required on an annual basis. All pumps and gates will be operated to assure proper working order. Debris and shoaled sediment will be removed. Vegetation on the levees will be cut to facilitate inspection and to prevent roots from causing weak levee locations. Rills or rivulets will be filled and damaged revetment will be repaired.

3.3.1.4 Real Estate Requirements

Real Estate requirements for Line of Defense 3, Pearlington Ring Levee include lands, easements, rights-of-way and relocations, and disposal/borrow areas (LERRD), and the right to construct an earthen levee, drainage ditches, and 6 culvert/pump station facilities.

Based on the footprint of the Option A 20.0 foot elevation, it was determined that approximately 111 parcels and 28 structures would be impacted. The acreage to be acquired for the levee is unknown. It is known that the 6 pump stations will require approximately 0.23 of an acre each for a total of 1.38 acres. Lands required for construction of the levee will be acquired in fee simple interest. Based on the number of structures being impacted, the assumption is that there will be 28 relocations. For cost purposes, the relocations are assumed to be residential.

Based on the footprint of the Option B 30.0 foot elevation, it was determined that 120 parcels and 30 structures would be impacted. The acreage to be acquired for the levee is unknown. It is known that the 6 pump stations will require approximately 0.23 of an acre each for a total of 1.38 acres. Lands required for construction of the levee will be acquired in fee simple interest. Based on the number of structures being impacted, the assumption is that there will be 30 relocations. For cost purposes, the relocations are assumed to be residential.

Ditches that will be constructed to provide drainage for the interior of the ring levee are expected to be located within the footprint of the levee. Until final plans and specifications are completed, an assumption is made that the ditches will be constructed on the same lands acquired for construction of the levee. If any additional lands are required, this will be determined during PED.

Any modifications to the roadways will most probably need to be accomplished under a relocation contract. This will be further investigated and confirmed during PED.

An assumption is made that excavated materials from clearing, snagging, and construction of ditches, etc. will be disposed of in county owned or commercial landfills. However, In the event that the excavated material is not suitable for a landfill a disposal site will have to be acquired. Typically if disposal sites are required, this would be considered as part of the LERRD requirement. Real Estate would provide an analysis during PED to compare the cost of acquiring an upland disposal site with the cost of using a commercial landfill and make a determination which method is most cost effective.

The recommended plan proposes to use material from an inventory of upland borrow sites to construct the levee. A specific site has not been identified or confirmed for use at time of this report. Typically if borrow sites are required, this would be considered a part of the LERRD requirement. Real Estate would provide an analysis during PED to compare the cost of acquiring an upland borrow site with the cost of using a commercial borrow site and make a determination which method is most cost effective. The requirement for temporary work areas is unknown. Sponsor owned lands will be used if available. Otherwise, this may be an additional real estate requirement, and will be further defined during PED.

3.3.1.5 Utility/Facility Relocation

The plan calls for roads to be ramped over the proposed levee. An assumption is made that this work will be accomplished through a relocation contract. This will be further investigated and confirmed during PED. See Chapter 2 Section 2.10 for more detailed discussion.

3.3.1.6 Existing Projects/Studies

Relevant projects and studies are found in the main report at Section 1.6, History of the Investigation and Section 1.7, Prior and On-Going Studies, Reports and Programs.

3.3.1.7 Environmental Impacts

See the Main Report, Chapter 6. Environmental Effects of Plans and the Environmental Appendix, for a full discussion on environmental effects.

3.3.1.8 Project Sponsor Responsibilities and Capabilities

The State of Mississippi will be the non-Federal Project Sponsor (NFS). The NFS has the responsibility to acquire all real estate interests required for the Project. The NFS shall accomplish all alterations and relocations of facilities, structures and improvements determined by the government to be necessary for construction of the Project. Title to any acquired real estate will be retained by the Project Sponsor and will not be conveyed to the United States Government. Prior to advertisement of any construction contract, the NFS shall furnish to the government an Authorization for Entry for Construction (Exhibit "A" to the Real Estate Appendix) to all lands, easements and rights-of-way, as necessary. The NFS will also furnish to the government evidence supporting their legal authority to grant rights-of-way to such lands. The NFS shall comply with applicable provisions of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970, Public Law 91-646, approved 2 January 1971, and amended by Title IV of the Surface Transportation Uniform Relocation Assistance Act of 1987, Public Law 100-17, effective 2 April 1989, in acquiring real estate interests for the Project, and inform all affected persons of applicable benefits, policies, and procedures in connection with said Act(s). A form for the Assessment of the Non-Federal Sponsor's Capability to Acquire Real Estate is at Exhibit "B" to the Real Estate Appendix. The assessment will be made during PED phase.

The non-Federal sponsor is entitled to receive credit against its share of project costs for the value of lands it provides and the value of the relocations that are required for the project. Generally, for the purpose of determining the amount of credit to be afforded, the value of the LER is the fair market value of the real property interest, plus certain incidental costs of acquiring those interests, that the

non-federal sponsor provided for the project as required by the Government. The NFS cannot receive credit for the value of any LER, including incidental costs, which were previously provided as an item of cooperation for another Federal project, including projects that preceded enactment of WRDA 1986.

3.3.1.9 Government Owned Property

There are no known Government owned lands in the proposed project.

3.3.1.10 Historical Significance

See the Main Report, Section 3.2.9 Cultural and Archaeological Resources, for a general discussion on cultural and archaeological resources.

3.3.1.11 Mineral Rights

There are no known mineral activities within the scope of the proposed project.

3.3.1.12 Hazardous, Toxic, and Radioactive Waste (HTRW)

Due to the extent of the project, no preliminary assessment was performed to identify the possibility of hazardous waste on the sites. These studies will be conducted during the next phase of work. See Sections 3.2.8 and 6.16 of the Main Report for a discussion on HTRW.

3.3.1.13 Public Law 91-646, Relocation Assistance Benefits

The Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970 establishes a uniform policy for fair and equitable treatment of persons displaced as a result of federal and federally assisted programs in order that such persons shall not suffer disproportionate injuries as a result of programs designed for the benefits of the public as a whole. A qualified displaced person may be entitled to certain relocation assistance benefits which include reimbursement of moving costs and a replacement housing benefit. Moving expense can be reimbursed either based on actual costs or a fixed moving cost schedule. The replacement housing payment is separated into 3 basic types - purchase supplement, rental assistance and down payment. All replacement housing must be decent, safe, and sanitary (DSS) before a replacement housing payment can be made.

It is estimated that there are approximately 28 relocations in Option A and approximately 30 relocations in Option B. No relocation plan has been completed nor has a relocation survey been done. All estimates are based on information from county public records. The number of business relocations as compared to residential relocations is unknown. In order to accomplish the relocation activity in a timely manner, the plan set forth in Chapter 2. Section 2.5 can be used.

3.3.1.14 Attitude of Property Owners

Real Estate has not interviewed property owners or tenants during the study phase for the MsCIP. However, numerous public meetings have been held at different locations throughout the study area to inform stakeholders and property owners about the study and the protective measures under consideration for the Mississippi coastal area. A number of local newspapers have published articles that discuss the MsCIP study and the perceived positive effects as well as the negative impacts that may occur as a result of the project. Some of these articles can be found on web sites. While many of the locals may welcome the benefits of the proposed project, there are some who oppose the project.

3.3.1.15 Acquisition Schedule

An acquisition schedule will be developed when plans and specifications become available and more definite information is available pertaining to the specific areas and number of parcels for acquisition. The acquisition schedule will be developed during PED and will be a joint effort of the NFS, the project manager and Real Estate. The schedule will set forth a time line for title, survey, appraisal, negotiation, preparation of documents and closing activity. After acquisition activity is completed certification of lands acquired/owned by the sponsor will be necessary prior to advertisement for construction. The Certification of Real Estate can be accomplished within 30 - 60 days after acquisition. See Chapter 2. Section 2.5. for discussion on an acquisition implementation/management plan.

3.3.1.16 Estates for Proposed Project

All lands required for the levee will be acquired in Fee Simple. Should a borrow site be required, the Borrow Easement will be used. The Temporary Work Area Easement will be used for staging or temporary work areas, and the Drainage Ditch Easement will be used as required. The estates recommended are standard estates.

FEE.

The fee simple title to (the land described in Schedule A) l/(Tracts Nos. ____, ____ and ___), subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

BORROW EASEMENT.

A (temporary) (perpetual and assignable) right and easement to clear, borrow, excavate and remove sand, soil, dirt, and other materials from (the land described in Schedule A) (Tracts Nos. _____, _____ and _____); subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines; reserving, however, to the landowners, their heirs and assigns, all such rights and privileges in said land as may be used without interfering with or abridging the rights and easement hereby acquired.

TEMPORARY WORK AREA EASEMENT.

A temporary easement and right-of-way in, on, over and across (the land described in Schedule A) (Tracts Nos. _____, _____ and _____), for a period not to exceed ____________________, beginning with date possession of the land is granted to the Project Sponsor, for use by the Project Sponsor, its representatives, agents, and contractors as a work area, including the right to deposit backfill, move, store and remove equipment and supplies, and erect and remove temporary structures on the land and to perform any other work necessary and incident to the construction of the ____________________ Project, together with the right to trim, cut, fell and remove there from all trees, underbrush, obstructions, and any other vegetation, structures, or obstacles within the limits of the right-of-way; reserving, however, to the landowners, their heirs and assigns, all such rights and privileges as may be used without interfering with or abridging the rights and easement hereby acquired; subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

DRAINAGE DITCH EASEMENT.

A perpetual and assignable easement and right-of-way in, over and across (the land described in Schedule A) (Tracts Nos. ____, ____ and _____) to construct, maintain, repair, operate, patrol and replace a drainage ditch, reserving, however, to the owners, their heirs and assigns, all such rights and privileges in the land as may be used without interfering with or abridging the rights and easement hereby acquired; subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

3.3.1.17 Real Estate Estimate

A summary of the cost for each option is at Table 3.3.1.17-1. The real estate cost estimates at Table 3.3.1.17-2 and Table 3.3.1.17-3 include the land cost for acquisition of land, relocation benefits to include a replacement housing payment and fixed rate move expenses, and Federal and non-Federal administrative costs. Administrative costs are those costs incurred for verifying ownership of lands, certification of those lands required for project purposes, legal opinions, analysis or other requirements that may be necessary, during PED. No cost is included for a borrow site or temporary work area. The requirement, if any, for a borrow site or temporary work area will be identified during PED. If further real estate requirements are identified during PED or if there is a significant increase in cost, a supplement to the Real Estate Appendix will be prepared. A 25% contingency is applied to the current estimate.

Table 3.3.1.17-1.
Real Estate Cost Summary

Option	Impacted Parcels	Relocations	Total Cost
Option A - 20.0	111	28	8,883,000
Option B - 30.0	120	30	9,340,000

Table 3.3.1.17-2.
LOD3 Hancock County Ring Levee, Pearlington - Option A 20.0 Estimate

a. Lands and Improvements/Permits					
111 Ownerships, 28					
Improvements					3,527,608
(6 Pump Stations)					87,399
				Subtotal	3,615,007
b. Mineral Rights					0
c. Damages					0
d. P.L. 91-646 Relocation costs - 28 relocations					784,000
e. Administrative Cost					2,707,500
		Relocation	Acquisition	Total	
	Federal	42,000	277,500	319,500	
	Non-Federal	168,000	2,220,000	2,388,000	
		210,000	2,497,500	2,707,500	
Subtotal					7,106,507
Contingencies (25%)					1,776,627
	Totals				**8,883,134**
	Rounded				**8,883,000**

Table 3.3.1.17-3.
LOD3 Hancock County Ring Levee, Pearlington - Option B 30.0 Estimate

a. Lands and Improvements/Permits 120 Ownerships, 30 Improvements					3,630,995
(6 Pump Stations)					87,399
				Subtotal	3,718,394
b. Mineral Rights					0
c. Damages					0
d. P.L. 91-646 Relocation costs – 30 relocations					828,800
e. Administrative Cost					2,925,000
		Relocation	Acquisition	Total	
	Federal	45,000	300,000	345,000	
	Non-Federal	180,000	2,400,000	2,580,000	
		225,000	2,700,000	2,925,000	
Subtotal					7,472,194
Contingencies (25%)					1,868,049
	Totals				**9,340,243**
	Rounded				**9,340,000**

3.3.1.18 Summary of Potential Real Estate Issues

The requirement for temporary work areas, disposal or borrow areas has not been identified. Should these areas be required, these would be considered as part of the LERRD requirements. Typically if disposal or borrow sites are required, Real estate would provide an analysis during PED to compare the cost of acquiring an these sites with the cost of using a commercial sites and make a determination which method is most cost effective. See Section 2.8 Borrow Areas on page 5.

Should drainage ditches, temporary work areas, disposal or borrow areas become a necessary real estate acquisition requirement, valuation of lands will be performed. Land costs associated with these areas, and administrative costs will be added to the Real Estate Cost Estimate. If further real estate requirements are identified during PED or if there is a significant increase in cost, a supplement to the Real Estate Appendix will be prepared.

Any requirements for relocation contracts pertaining to facilities/utilities will be identified and completed during PED.

Any requirement for mitigation lands will be identified during PED.

Should condemnation of any required real estate interest be necessary, it is the responsibility of the NFS. This issue is addressed during the Assessment of the Non-Federal Sponsor's Real Estate

Acquisition Capability. However, if the real estate interest is one that the NFS does not have authority to condemn, the Federal Government can perform the condemnation on behalf of the NFS.

A Real Estate Relocation Plan should be prepared during PED to address potential relocation activity under PL.91-646. There are a number of factors pertaining to relocations that can impact the project both in cost and in schedule. Payments for Housing of Last Resort, which would exceed the standard housing replacement payments, are very likely due to the size of the project and the lack of available decent, safe and sanitary housing in the area. Another factor that could increase cost and impact schedule is the cost of business relocations. Depending on the type of business and the operation, this could involve moving equipment and machinery to new locations. It is necessary to interview each impacted individual and business during Pre-Construction, Engineering and Design Phase to determine the requirements for relocation and to estimate a cost for the relocation.

3.3.1.19 Chart of Accounts

The cost estimate for all Federal and non-Federal real estate activities necessary for implementation of the project after completion of the feasibility study for land acquisition, construction, LERRD, and other items are coded as delineated in the Cost Work Breakdown Structure (CWBS). This real estate cost estimate is then incorporated into the Total Current Working Estimate utilizing the Microcomputer Aided Cost Engineering System (MCACES). The Chart of Accounts at Tables 3.3.1.19-1 and 3.3.1.19-2 shows the CWBS for real estate activities.

Table 3.3.1.19-1.
Chart of Accounts - LOD3 Hancock County Ring Levee, Pearlington - Option A

01A	Project Planning	Federal	Non-Federal	Totals
	Other			
	Project Cooperation Agreement			
01AX	Contingencies (25%)			
	Subtotal			
01B	Lands and Damage/Permits			
01B40	Acquisition/Review of NFS	277,500		277,500
01B20	Acquisition by NFS		2,220,000	2,220,000
01BX	Contingencies (25%)	69,375	555,000	624,375
	Subtotal	346,875	2,775,000	3,121,875
01F	PL 91-646 Assistance			
01F20	By NFS		168,000	168,000
01FX	Contingencies (25%)		42,000	42,000
	Subtotal		210,000	210,000
01R	Real Estate Land Payments			
01R1B	Land Payments by NFS		3,615,007	3,615,007
01R2B	PL91-646 Relocation Payment by NFS		784,000	784,000
01R2D	Review of NFS	42,000		42,000
01RX	Contingencies (25%)	10,500	1,099,752	1,110,252
	Subtotal	52,500	5,498,759	5,551,259
	Totals	**399,375**	**8,483,759**	**8,883,134**
	Rounded			**8,883,000**

Table 3.3.1.19-2.
Chart of Accounts - LOD3 Hancock County Ring Levee, Pearlington - Option B

01A	Project Planning	Federal	Non-Federal	Totals
	Other			
	Project Cooperation Agreement			
01AX	Contingencies (25%)			
	Subtotal			
01B	Lands and Damage/Permits			
01B40	Acquisition/Review of NFS	300,000		300,000
01B20	Acquisition by NFS		2,400,000	2,400,000
01BX	Contingencies (25%)	75,000	600,000	675,000
	Subtotal	375,000	3,000,000	3,375,000
01F	PL 91-646 Assistance			
01F20	By NFS		180,000	180,000
01FX	Contingencies (25%)		45,000	45,000
	Subtotal		225,000	225,000
01R	Real Estate Land Payments			
01R1B	Land Payments by NFS		3,718,394	3,718,394
01R2B	PL91-646 Relocation Payment by NFS		828,800	828,800
01R2D	Review of NFS	45,000		45,000
01RX	Contingencies (25%)	11,250	1,136,799	1,148,049
	Subtotal	56,250	5,683,993	5,740,243
	Totals	**431,250**	**8,908,993**	**9,340,243**
	Rounded			**9,340,000**

3.3.2 Hancock County Ring Levees, Bay St. Louis

The City of Bay St. Louis is located in the eastern part of Hancock County as shown in Figure 3.3.2-1. The town is bordered by the Mississippi Sound. The Shoreline Park subdivision area to the north of Bay St. Louis is very low at elevations 4-6 ft NAVD88 and subject to frequent flooding from storm surge. During the 2005 hurricane season, water reached a depth of 10-20 ft over the coastal community. For purposes of providing protection to residential and commercial structures for future storm events, the construction of an earthen ring levee is evaluated. The options in this study are identified as Option A and Option B.

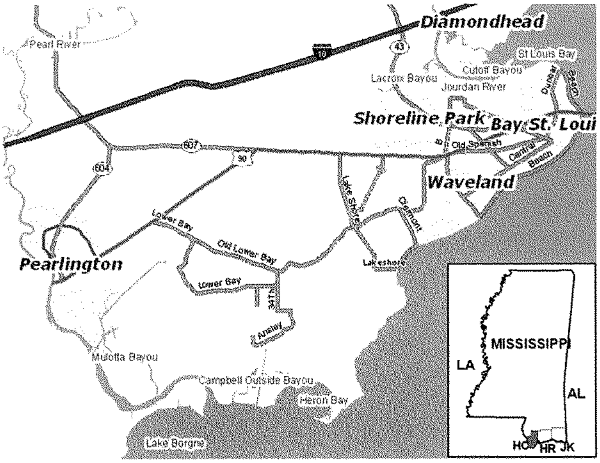

Figure 3.3.2-1.
Vicinity Map, Bay St. Louis

3.3.2.1 Option A - Elevation 20.0 NAVD88

This option consists of an earthen dike around the most densely populated areas of Bay St. Louis along with the internal sub-basins and levee culvert/pump locations. The levee would have an elevation of 20.0 feet with a top width of 15 ft and slopes of 1 vertical to 3 horizontal.

3.3.2.2 Option B - Elevation 30.0 NAVD88

The alignment of the levee is the same as Option A, above but with an elevation of 30.0 feet. The only difference between the description of this option and preceding description of Option A is the height of the levee, pumping facilities, number of roadway and railroad intersections, and the length of the levee culverts.

3.3.2.3 Project Description

Figure 3.3.2.3-1 below shows the location of the proposed project alternatives. As described above, the levee will be an earthen berm constructed either at elevation 20.0 feet or 30.0 feet along with the internal sub-basins and levee culvert/pump locations. Drainage on the interior of the ring levee would be collected at the levee and channeled to culverts placed in the levee. 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. In addition, pumps would be constructed near the outflow points to remove water from the interior during storm events occurring when the culverts are closed because of high water in the sound. Drainage ditches along the toe of the levee will be required to assure that smaller basins can be drained to a culvert/pump site. Figure 3.3.2.3-2 shows the proposed location of the pump/culvert sites. 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. Further studies will detail the requirement for the appropriate ponding areas, pump sizes, or buyouts in the affected areas.

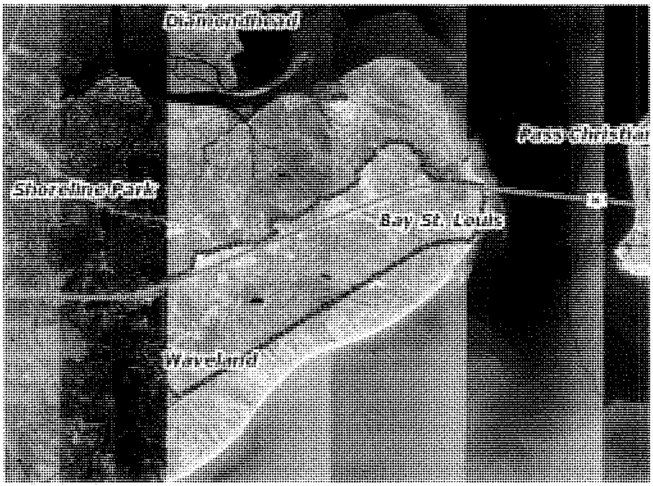

Figure 3.3.2.3-1.
Bay St. Louis Ring Levee

Figure 3.3.2.3-2.
Pump/Culvert/Sub-basin Site Locations

The inland barrier earthen levee section will have one vertical to three horizontal side slopes with a fifteen foot crest width. All work areas to receive fill shall be cleared and grubbed of all trees and surface organics and all existing foundations, streets, utilities, etc. will be removed and the subsequent cavities backfilled and compacted. The levee will be constructed of sand clay materials obtained from off site commercial sources, and trucked to the work area. The final surface will be armored by the placement of 24 inch thick gabion mattress filled with small stone for erosion protection during an event that overtops the levee. The armoring will be anchored on the front face by trenching and extend across the downstream slope and a 25 foot area beyond the toe. The front side of the levee and all non critical surface areas will be subsequently covered by grassing. In order to maintain the natural runoff patterns culverts would be inserted through the protection line at appropriate locations. For this study these were configured as cast-in-place reinforced concrete box structures fitted with flap gates to minimize normal backflows and sluice gates to provide storm closure when needed. Pump facilities are required at 12 locations.

Road crossings will incorporate small gate structures or ramping over the embankment where the surface elevation is near that of the crest elevation. The elevation relationship of the crest and the adjacent railroad will be a governing factor. At each point where a roadway crosses the protection line the decision must be made whether to maintain this artery and adapt the protection line to accommodate it, or to terminate the artery at the protection line and divert traffic to cross the protection line at another location. For this study it was assumed that all roadways and railways crossing the levee alignment would be retained except where it was very evident that traffic could be combined without undue congestion. Once the decision has been made to retain a particular roadway, it must then be determined how best to configure the artery to conduct traffic across the protection line. The simplest means of passing roadway traffic is to ramp the roadway over the protection line. This alternative is not always viable because of severe right-of-way restraints caused by extreme levee height, urban congestion, etc. In such instances other methods can be used including partial ramping in combination with low profile roller gates. In more restricted areas full height gates which would leave the roadway virtually unaltered might be preferable, even though this alternative would usually be more costly than ramping. In some extreme circumstances where high levees are required to pass through very congested areas, installation of tunnels with closure gates may be required.

Because of the extreme gradient restrictions necessarily placed on railway construction, it is practically never acceptable to elevate a railway up and over a levee. Therefore, the available alternatives would include gated pass through structures. Because of the vertical clearance requirements of railroad traffic all railroad pass through structures for this study were configured having vertical walls on either side of the railway with double swing gates extending to the full height of the levee.

With the installation of a ring levee around the Bay St. Louis area to elevation 20.0, 21 roadway intersections would have to be accommodated. For this study it was estimated that of this number, 4 would require swing gate structures, with the rest requiring roller gates of various heights. With the installation of a ring levee around the Bay St. Louis area to elevation 30, 69 roadway intersections would have to be accommodated, and it was estimated that of this number, 62 would require swing gate structures, with the remaining 7 requiring roller gates of various heights.

Operation and maintenance activities for this project will be required on an annual basis. All pumps and gates will be operated to assure proper working order. Debris and shoaled sediment will be removed. Vegetation on the levees will be cut to facilitate inspection and to prevent roots from causing weak levee locations. Rills will be filled and damaged revetment will be repaired.

3.3.2.4 Real Estate Requirements

Real Estate requirements for Line of Defense 3, Bay St. Louis Ring Levees include lands, easements, rights-of-way and relocations, and disposal/borrow areas (LERRD), and the right to construct an earthen levee, drainage ditches and 12 culvert/pump station facilities.

Based on the footprint of the Option A 20.0 foot elevation, it was determined that approximately 442 parcels and 149 structures would be impacted. The acreage to be acquired for the levee is unknown. It is known that the 11 pump stations will require approximately 0.23 of an acre each for a total of 2.53 acres. Lands required for construction of the levee will be acquired in fee simple interest, and lands for the drainage ditches that will be constructed outside the levee footprint will be acquired either in easement or fee as necessary. Based on the number of structures being impacted, the assumption is that there will be 149 relocations.

Based on the footprint of the Option B 30.0 foot elevation, it was determined that 576 parcels and 212 structures would be impacted. The acreage to be acquired for the levee is unknown. It is known that the 12 pump stations will require approximately 0.23 of an acre each for a total of 2.76 acres. Lands required for construction of the levee will be acquired in fee simple interest, and lands for the drainage ditches that will be constructed outside the levee footprint will be acquired either in easement or fee as necessary. Based on the number of structures being impacted, the assumption is that there will be 212 relocations.

Any modifications to the roadways will most probably need to be accomplished under a relocation contract. This will be further investigated and confirmed during PED.

An assumption is made that excavated materials from clearing, snagging, and construction of ditches, etc. will be disposed of in county owned or commercial landfills. However, In the event that the excavated material is not suitable for a landfill a disposal site will have to be acquired. Typically if disposal sites are required, this would be considered as part of the LERRD requirement. Real Estate would provide an analysis during PED to compare the cost of acquiring an upland disposal site with the cost of using a commercial landfill and make a determination which method is most cost effective.

The recommended plan proposes to use material from an inventory of upland borrow sites to construct the levee. A specific site has not been identified or confirmed for use at time of this report. Typically if borrow sites are required, this would be considered a part of the LERRD requirement. Real Estate would provide an analysis during PED to compare the cost of acquiring an upland borrow site with the cost of using a commercial borrow site and make a determination which method is most cost effective. The requirement for temporary work areas is unknown. Sponsor owned lands will be used if available. Otherwise, this may be an additional real estate requirement, and will be further defined during PED.

3.3.2.5 Utility/Facility Relocation

The plan calls for roads to be ramped over the proposed levee. An assumption is made that this work will be accomplished under a relocation contract. This will be further investigated and confirmed during PED. See Chapter 2 Section 2.10 for more detailed discussion.

3.3.2.6 Existing Projects/Studies

Relevant projects and studies are found in the main report at Section 1.6, History of the Investigation and Section 1.7, Prior and On-Going Studies, Reports and Programs.

3.3.2.7 Environmental Impacts

See the Main Report, Chapter 6. Environmental Effects of Plans and the Environmental Appendix, for a full discussion on environmental effects.

3.3.2.8 Project Sponsor Responsibilities and Capabilities

The State of Mississippi will be the non-Federal Project Sponsor (NFS). The NFS has the responsibility to acquire all real estate interests required for the Project. The NFS shall accomplish all alterations and relocations of facilities, structures and improvements determined by the government to be necessary for construction of the Project.

Title to any acquired real estate will be retained by the Project Sponsor and will not be conveyed to the United States Government. Prior to advertisement of any construction contract, the NFS shall furnish to the government an Authorization for Entry for Construction (Exhibit "A" to the Real Estate Appendix) to all lands, easements and rights-of-way, as necessary. The NFS will also furnish to the government evidence supporting their legal authority to grant rights-of-way to such lands. The NFS shall comply with applicable provisions of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970, Public Law 91-646, approved 2 January 1971, and amended by Title IV of the Surface Transportation Uniform Relocation Assistance Act of 1987, Public Law 100-17, effective 2 April 1989, in acquiring real estate interests for the Project, and inform all affected persons of applicable benefits, policies, and procedures in connection with said Act(s). A form for the Assessment of the Non-Federal Sponsor's Capability to Acquire Real Estate is at Exhibit "B" to the Real Estate Appendix. The assessment will be made during PED phase.

The non-Federal sponsor is entitled to receive credit against its share of project costs for the value of lands it provides and the value of the relocations that are required for the project. Generally, for the purpose of determining the amount of credit to be afforded, the value of the LER is the fair market value of the real property interest, plus certain incidental costs of acquiring those interests, that the

non-federal sponsor provided for the project as required by the Government. The NFS cannot receive credit for the value of any LER, including incidental costs, which were previously provided as an item of cooperation for another Federal project, including projects that preceded enactment of WRDA 1986.

3.3.2.9 Government Owned Property

There are no known Government owned lands within the proposed project.

3.3.2.10 Historical Significance

See the Main Report, Section 3.2.9 Cultural and Archaeological Resources, for a general discussion on cultural and archaeological resources.

3.3.2.11 Mineral Rights

There are no known mineral activities within the scope of the proposed project.

3.3.2.12 Hazardous, Toxic, and Radioactive Waste (HTRW)

Due to the extent of the project, no preliminary assessment was performed to identify the possibility of hazardous waste on the sites. These studies will be conducted during the next phase of work. See Sections 3.2.8 and 6.16 of the Main Report for a discussion on HTRW.

3.3.2.13 Public Law 91-646, Relocation Assistance Benefits

The Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970 establishes a uniform policy for fair and equitable treatment of persons displaced as a result of federal and federally assisted programs in order that such persons shall not suffer disproportionate injuries as a result of programs designed for the benefits of the public as a whole. A qualified displaced person may be entitled to certain relocation assistance benefits which include reimbursement of moving costs and a replacement housing benefit. Moving expense can be reimbursed either based on actual costs or a fixed moving cost schedule. The replacement housing payment is separated into 3 basic types - purchase supplement, rental assistance and down payment. All replacement housing must be decent, safe, and sanitary (DSS) before a replacement housing payment can be made.

It is estimated that there are approximately 149 relocations in Option A and approximately 212 relocations in Option B. No relocation plan has been completed nor has a relocation survey been done. All estimates are based on information from county public records. The number of business relocations as compared to residential relocations is unknown. In order to accomplish the relocation activity in a timely manner, the plan set forth in Chapter 2. Section 2.5 can be used.

3.3.2.14 Attitude of Property Owners

Real Estate has not interviewed property owners or tenants during the study phase for the MsCIP. However, numerous public meetings have been held at different locations throughout the study area to inform stakeholders and property owners about the study and the protective measures under consideration for the Mississippi coastal area. A number of local newspapers have published articles that discuss the MsCIP study and the perceived positive effects as well as the negative impacts that may occur as a result of the project. Some of these articles can be found on web sites. While many of the locals may welcome the benefits of the proposed project, there are some who oppose the project.

3.3.2.15 Acquisition Schedule

An acquisition schedule will be developed when plans and specifications become available and more definite information is available pertaining to the specific areas and number of parcels for acquisition. The acquisition schedule will be developed during PED and will be a joint effort of the NFS, the project manager and Real Estate. The schedule will set forth a time line for title, survey, appraisal, negotiation, preparation of documents and closing activity. After acquisition activity is completed certification of lands acquired/owned by the sponsor will be necessary prior to advertisement for construction. The Certification of Real Estate can be accomplished within 30 - 60 days after acquisition. See Chapter 2. Section 2.5. for discussion on an acquisition implementation/management plan.

3.3.2.16 Estates for Proposed Project

All lands required for the levee will be acquired in Fee Simple. Should a borrow site be required, the Borrow Easement will be used. The Temporary Work Area Easement will be used for staging or temporary work areas, and the Drainage Ditch Easement will be used as required. The estates recommended are standard estates.

FEE.

The fee simple title to (the land described in Schedule A) I/(Tracts Nos. ____, ____ and ___), subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

BORROW EASEMENT.

A (temporary) (perpetual and assignable) right and easement to clear, borrow, excavate and remove sand, soil, dirt, and other materials from (the land described in Schedule A) (Tracts Nos. _____, _____ and _____); subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines; reserving, however, to the landowners, their heirs and assigns, all such rights and privileges in said land as may be used without interfering with or abridging the rights and easement hereby acquired.

TEMPORARY WORK AREA EASEMENT.

A temporary easement and right-of-way in, on, over and across (the land described in Schedule A) (Tracts Nos. _____, _____ and _____), for a period not to exceed ___________________, beginning with date possession of the land is granted to the Project Sponsor, for use by the Project Sponsor, its representatives, agents, and contractors as a work area, including the right to deposit backfill, move, store and remove equipment and supplies, and erect and remove temporary structures on the land and to perform any other work necessary and incident to the construction of the ___________________ Project, together with the right to trim, cut, fell and remove there from all trees, underbrush, obstructions, and any other vegetation, structures, or obstacles within the limits of the right-of-way; reserving, however, to the landowners, their heirs and assigns, all such rights and privileges as may be used without interfering with or abridging the rights and easement hereby acquired; subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

DRAINAGE DITCH EASEMENT.

A perpetual and assignable easement and right-of-way in, over and across (the land described in Schedule A) (Tracts Nos. ____, ____ and _____) to construct, maintain, repair, operate, patrol and replace a drainage ditch, reserving, however, to the owners, their heirs and assigns, all such rights and privileges in the land as may be used without interfering with or abridging the rights and easement hereby acquired; subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

3.3.2.17 Real Estate Estimate

A summary of the cost for each option is at Table 3.3.2.17-1. The real estate cost estimates at Table 3.3.2.17-2 and Table 3.3.2.17-3 include the land cost for acquisition of land, relocation benefits to include a replacement housing payment and fixed rate move expenses, and Federal and non-Federal administrative costs. Administrative costs are costs incurred for verifying ownership of lands, certification of those lands required for project purposes, legal opinions, analysis or other requirements that may be necessary during PED. No cost is included for a borrow site or temporary work area. The requirement, if any, for a borrow site or temporary work area will be identified during PED. If further real estate requirements are identified during PED or if there is a significant increase in cost, a supplement to the Real Estate Appendix will be prepared. A 25% contingency is applied to the current estimate.

Table 3.3.2.17-1.
Real Estate Cost Summary

Option	Impacted Parcels	Relocations	Total Cost
Option A - 20.0	442	149	120,246,000
Option B - 30.0	576	212	156,364,000

Table 3.3.2.17-2.
LOD3 Hancock County Ring Levee, Bay St. Louis - Option A 20.0 Estimate

a. Lands and Improvements/Permits					
300 Ownerships for Levee, 123 Improvements					71,036,318
131 Ownerships for Ditches, 26 Improvements					9,805,320
11 Pump Stations					160,231
442 Ownerships				Subtotal	81,001,869
b. Mineral Rights					0
c. Damages					0
d. P.L. 91-646 Relocation costs - 149 relocations					4,132,800
e. Administrative Cost					11,062,500
	Relocation	Acquisition	Total		
Federal	223,500	1,105,000	1,328,500		
Non-Federal	894,000	8,840,000	9,734,000		
	1,117,500	9,945,000	11,062,500		
Sub-Total					96,197,169
Contingencies (25%)					24,049,292
Totals					**120,246,461**
Rounded					**120,246,000**

Table 3.3.2.17-3.
LOD3 Hancock County Ring Levee, Bay St. Louis - Option B 30.0 Estimate

a. Lands and Improvements/Permits					
433 Ownerships for Levee, 186 Improvements					94,636,388
131 Ownerships for Ditches, 26 Improvements					9,805,320
12 Pump Stations					174,798
576 Ownerships				Subtotal	104,616,506
b. Mineral Rights					0
c. Damages					0
d. P.L. 91-646 Relocation costs - 212 relocations					5,924,800
e. Administrative Cost					14,550,000
		Relocation	Acquisition	Total	
	Federal	318,000	1,440,000	1,758,000	
	Non-Federal	1,272,000	11,520,000	12,792,000	
		1,590,000	12,960,000	14,550,000	
Sub-Total					125,091,306
Contingencies (25%)					31,272,827
	Totals				**156,364,133**
	Rounded				**156,364,000**

3.3.2.18 Summary of Potential Real Estate Issues

The requirement for temporary work areas, disposal or borrow areas has not been identified. Should these areas be required, these would be considered as part of the LERRD requirements. Typically if disposal or borrow sites are required, Real estate would provide an analysis during PED to compare the cost of acquiring an these sites with the cost of using a commercial sites and make a determination which method is most cost effective. See Section 2.8 Borrow Areas on page 5.

Should drainage ditches, temporary work areas, disposal or borrow areas become a necessary real estate acquisition requirement, valuation of lands will be performed. Land costs associated with these areas, and administrative costs will be added to the Real Estate Cost Estimate. If further real estate requirements are identified during PED or if there is a significant increase in cost, a supplement to the Real Estate Appendix will be prepared.

Any requirements for relocation contracts pertaining to facilities/utilities will be identified and completed during PED.

Any requirement for mitigation lands will be identified during PED.

Should condemnation of any required real estate interest be necessary, it is the responsibility of the NFS. This issue is addressed during the Assessment of the Non-Federal Sponsor's Real Estate

Acquisition Capability. However, if the real estate interest is one that the NFS does not have authority to condemn, the Federal Government can perform the condemnation on behalf of the NFS.

A Real Estate Relocation Plan should be completed during PED to address potential relocation activity under P.L. 91-646. There are a number of factors pertaining to relocations that can impact the project both in cost and in schedule. Payments for Housing of Last Resort, which would exceed the standard housing replacement payments, are very likely due to the size of the project and the lack of available decent, safe and sanitary housing in the area. Another factor that could increase cost and impact schedule is the cost of business relocations. Depending on the type of business and the operation, this could involve moving equipment and machinery to new locations. It is necessary to interview each impacted individual and business during Pre-Construction, Engineering and Design Phase to determine the requirements for relocation and to estimate a cost for the relocation.

3.3.2.19 Chart of Accounts

The cost estimate for all Federal and non-Federal real estate activities necessary for implementation of the project after completion of the feasibility study for land acquisition, construction, LERRD, and other items are coded as delineated in the Cost Work Breakdown Structure (CWBS). This real estate cost estimate is then incorporated into the Total Current Working Estimate utilizing the Microcomputer Aided Cost Engineering System (MCACES). The Chart of Accounts at Tables 3.3.2.19-1 and 3.3.2.19-2 shows the CWBS for real estate activities.

Table 3.3.2.19-1.
Chart of Accounts - LOD3 Hancock County Ring Levee, Bay St. Louis - Option A

01A	Project Planning	Federal	Non-federal	Totals
	Other			
	Project Cooperation Agreement			
01AX	Contingencies (25%)			
	Subtotal			
01B	Lands and Damages/Permits			
01B40	Acq/Review of NFS	1,105,000		1,105,000
01B20	Acquisition by NFS		8,840,000	8,840,000
01BX	Contingencies (25%)	276,250	2,210,000	2,486,250
	Subtotal	1,381,250	11,050,000	12,431,250
01F	PL 91-646 Assistance			
01F20	By NFS		894,000	894,000
01FX	Contingencies (25%)		223,500	223,500
	Subtotal		1,117,500	1,117,500
01R	Real Estate Land Payments			
01R1B	Land Payments by NFS		81,001,869	81,001,869
01R2B	PL91-646 Relocation Payment by NFS		4,132,800	4,132,800
01R2D	Review of NFS	223,500		223,500
01RX	Contingencies (25%)	55,875	21,283,667	21,339,542
	Subtotal	279,375	106,418,336	106,697,711
	Totals	**1,660,625**	**118,585,836**	**120,246,461**
	Rounded			**120,246,000**

Table 3.3.2.19-2.
Chart of Accounts - LOD3 Hancock County Ring Levee, Bay St. Louis - Option B

01A	Project Planning	Federal	Non-federal	Totals
	Other			
	Project Cooperation Agreement			
01AX	Contingencies (25%)			
	Subtotal			
01B	Lands and Damages/Permits			
01B40	Acq/Review of NFS	1,440,000		1,440,000
01B20	Acquisition by NFS		11,520,000	11,520,000
01BX	Contingencies (25%)	360,000	2,880,000	3,240,000
	Subtotal	1,800,000	14,400,000	16,200,000
01F	PL 91-646 Assistance			
01F20	By NFS		1,272,000	1,272,000
01FX	Contingencies (25%)		318,000	318,000
	Subtotal		1,590,000	1,590,000
01R	Real Estate Land Payments			
01R1B	Land Payments by NFS		104,616,506	104,616,506
01R2B	PL91-646 Relocation Payment by NFS		5,924,800	5,924,800
01R2D	Review of NFS	318,000		318,000
01RX	Contingencies (25%)	79,500	27,635,327	27,714,827
	Subtotal	397,500	138,176,633	138,574,133
	Totals	**2,197,500**	**154,166,633**	**156,364,133**
	Rounded			**156,364,000**

3.3.3 Hancock County, Elevated Roadway

Residential and business areas along the coast in Hancock County are susceptible to storm surge damage. The beach front road in Hancock County joins the communities of Bay St. Louis and Waveland at the mouth of St. Louis Bay. Drainage at Bay St. Louis and Waveland is to the Mississippi Sound to the south and to tributaries of St. Louis Bay to the north. The Shoreline Park subdivision area to the north of Bay St. Louis is very low at elevations and subject to frequent flooding from storm surge. Impacts from the 2005 hurricanes were devastating to the area. A damage reduction option to raise the beach front road in Hancock County to elevation 11ft NAVD88 was evaluated. The location of the project is shown in Figure 3.3.3-1.

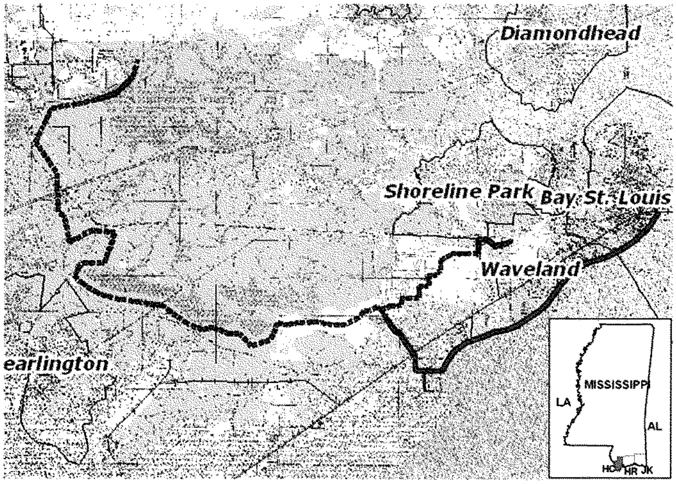

Figure 3.3.3-1.
Vicinity Map near Waveland

3.3.3.1 Project Description

The proposed road alignment is shown in red in Figure 3.3.3-1. The option consists of more than one element and function. This option also contains a provision for a levee at elevation 16 ft NAVD88, shown in blue in the above Figure 3.3.3-1. The elevation 16 ft NAVD88 levee functions in coordination with the Harrison County Elevated Hwy 90 Roadway also at elevation 16 ft NAVD and the St. Louis Bay closure structure. This option consists of raising the beach front road to elevation 11 ft NAVD88 in the Bay St. Louis/Waveland area as shown on the following Figure 3.3.3.1-1, along with the internal sub-basins and levee culvert/pump locations. There is one culvert but no pumps associated with the Elevation 16 ft NAVD88 levee as shown on Figure 3.3.3.1-2. This levee runs mostly along the ridge line so the drainage is away from the levee. A small boat access structure is also shown at the mouth of one basin. Rising sector gates will be provided at this gate allowing shallow draft traffic most of the time. The gate will be closed prior to hurricane storm surge.

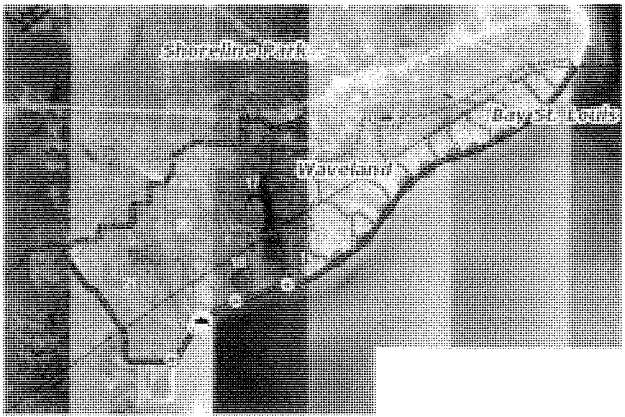

Figure 3.3.3.1-1.
Pump/Culvert/Boat Access Site Locations and Sub-basins

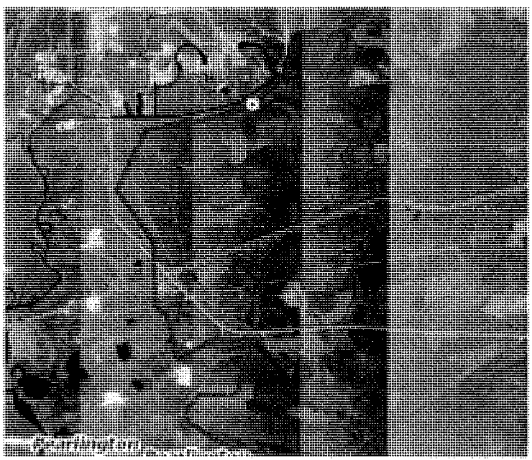

Figure 3.3.3.1-2.
Culvert Site Location

The Line 3 defense elevates the roadway and accompanying seawall by extending the seaway at its present slope to grade, creating the roadway sub grade then, sloping the backside to one vertical to three horizontal side slopes with a twenty five foot toe width for access and drainage. All work areas to receive fill shall be cleared and grubbed of all trees and surface organics and all existing foundations, streets, utilities, etc. will be removed and the subsequent cavities backfilled and compacted. The embankment will be constructed of sand clay materials obtained from off site commercial sources, trucked to the work area. The final surface on the back side will be armored by the placement of 12 inch thick gabion mattress filled with small stone for erosion protection during an event that overtops the road. All non critical surface areas will be subsequently covered by grassing. Road crossings will incorporate ramping over the embankment where the surface elevation is near that of the crest elevation. Drainage on the interior of the raised roadway would be collected at the highway and channeled to culverts. Drainage ditches along the toe of the highway will be required to assure that smaller basins can be drained to a culvert/pump site. 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 for control in the event the flap gate malfunctions. 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.

The features that require periodic operations will be the raising and lowering of sluice gates and the functioning flap gates, grass cutting of the embankment slopes and toe areas and the filling of rilled areas within the embankment due to surface erosion.

3.3.3.2 Real Estate Requirements

Real Estate requirements for Line of Defense 3, Hancock County Elevated Road measure include lands, easements, rights-of-way and relocations, and disposal/borrow areas (LERRD), and the right to raise a road and construct an earthen levee and 10 culvert/pump station facilities. Based on the project footprint, it was determined that approximately 427 parcels and 66 structures would be impacted. The acreage to be acquired for the levee is unknown. It is known that the 10 pump stations will require approximately 0.23 of an acre each for a total of 2.3 acres. Lands required for construction of the levee will be acquired in fee simple interest. Based on the number of structures being impacted, the assumption is that there will be 66 relocations.

Ditches that will be constructed to provide drainage for the levee are expected to be located within the footprint of the levee. Until final plans and specifications are completed, an assumption is made that the ditches will be constructed on the same lands acquired for construction of the levee. If any additional lands are required, this will be determined during PED.

Raising of the roadway will most probably need to be accomplished through a relocation contract. This will be further investigated and confirmed during PED.

In some areas the levee alignment would cross a moderately sized water course where it is apparent that boats currently traverse the area. To allow continued free boat access to areas behind the levee these water courses will be fitted with a scaled down adaptation of the larger rising sector gate structure used for the bay barriers at Biloxi and Bay St. Louis. A small boat access structure is shown at the mouth of one basin in the project footprint. Rising sector gates will be provided at this gate allowing shallow draft traffic most of the time. The gate will be closed prior to hurricane storm surge. No additional real estate interest is identified for boat access points as they fall within the footprint of the project and impacted parcels are included in the total that is projected. For those lands required for construction that lay below the mean high water mark, navigation servitude will apply.

An assumption is made that excavated materials from clearing, snagging, and construction of ditches, etc. will be disposed of in county owned or commercial landfills. However, In the event that the excavated material is not suitable for a landfill a disposal site will have to be acquired. Typically if disposal sites are required, this would be considered as part of the LERRD requirement. Real Estate would provide an analysis during PED to compare the cost of acquiring an upland disposal site with the cost of using a commercial landfill and make a determination which method is most cost effective.

The recommended plan proposes to use material from an inventory of upland borrow sites to construct the project. A specific site has not been identified or confirmed for use at time of this report. Typically if borrow sites are required, this would be considered a part of the LERRD requirement. Real Estate would provide an analysis during PED to compare the cost of acquiring an upland borrow site with the cost of using a commercial borrow site and make a determination which method is most cost effective. The requirement for temporary work areas is unknown. Sponsor owned lands will be used if available. Otherwise, this may be an additional real estate requirement, and will be further defined during PED.

3.3.3.3 Utility/Facility Relocation

The plan calls for elevation of the beachfront road. An assumption is made that this work will be accomplished through a relocation contract. This will be further investigated and confirmed during PED. See Chapter 2 Section 2.10 for more detailed discussion.

3.3.3.4 Existing Projects/Studies

Relevant projects and studies are found in the main report at Section 1.6, History of the Investigation and Section 1.7, Prior and On-Going Studies, Reports and Programs.

3.3.3.5 Environmental Impacts

See the Main Report, Chapter 6. Environmental Effects of Plans and the Environmental Appendix, for a full discussion on environmental effects.

3.3.3.6 Project Sponsor Responsibilities and Capabilities

The State of Mississippi will be the non-Federal Project Sponsor (NFS). The NFS has the responsibility to acquire all real estate interests required for the Project. The NFS shall accomplish all alterations and relocations of facilities, structures and improvements determined by the government to be necessary for construction of the Project.

Title to any acquired real estate will be retained by the Project Sponsor and will not be conveyed to the United States Government. Prior to advertisement of any construction contract, the NFS shall furnish to the government an Authorization for Entry for Construction (Exhibit "A" to the Real Estate Appendix) to all lands, easements and rights-of-way, as necessary. The NFS will also furnish to the government evidence supporting their legal authority to grant rights-of-way to such lands. The NFS shall comply with applicable provisions of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970, Public Law 91-646, approved 2 January 1971, and amended by Title IV of the Surface Transportation Uniform Relocation Assistance Act of 1987, Public Law 100-17, effective 2 April 1989, in acquiring real estate interests for the Project, and inform all affected persons of applicable benefits, policies, and procedures in connection with said Act(s). A form for the Assessment of the Non-Federal Sponsor's Capability to Acquire Real Estate is at Exhibit "B" to the Real Estate Appendix. The assessment will be made during PED phase.

The non-Federal sponsor is entitled to receive credit against its share of project costs for the value of lands it provides and the value of the relocations that are required for the project. Generally, for the purpose of determining the amount of credit to be afforded, the value of the LER is the fair market value of the real property interest, plus certain incidental costs of acquiring those interests, that the non-federal sponsor provided for the project as required by the Government. The NFS cannot receive credit for the value of any LER, including incidental costs, which were previously provided as an item of cooperation for another Federal project, including projects that preceded enactment of WRDA 1986.

3.3.3.7 Government Owned Property

There are no known Government owned lands within the proposed project.

3.3.3.8 Historical Significance

See the Main Report, Section 3.2.9 Cultural and Archaeological Resources, for a general discussion on cultural and archaeological resources.

3.3.3.9 Mineral Rights

There are no known mineral activities within the scope of the proposed project.

3.3.3.10 Hazardous, Toxic, and Radioactive Waste (HTRW)

Due to the extent of the project, no preliminary assessment was performed to identify the possibility of hazardous waste on the sites. These studies will be conducted during the next phase of work. See Sections 3.2.8 and 6.16 of the Main Report for a discussion on HTRW.

3.3.3.11 Public Law 91-646, Relocation Assistance Benefits

The Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970 establishes a uniform policy for fair and equitable treatment of persons displaced as a result of federal and federally assisted programs in order that such persons shall not suffer disproportionate injuries as a result of programs designed for the benefits of the public as a whole. A qualified displaced person may be entitled to certain relocation assistance benefits which include reimbursement of moving costs and a replacement housing benefit. Moving expense can be reimbursed either based on actual costs or a fixed moving cost schedule. The replacement housing payment is separated into 3 basic types - purchase supplement, rental assistance and down payment. All replacement housing must be decent, safe, and sanitary (DSS) before a replacement housing payment can be made.

It is estimated that there are approximately 66 relocations in this alternative. No relocation plan has been completed nor has a relocation survey been done. All estimates are based on information from county public records. The number of business relocations as compared to residential relocations is unknown. In order to accomplish the relocation activity in a timely manner, the plan set forth in Chapter 2. Section 2.5 can be used.

3.3.3.12 Attitude of Property Owners

Real Estate has not interviewed property owners or tenants during the study phase for the MsCIP. However, numerous public meetings have been held at different locations throughout the study area to inform stakeholders and property owners about the study and the protective measures under consideration for the Mississippi coastal area. A number of local newspapers have published articles that discuss the MsCIP study and the perceived positive effects as well as the negative impacts that may occur as a result of the project. Some of these articles can be found on web sites. While many of the locals may welcome the benefits of the proposed project, there are some who oppose the project.

3.3.3.13 Acquisition Schedule

An acquisition schedule will be developed when plans and specifications become available and more definite information is available pertaining to the specific areas and number of parcels for acquisition. The acquisition schedule will be developed during PED and will be a joint effort of the NFS, the project manager and Real Estate. The schedule will set forth a time line for title, survey, appraisal, negotiation, preparation of documents and closing activity. After acquisition activity is completed certification of lands acquired/owned by the sponsor will be necessary prior to advertisement for construction. The Certification of Real Estate can be accomplished within 30 - 60 days after acquisition. See Chapter 2. Section 2.5. for discussion on an acquisition implementation/management plan.

3.3.3.14 Estates for Proposed Project

All lands required for the levee will be acquired in Fee Simple. Should a borrow site be required, the Borrow Easement will be used. The Temporary Work Area Easement will be used for staging or temporary work areas, and the Drainage Ditch Easement will be used as required. The estates recommended are standard estates.

FEE.

The fee simple title to (the land described in Schedule A) l/(Tracts Nos. ____, ____ and ___), subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

BORROW EASEMENT.

A (temporary) (perpetual and assignable) right and easement to clear, borrow, excavate and remove sand, soil, dirt, and other materials from (the land described in Schedule A) (Tracts Nos. _____, _____ and _____); subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines; reserving, however, to the landowners, their heirs and assigns, all such rights and privileges in said land as may be used without interfering with or abridging the rights and easement hereby acquired.

TEMPORARY WORK AREA EASEMENT.

A temporary easement and right-of-way in, on, over and across (the land described in Schedule A) (Tracts Nos. _____, _____ and _____), for a period not to exceed __________________, beginning with date possession of the land is granted to the Project Sponsor, for use by the Project Sponsor, its representatives, agents, and contractors as a work area, including the right to deposit backfill, move, store and remove equipment and supplies, and erect and remove temporary structures on the land and to perform any other work necessary and incident to the construction of the __________________ Project, together with the right to trim, cut, fell and remove there from all trees, underbrush, obstructions, and any other vegetation, structures, or obstacles within the limits of the right-of-way; reserving, however, to the landowners, their heirs and assigns, all such rights and privileges as may be used without interfering with or abridging the rights and easement hereby acquired; subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

3.3.3.15 Real Estate Estimate

The real estate cost estimate at Table 3.3.3.15-1 includes the land cost for acquisition of land, relocation benefits to include a replacement housing payment and fixed rate move expenses, and Federal and non-Federal administrative costs. Administrative costs are those costs incurred for verifying ownership of lands, certification of those lands required for project purposes, legal opinions, analysis or other requirements that may be necessary, during PED. No cost is included for a borrow site or temporary work area. The requirement, if any, for a borrow site or temporary work area will be identified during PED. If further real estate requirements are identified during PED or if there is a significant increase in cost, a supplement to the Real Estate Appendix will be prepared. A 25% contingency is applied to the current estimate.

Table 3.3.3.15-1.
LOD3 Hancock County Elevated Road Estimate

a. Lands and Improvements/Permits		
417 Ownerships for Levee, 66 Improvements		23,843,680
10 Pump Stations		145,665
427 Ownerships	Subtotal	23,989,345
b. Mineral Rights		0
c. Damages		0
d. P.L. 91-646 Relocation costs – 66 relocations		1,859,200
e. Administrative Cost		10,102,500
Subtotal		35,951,045
Contingencies (25%)		8,987,761
	Totals	**44,938,806**
	Rounded	**44,939,000**

	Relocation	Acquisition	Total
Federal	99,000	1,067,500	1,166,500
Non-Federal	396,000	8,540,000	8,936,000
	495,000	9,607,500	10,102,500

3.3.3.16 Summary of Potential Real Estate Issues

The requirement for temporary work areas, disposal or borrow areas has not been identified. Should these areas be required, these would be considered as part of the LERRD requirements. Typically if disposal or borrow sites are required, Real estate would provide an analysis during PED to compare the cost of acquiring an these sites with the cost of using a commercial sites and make a determination which method is most cost effective. See Section 2.8 Borrow Areas on page 5.

Should drainage ditches, temporary work areas, disposal or borrow areas become a necessary real estate acquisition requirement, valuation of lands will be performed. Land costs associated with these areas, and administrative costs will be added to the Real Estate Cost Estimate. If further real estate requirements are identified during PED or if there is a significant increase in cost, a supplement to the Real Estate Appendix will be prepared.

Any requirements for relocation contracts pertaining to facilities/utilities will be identified and completed during PED.

Any requirement for mitigation lands will be identified during PED.

Should condemnation of any required real estate interest be necessary, it is the responsibility of the NFS. This issue is addressed during the Assessment of the Non-Federal Sponsor's Real Estate Acquisition Capability. However, if the real estate interest is one that the NFS does not have authority to condemn, the Federal Government can perform the condemnation on behalf of the NFS.

A relocation plan will need to be completed during PED to address potential relocation activity under P.L. 91-646. There are a number of factors pertaining to relocations that can impact the project both in cost and in schedule. Payments for Housing of Last Resort, which would exceed the standard housing replacement payments, are very likely due to the size of the project and the lack of available decent, safe and sanitary housing in the area. Another factor that could increase cost and impact schedule is the cost of business relocations. Depending on the type of business and the operation, this could involve moving equipment and machinery to new locations. It is necessary to interview each impacted individual and business during Pre-Construction, Engineering and Design Phase to determine the requirements for relocation and to estimate a cost for the relocation.

3.3.3.17 Chart of Accounts

The cost estimate for all Federal and non-Federal real estate activities necessary for implementation of the project after completion of the feasibility study for land acquisition, construction, LERRD, and other items are coded as delineated in the Cost Work Breakdown Structure (CWBS). This real estate cost estimate is then incorporated into the Total Current Working Estimate utilizing the Microcomputer Aided Cost Engineering System (MCACES). The Chart of Accounts at Table 3.3.3.17-1 shows the CWBS for real estate activities.

Table 3.3.3.17-1.
Chart of Accounts - LOD3 Hancock County Elevated Road

01A	Project Planning	Federal	Non-Federal	Totals
	Other			
	Project Cooperation Agreement			
01AX	Contingencies (25%)			
	Subtotal			
01B	Lands and Damage/Permits			
01B40	Acquisition/Review of NFS	1,067,500		1,067,500
01B20	Acquisition by NFS		8,540,000	8,540,000
01BX	Contingencies (25%)	266,875	2,135,000	2,401,875
	Subtotal	1,334,375	10,675,000	12,009,375
01F	PL 91-646 Assistance			
01F20	By NFS		396,000	396,000
01FX	Contingencies (25%)		99,000	99,000
	Subtotal		495,000	495,000
01R	Real Estate Land Payments			
01R1B	Land Payments by NFS		23,989,345	23,989,345
01R2B	PL91-646 Relocation Payment by NFS		1,859,200	1,859,200
01R2D	Review of NFS	99,000		99,000
01RX	Contingencies (25%)	24,750	6,462,136	6,486,886
	Subtotal	123,750	32,310,681	32,434,431
	Totals	**1,458,125**	**43,480,681**	**44,938,806**
	Rounded			**44,939,000**

3.3.4 Harrison County, Elevated Roadway

Residential and business areas along the coast in Harrison County are susceptible to storm surge damage. In Harrison County, ground elevations over most of the residential and business areas vary between elevation 8-12 feet NAVD88 on the coast and rising within 1000 feet to elevation 30-36 along a ridge parallel to the coastline, then decreasing to the north. A damage reduction option to raise Highway 90 to elevation 16 feet NAVD88 was evaluated. The location of the project is shown in Figure 3.3.4-1.

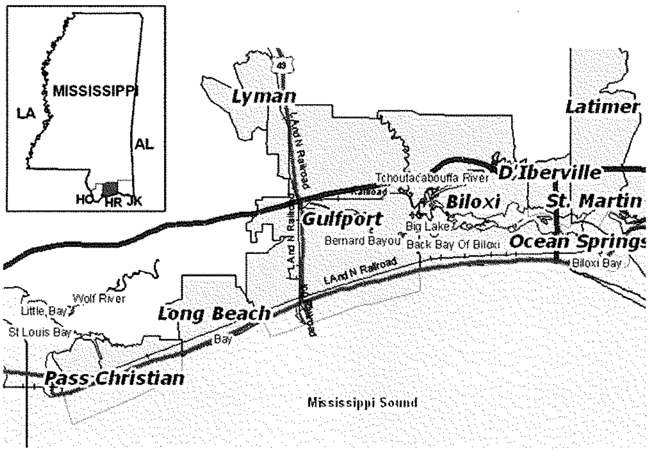

Figure 3.3.4-1.
Vicinity Map, Harrison County

3.3.4.1 Project Description

The proposed project is shown in red in Figures 3.3.4.1-1 through Figure 3.3.4.1-4. Highway 90 in Harrison County extends from Biloxi Bay to pass Christian.

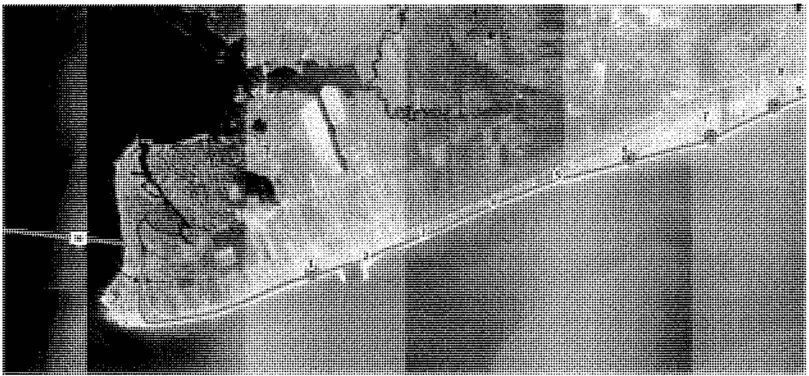

Figure 3.3.4.1-1.
Pump/Culvert/Sub-basin Site Locations, Harrison County

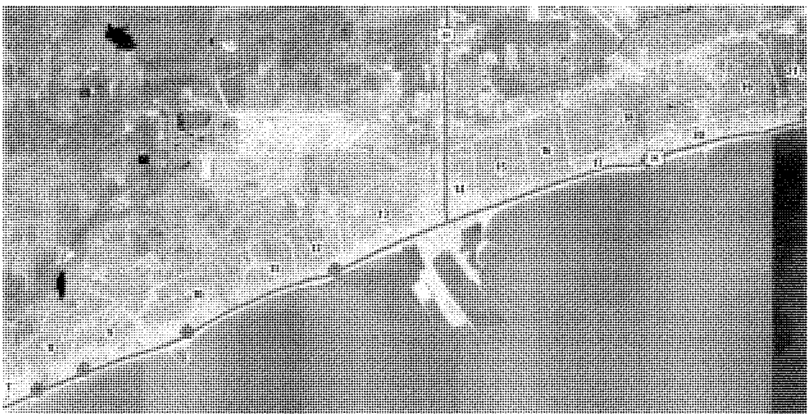

Figure 3.3.4.1-2.
Pump/Culvert/Sub-basin Site Locations, Harrison County

Figure 3.3.4.1-3.
Pump/Culvert/Sub-basin Site Locations, Harrison County

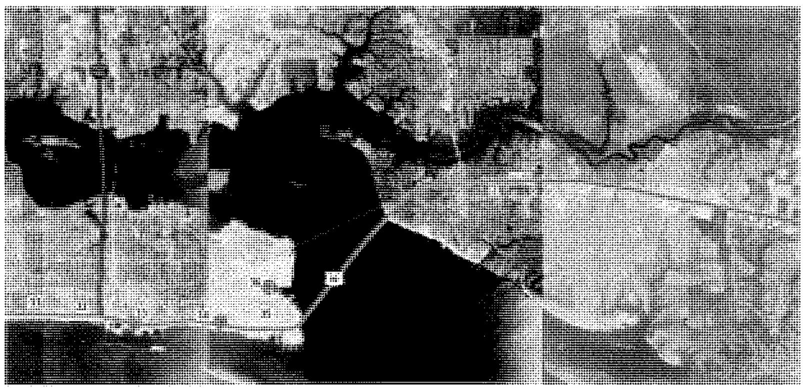

Figure 3.3.4.1-4.
Pump/Culvert/Sub-basin Site Locations, Harrison County

This option consists of raising US Highway 90 along the coast of Harrison County to elevation 16 feet NAVD88 along with the internal sub-basins and levee culvert/pump locations as shown above. The Line 3 defense elevates the roadway and accompanying seawall by extending the seaway at its present slope to grade, creating the roadway sub grade then, sloping the backside to one vertical to three horizontal side slopes with a twenty five foot toe width for access and drainage. All work areas to receive fill shall be cleared and grubbed of all trees and surface organics and all existing foundations, streets, utilities, etc. will be removed and the subsequent cavities backfilled and compacted. The embankment will be constructed of sand clay materials obtained from off site commercial sources, trucked to the work area. The final surface on the back side will be armored by the placement of 12 inch thick gabion mattress filled with small stone for erosion protection during an event that overtops the road. All non critical surface areas will be subsequently covered by grassing. Road crossings will incorporate ramping over the embankment where the surface elevation is near that of the crest elevation. Drainage on the interior of the raised roadway would be collected at the highway and channeled to culverts Drainage ditches along the toe of the highway, will be required to assure that smaller basins can be drained to a culvert/pump site. 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 for control in the event the flap gate malfunctions. 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.

Operation and maintenance activities for this project will be required on an annual basis. All pumps and gates will be operated to assure proper working order. Debris and shoaled sediment will be removed. Vegetation on the levees will be cut to facilitate inspection and to prevent roots from causing weak levee locations.

3.3.4.2 Real Estate Requirements

Real Estate requirements for Line of Defense 3, Harrison County Elevated Road measure include lands, easements, rights-of-way and relocations, and disposal/borrow areas (LERRD), and the right to raise a road and construct an earthen levee, drainage ditches and 15 culvert/pump station facilities. Based on the project footprint, it was determined that approximately 1031 parcels and 80 structures would be impacted. The acreage to be acquired is unknown. It is known that the 15 pump stations will require approximately 0.23 of an acre each for a total of 3.45 acres. Lands required for construction of the levee will be acquired in fee simple interest. Based on the number of structures being impacted, the assumption is that there will be 80 relocations.

Ditches that will be constructed to provide drainage for the levee are expected to be located within the footprint of the levee. Until final plans and specifications are completed, an assumption is made that the ditches will be constructed on the same lands acquired for construction of the levee. If any additional lands are required, this will be determined during PED.

Raising of the roadway and relocation of any utilities will most probably need to be accomplished through a relocation contract. This will be further investigated and confirmed during PED.

An assumption is made that excavated materials from clearing, snagging, and construction of ditches, etc. will be disposed of in county owned or commercial landfills. However, In the event that the excavated material is not suitable for a landfill a disposal site will have to be acquired. Typically if disposal sites are required, this would be considered as part of the LERRD requirement. Real Estate would provide an analysis during PED to compare the cost of acquiring an upland disposal site with the cost of using a commercial landfill and make a determination which method is most cost effective.

The recommended plan proposes to use material from an inventory of upland borrow sites to construct the project. A specific site has not been identified or confirmed for use at time of this report. Typically if borrow sites are required, this would be considered a part of the LERRD requirement. Real Estate would provide an analysis during PED to compare the cost of acquiring an upland borrow site with the cost of using a commercial borrow site and make a determination which method is most cost effective. The requirement for temporary work areas is unknown. Sponsor owned lands will be used if available. Otherwise, this may be an additional real estate requirement, and will be further defined during PED.

3.3.4.3 Utility/Facility Relocation

The plan calls for elevation of Highway 90. Some removal/relocation of utilities may be required. An assumption is made that this work will be accomplished through a relocation contract. This will be further investigated and confirmed during PED. See Chapter 2 Section 2.10 for more detailed discussion.

3.3.4.4 Existing Projects/Studies

Relevant projects and studies are found in the main report at Section 1.6, History of the Investigation and Section 1.7, Prior and On-Going Studies, Reports and Programs.

3.3.4.5 Environmental Impacts

See the Main Report, Chapter 6. Environmental Effects of Plans and the Environmental Appendix, for a full discussion on environmental effects.

3.3.4.6 Project Sponsor Responsibilities and Capabilities

The State of Mississippi will be the non-Federal Project Sponsor (NFS). The NFS has the responsibility to acquire all real estate interests required for the Project. The NFS shall accomplish all alterations and relocations of facilities, structures and improvements determined by the government to be necessary for construction of the Project.

Title to any acquired real estate will be retained by the Project Sponsor and will not be conveyed to the United States Government. Prior to advertisement of any construction contract, the NFS shall furnish to the government an Authorization for Entry for Construction (Exhibit "A" to the Real Estate Appendix) to all lands, easements and rights-of-way, as necessary. The NFS will also furnish to the government evidence supporting their legal authority to grant rights-of-way to such lands. The NFS shall comply with applicable provisions of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970, Public Law 91-646, approved 2 January 1971, and amended by Title IV of the Surface Transportation Uniform Relocation Assistance Act of 1987, Public Law 100-17, effective 2 April 1989, in acquiring real estate interests for the Project, and inform all affected persons of applicable benefits, policies, and procedures in connection with said Act(s). A form for the Assessment of the Non-Federal Sponsor's Capability to Acquire Real Estate is at Exhibit "B" to the Real Estate Appendix. The assessment will be made during PED phase.

The non-Federal sponsor is entitled to receive credit against its share of project costs for the value of lands it provides and the value of the relocations that are required for the project. Generally, for the purpose of determining the amount of credit to be afforded, the value of the LER is the fair market value of the real property interest, plus certain incidental costs of acquiring those interests, that the non-federal sponsor provided for the project as required by the Government. The NFS cannot receive credit for the value of any LER, including incidental costs, which were previously provided as an item of cooperation for another Federal project, including projects that preceded enactment of WRDA 1986.

3.3.4.7 Government Owned Property

There 4 Government owned parcels within the footprint of the project. In viewing the footprint, it appears that these parcels will be minimally impacted where they abut Highway 90. Land and structure values are not listed in the public records. Ownership is listed in public records as US Govt, US Veterans Hospital, and United States of America. Specific impacts to Government owned lands will be determined during PED.

3.3.4.8 Historical Significance

See the Main Report, Section 3.2.9 Cultural and Archaeological Resources, for a general discussion on cultural and archaeological resources.

3.3.4.9 Mineral Rights

There are no known mineral activities within the scope of the proposed project.

3.3.4.10 Hazardous, Toxic, and Radioactive Waste (HTRW)

Due to the extent of the project, no preliminary assessment was performed to identify the possibility of hazardous waste on the sites. These studies will be conducted during the next phase of work. See Sections 3.2.8 and 6.16 of the Main Report for a discussion on HTRW.

3.3.4.11 Public Law 91-646, Relocation Assistance Benefits

The Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970 establishes a uniform policy for fair and equitable treatment of persons displaced as a result of federal and federally assisted programs in order that such persons shall not suffer disproportionate injuries as a result of programs designed for the benefits of the public as a whole. A qualified displaced person may be entitled to certain relocation assistance benefits which include reimbursement of moving costs and a replacement housing benefit. Moving expense can be reimbursed either based on actual costs or a fixed moving cost schedule. The replacement housing payment is separated into 3 basic types - purchase supplement, rental assistance and down payment. All replacement housing must be decent, safe, and sanitary (DSS) before a replacement housing payment can be made.

It is estimated that there are approximately 80 relocations in this alternative. All estimates are based on information from county public records. The number of business relocations as compared to residential relocations is unknown. In order to accomplish the relocation activity in a timely manner, the plan set forth in Chapter 2. Section 2.5 can be used.

3.3.4.12 Attitude of Property Owners

Real Estate has not interviewed property owners or tenants during the study phase for the MsCIP. However, numerous public meetings have been held at different locations throughout the study area to inform stakeholders and property owners about the study and the protective measures under consideration for the Mississippi coastal area. A number of local newspapers have published articles that discuss the MsCIP study and the perceived positive effects as well as the negative impacts that may occur as a result of the project. Some of these articles can be found on web sites. While many of the locals may welcome the benefits of the proposed project, there are some who oppose the project.

3.3.4.13 Acquisition Schedule

An acquisition schedule will be developed when plans and specifications become available and more definite information is available pertaining to the specific areas and number of parcels for acquisition. The acquisition schedule will be developed during PED and will be a joint effort of the NFS, the project manager and Real Estate. The schedule will set forth a time line for title, survey, appraisal, negotiation, preparation of documents and closing activity. After acquisition activity is completed certification of lands acquired/owned by the sponsor will be necessary prior to advertisement for construction. The Certification of Real Estate can be accomplished within 30 - 60 days after acquisition. See Chapter 2. Section 2.5. for discussion on an acquisition implementation/management plan.

3.3.4.14 Estates for Proposed Project

All lands required for the levee will be acquired in Fee Simple. Should a borrow site be required, the Borrow Easement will be used. The Temporary Work Area Easement will be used for staging or temporary work areas, and the Drainage Ditch Easement will be used as required. The estates recommended are standard estates.

FEE.

The fee simple title to (the land described in Schedule A) l/(Tracts Nos. ____, ____ and ___), subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

BORROW EASEMENT.

A (temporary) (perpetual and assignable) right and easement to clear, borrow, excavate and remove sand, soil, dirt, and other materials from (the land described in Schedule A) (Tracts Nos. _____, _____ and _____); subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines; reserving, however, to the landowners, their heirs and assigns, all such rights and privileges in said land as may be used without interfering with or abridging the rights and easement hereby acquired.

TEMPORARY WORK AREA EASEMENT.

A temporary easement and right-of-way in, on, over and across (the land described in Schedule A) (Tracts Nos. _____, _____ and _____), for a period not to exceed __________________, beginning with date possession of the land is granted to the Project Sponsor, for use by the Project Sponsor, its representatives, agents, and contractors as a work area, including the right to deposit backfill, move, store and remove equipment and supplies, and erect and remove temporary structures on the land and to perform any other work necessary and incident to the construction of the __________________ Project, together with the right to trim, cut, fell and remove there from all trees, underbrush, obstructions, and any other vegetation, structures, or obstacles within the limits of the right-of-way; reserving, however, to the landowners, their heirs and assigns, all such rights and privileges as may be used without interfering with or abridging the rights and easement hereby acquired; subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

DRAINAGE DITCH EASEMENT.

A perpetual and assignable easement and right-of-way in, over and across (the land described in Schedule A) (Tracts Nos. ____, ____ and _____) to construct, maintain, repair, operate, patrol and replace a drainage ditch, reserving, however, to the owners, their heirs and assigns, all such rights and privileges in the land as may be used without interfering with or abridging the rights and easement hereby acquired; subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

3.3.4.15 *Real Estate Estimate*

The real estate cost estimate at Table 3.3.4.15-1 includes the land cost for acquisition of land, relocation benefits to include a replacement housing payment and fixed rate move expenses, and Federal and non-Federal administrative costs. Administrative costs are those costs incurred for verifying ownership of lands, certification of those lands required for project purposes, legal opinions, analysis or other requirements that may be necessary, during PED. No cost is included for a borrow site or temporary work area. The requirement, if any, for a borrow site or temporary work area will be identified during PED. If further real estate requirements are identified during PED or if there is a significant increase in cost, a supplement to the Real Estate Appendix will be prepared. A 25% contingency is applied to the current estimate.

Table 3.3.4.15-1.
LOD3 Harrison County Elevated Road Estimate

a. Lands and Improvements/Permits				
1016 Ownerships for Levee, 80 Improvements				375,464,802
15 Pump Stations				270,004
1031 Ownerships			Subtotal	375,734,806
b. Mineral Rights				0
c. Damages				0
d. P.L. 91-646 Relocation costs – 80 relocations				2,240,000
e. Administrative Cost				0
	Relocation	Acquisition	Total	
Federal	120,000	2,577,500	2,697,500	
Non-Federal	480,000	20,620,000	21,100,000	
	600,000	23,197,500	23,797,500	
Subtotal				401,772,306
Contingencies (25%)				100,443,077
Totals				**502,215,383**
Rounded				**502,215,000**

3.3.4.16 *Summary of Potential Real Estate Issues*

The requirement for temporary work areas, disposal or borrow areas has not been identified. Should these areas be required, these would be considered as part of the LERRD requirements. Typically if disposal or borrow sites are required, Real estate would provide an analysis during PED to compare the cost of acquiring an these sites with the cost of using a commercial sites and make a determination which method is most cost effective. See Section 2.8 Borrow Areas on page 5.

Should drainage ditches, temporary work areas, disposal or borrow areas become a necessary real estate acquisition requirement, valuation of lands will be performed. Land costs associated with these areas, and administrative costs will be added to the Real Estate Cost Estimate. If further real estate requirements are identified during PED or if there is a significant increase in cost, a supplement to the Real Estate Appendix will be prepared.

Any requirements for relocation contracts pertaining to facilities/utilities will be identified and completed during PED.

Any requirement for mitigation lands will be identified during PED.

Should condemnation of any required real estate interest be necessary, it is the responsibility of the NFS. This issue is addressed during the Assessment of the Non-Federal Sponsor's Real Estate Acquisition Capability. However, if the real estate interest is one that the NFS does not have authority to condemn, the Federal Government can perform the condemnation on behalf of the NFS.

A relocation plan will need to be completed during PED to address potential relocation activity under P.L. 91-646. There are a number of factors pertaining to relocations that can impact the project both in cost and in schedule. Payments for Housing of Last Resort, which would exceed the standard housing replacement payments, are very likely due to the size of the project and the lack of available decent, safe and sanitary housing in the area. Another factor that could increase cost and impact schedule is the cost of business relocations. Depending on the type of business and the operation, this could involve moving equipment and machinery to new locations. It is necessary to interview each impacted individual and business during Pre-Construction, Engineering and Design Phase to determine the requirements for relocation and to estimate a cost for the relocation.

3.3.4.17 Chart of Accounts

The cost estimate for all Federal and non-Federal real estate activities necessary for implementation of the project after completion of the feasibility study for land acquisition, construction, LERRD, and other items are coded as delineated in the Cost Work Breakdown Structure (CWBS). This real estate cost estimate is then incorporated into the Total Current Working Estimate utilizing the Microcomputer Aided Cost Engineering System (MCACES). The Chart of Accounts at Table 3.3.4.17-1 shows the CWBS for real estate activities.

Table 3.3.4.17-1.
Chart of Accounts - LOD3 Harrison County Elevated Road

01A	Project Planning	Federal	Non-Federal	Totals
	Other			
	Project Cooperation Agreement			
01AX	Contingencies (25%)			
	Subtotal			
01B	Lands and Damage/Permits			
01B40	Acquisition/Review of NFS	2,577,500		2,577,500
01B20	Acquisition by NFS		20,620,000	20,620,000
01BX	Contingencies (25%)	644,375	5,155,000	5,799,375
	Subtotal	3,221,875	25,775,000	28,996,875
01F	PL 91-646 Assistance			
01F20	By NFS		480,000	480,000
01FX	Contingencies (25%)		120,000	120,000
	Subtotal		600,000	600,000
01R	Real Estate Land Payments			
01R1B	Land Payments by NFS		375,734,806	375,734,806
01R2B	PL91-646 Relocation Payment by NFS		2,240,000	2,240,000
01R2D	Review of NFS	120,000		120,000
01RX	Contingencies (25%)	30,000	94,493,702	94,523,702
	Subtotal	150,000	472,468,508	472,618,508
	Totals	**3,371,875**	**498,843,508**	**502,215,383**
	Rounded			**502,215,000**

3.3.5 Harrison County Forrest Heights Levee, City of Gulfport

The Forrest Heights community is located in an area known as North Gulfport within the city of Gulfport on the Mississippi Gulf Coast. The residential community lies on the bank of Turkey Creek about 2.6 miles from the mouth at Bernard Bayou, and has frequently been inundated by flood waters due to storm surges from the Mississippi Sound and from inland flooding along the lower Turkey Creek floodplain. Turkey Creek has a tendency to frequently exceed its stream channel capacity and flood adjacent low-lying areas. Water reached a depth of 2-8 feet over the entire community during Hurricane Katrina inundation. Ground elevations over most of the residential area are between elevations 10-14 feet NAVD88. Drainage is mostly along streets and through natural drainage ways to the Turkey Creek. A previous evaluation recommended the construction of an earthen levee to protect this area from storm surge flooding. The Forrest Heights levee is proposed to be constructed as a pilot project for the MsCIP comprehensive plan. The levee will address the combination of storm surge protection and inland surge protection. The levee is intended to be constructed to a height such that the levee might be certified under the National Flood Insurance Program. A preliminary engineering analysis suggests a levee built to approximately elevation 21 ft NAVD88 would satisfy or exceed certification elevation criteria. The location of the levee is shown in Figure 3.3.5-1. The options in this study are identified as Option A and Option B. The levees were evaluated at elevations 17 ft NAVD88 and 21 ft NAVD88. The top width was assumed 12 ft with side slopes of 1 vertical to 3 horizontal.

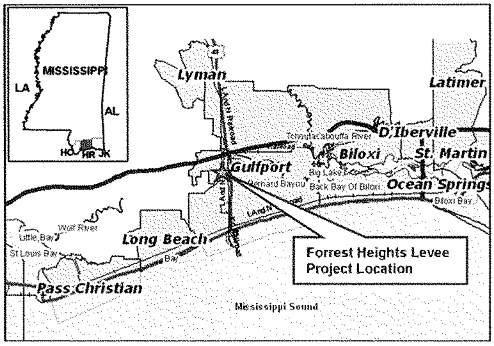

Figure 3.3.5-1.
Forrest Heights Levee Vicinity Map

3.3.5.1 Option A - Elevation 17.0 ft NAVD88

This option consists of an earthen dike around the Forrest Heights community along with the levee culvert/interior detention location. It generally will be trapezoidal in shape with an elevation of 17.0 feet and a top width of 12 ft and slopes of 1 vertical to 3 horizontal on both sides. The total length of the levee will be approximately 7,900 feet. The recommended plan includes selective clearing and snagging as a measure to prevent increases in water surface elevations upstream that would occur due to the placement of the levees in the floodplain.

3.3.5.2 Option B - Elevation 21.0 ft NAVD88

This option consists of an earthen levee around northern, western, and southern sides of the Forrest Heights community. Because of the height of the levee, the eastern side will be constructed with a concrete "T"-wall structure. The "T" wall will take less space than an earthen levee and encroach less into property along the alignment. Closure gates across the two access roads to the subdivision will be required. The lengths of the levee culverts will be slightly longer than those used in Option A. Other features and methods of analysis are the same.

The levee alignment for both Option A and B is generally the same and is shown in Figure 3.3.5.2-1.

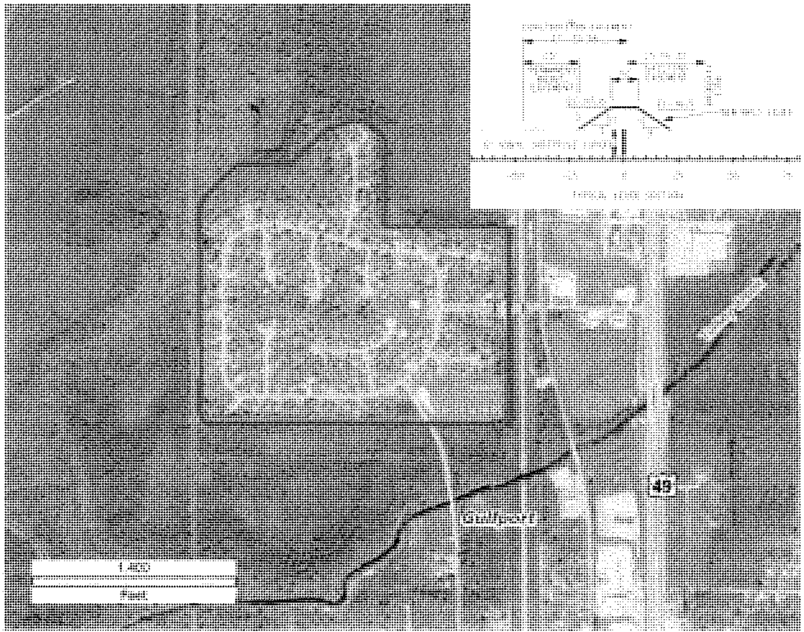

Figure 3.3.5.2-1.
Forrest Heights Levee Alignment with Detention Site Location

3.3.5.3 Project Description

As described above, the levee will be an earthen berm constructed either at elevation 17.0 feet or 21.0 feet along with culvert/interior detention locations. Interior flooding on the landward side of the levee will be improved by adding a storm water detention basin and pumping facility. The detention area will hold storm water until the creek water level recedes and water can drain through the culvert. 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 in the levee for control in the event the flap gate malfunctions.

The detention basin would have an area of approximately 3 acres but would not be excavated. The area is the lowest site in the subdivision and is presently used for recreation facilities such as baseball and tennis.

The Recommended Plan includes selective clearing and snagging for approximately 4.5 miles from the mouth of Turkey Creek at Bernard Bayou to the upstream limits as shown in Figure 3.3.5.3-1. Selective clearing and snagging would remove obstructions such as debris dams and excessive sedimentation that hinders the flow through the Turkey Creek channel. While the selective clearing and snagging component of the plan does not eliminate flooding along Turkey Creek, the plan does reduce flood damages along the creek and at the upper end of the canals at 28th Street. The main purpose of the selective clearing and snagging is to make sure that induced damages do not occur due to the construction of the recommended levees. Only debris, snags and sediment that obstruct the flow will be removed. Material to be removed includes: 1) fine sediment accumulations that obstruct flows and alter flow patterns; 2) Debris blockages that currently or in the near future cause obstructed flow and altered flow patterns; and 3) Rooted trees that obstruct flow or need to be cleared for equipment access. Access areas that are cleared will be reestablished at the conclusion of the selective clearing and snagging activities. Some access points, however, may remain for the non-Federal sponsor to use for maintenance activity of the completed project. The existing bank alignment along the entire reach will not be changed, including the downstream reaches of Turkey Creek along the meander bends. Specific reaches to be cleared and snagged will be identified by an interdisciplinary team prior to construction.

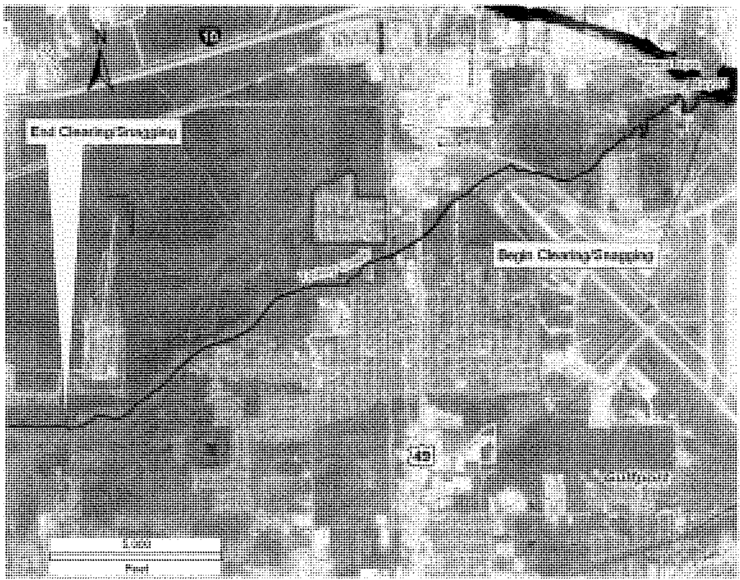

Figure 3.3.5.3-1.
Turkey Creek Channel Clearing and Snagging Limits

The inland barrier earthen levee section will have one vertical to three horizontal side slopes with a twelve foot crest width. All work areas to receive fill shall be cleared and grubbed of all trees and surface organics and all existing foundations, streets, utilities, etc. will be removed and the subsequent cavities backfilled and compacted. The levee will be constructed of sand clay materials obtained from off site commercial sources, and trucked to the work area. The final surface will be armored by the placement of 24 inch thick gabion mattress filled with small stone for erosion protection during an event that overtops the levee. The armoring will be anchored on the front face by trenching and extend across the downstream slope and a 25 foot area beyond the toe. The front side of the levee and all non critical surface areas will be subsequently covered by grassing. In order to maintain the natural runoff patterns culverts would be inserted through the protection line at appropriate locations. For this study these were configured as cast-in-place reinforced concrete box structures fitted with flap gates and sluice gates to provide protection from high water outside the levee.

With the installation of a ring levee around the Forrest Heights community at Option A, elevation 17.0 or Option B, elevation 21.0, 2 roadway intersections would have to be accommodated. For this study it was estimated that for Option A both roadway entrances could use ramps for crossing the restored levee. For Option B both roadway entrances would use sliding flood gates.

Operation and maintenance activities for this project will be required on an annual basis. All gates will be operated to assure proper working order. Debris and shoaled sediment will be removed from the interior ponding area. Vegetation on the levees will be cut to facilitate inspection and to prevent roots from causing weak levee locations. Rills will be filled and damaged revetment will be repaired.

3.3.5.4 Real Estate Requirements

Real Estate requirements for Line of Defense 3, Forrest Heights Levees include lands, easements, rights-of-way and relocations, and disposal/borrow areas (LERRD), and the right to construct an earthen levee, drainage ditches and detention ponding area. Based on the footprint of the Option A 17.0 foot elevation, it was determined that approximately 18 parcels and 2 structures will be impacted. The acreage to be acquired for the levee is unknown. It is known that the detention ponding area would require approximately 3.0 acres. Lands required for construction of the levee and the detention pond will be acquired in fee simple interest. Based on the number of structures being impacted, the assumption is that there will be 2 relocations. Approximately 55 acres will be acquired in Channel Improvement Easements from approximately 48 landowners.

Based on the footprint of the Option B 30.0 foot elevation, it was determined that the same number of parcels and structures will be impacted as for Option A, but the easement area required for the levee will be extended to permit construction of the higher levee.

Ditches that will be constructed to provide drainage for the interior of the ring levee are expected to be located within the footprint of the levee. Until final plans and specifications are completed, an assumption is made that the ditches will be constructed on the same lands acquired for construction of the levee. If any additional lands are required, this will be determined during PED.

Any modifications to the roadways and utilities will most probably need to be accomplished through a relocation contract. This will be further investigated and confirmed during PED.

An assumption is made that excavated materials from clearing, snagging, and construction of ditches, etc. will be disposed of in county owned or commercial landfills. However, In the event that the excavated material is not suitable for a landfill a disposal site will have to be acquired. Typically if disposal sites are required, this would be considered as part of the LERRD requirement. Real Estate would provide an analysis during PED to compare the cost of acquiring an upland disposal site with the cost of using a commercial landfill and make a determination which method is most cost effective.

The recommended plan proposes to use material from an inventory of upland borrow sites to construct the levee. A specific site has not been identified or confirmed for use at time of this report. Typically if borrow sites are required, this would be considered a part of the LERRD requirement. Real Estate would provide an analysis during PED to compare the cost of acquiring an upland borrow site with the cost of using a commercial borrow site and make a determination which method is most cost effective. The requirement for temporary work areas is unknown. Sponsor owned lands will be used if available. Otherwise, this may be an additional real estate requirement, and will be further defined during PED.

3.3.5.5 Utility/Facility Relocation

The plan calls for roads to be ramped over the proposed levee and possible relocation of utilities. An assumption is made that this work will be accomplished through a relocation contract. This will be further investigated and confirmed during PED. See Chapter 2 Section 2.10 for more detailed discussion.

3.3.5.6 Existing Projects/Studies

Relevant projects and studies are found in the main report at Section 1.6, History of the Investigation and Section 1.7, Prior and On-Going Studies, Reports and Programs.

3.3.5.7 Environmental Impacts

See the Main Report, Chapter 6. Environmental Effects of Plans and the Environmental Appendix, for a full discussion on environmental effects.

3.3.5.8 Project Sponsor Responsibilities and Capabilities

The State of Mississippi will be the non-Federal Project Sponsor (NFS). The NFS has the responsibility to acquire all real estate interests required for the Project. The NFS shall accomplish all alterations and relocations of facilities, structures and improvements determined by the government to be necessary for construction of the Project.

Title to any acquired real estate will be retained by the Project Sponsor and will not be conveyed to the United States Government. Prior to advertisement of any construction contract, the NFS shall furnish to the government an Authorization for Entry for Construction (Exhibit "A" to the Real Estate Appendix) to all lands, easements and rights-of-way, as necessary. The NFS will also furnish to the government evidence supporting their legal authority to grant rights-of-way to such lands. The NFS shall comply with applicable provisions of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970, Public Law 91-646, approved 2 January 1971, and amended by Title IV of the Surface Transportation Uniform Relocation Assistance Act of 1987, Public Law 100-17, effective 2 April 1989, in acquiring real estate interests for the Project, and inform all affected persons of applicable benefits, policies, and procedures in connection with said Act(s). A form for the Assessment of the Non-Federal Sponsor's Capability to Acquire Real Estate is at Exhibit "B" to the Real Estate Appendix. The assessment will be made during PED phase.

The non-Federal sponsor is entitled to receive credit against its share of project costs for the value of lands it provides and the value of the relocations that are required for the project. Generally, for the purpose of determining the amount of credit to be afforded, the value of the LER is the fair market value of the real property interest, plus certain incidental costs of acquiring those interests, that the non-federal sponsor provided for the project as required by the Government. The NFS cannot receive credit for the value of any LER, including incidental costs, which were previously provided as an item of cooperation for another Federal project, including projects that preceded enactment of WRDA 1986.

3.3.5.9 Government Owned Property

There are no known Government owned lands within the proposed project.

3.3.5.10 Historical Significance

See the Main Report, Section 3.2.9 Cultural and Archaeological Resources, for a general discussion on cultural and archaeological resources.

3.3.5.11 Mineral Rights

There are no known mineral activities within the scope of the proposed project.

3.3.5.12 Hazardous, Toxic, and Radioactive Waste (HTRW)

Due to the extent of the project, no preliminary assessment was performed to identify the possibility of hazardous waste on the sites. These studies will be conducted during the next phase of work. See Sections 3.2.8 and 6.16 of the Main Report for a discussion on HTRW.

3.3.5.13 Public Law 91-646, Relocation Assistance Benefits

The Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970 establishes a uniform policy for fair and equitable treatment of persons displaced as a result of federal and federally assisted programs in order that such persons shall not suffer disproportionate injuries as a result of programs designed for the benefits of the public as a whole. A qualified displaced person may be entitled to certain relocation assistance benefits which include reimbursement of moving costs and a replacement housing benefit. Moving expense can be reimbursed either based on actual costs or a fixed moving cost schedule. The replacement housing payment is separated into 3 basic types - purchase supplement, rental assistance and down payment. All replacement housing must be decent, safe, and sanitary (DSS) before a replacement housing payment can be made.

It is estimated that there are approximately 2 relocations in Option A and approximately 2 relocations in Option B. No relocation plan has been completed nor has a relocation survey been done. All estimates are based on information from county public records. In order to accomplish the relocation activity in a timely manner, the plan set forth in Chapter 2. Section 2.5 can be used.

3.3.5.14 Attitude of Property Owners

Real Estate has not interviewed property owners or tenants during the study phase for the MsCIP. However, numerous public meetings have been held at different locations throughout the study area to inform stakeholders and property owners about the study and the protective measures under consideration for the Mississippi coastal area. A number of local newspapers have published articles that discuss the MsCIP study and the perceived positive effects as well as the negative impacts that may occur as a result of the project. Some of these articles can be found on web sites. While many of the locals may welcome the benefits of the proposed project, there are some who oppose the project.

3.3.5.15 Acquisition Schedule

An acquisition schedule will be developed when plans and specifications become available and more definite information is available pertaining to the specific areas and number of parcels for acquisition. The acquisition schedule will be developed during PED and will be a joint effort of the NFS, the project manager and Real Estate. The schedule will set forth a time line for title, survey, appraisal, negotiation, preparation of documents and closing activity. After acquisition activity is completed certification of lands acquired/owned by the sponsor will be necessary prior to advertisement for construction. The Certification of Real Estate can be accomplished within 30 - 60 days after acquisition. See Chapter 2. Section 2.5. for discussion on an acquisition implementation/management plan.

3.3.5.16 Estates for Proposed Project

All lands required for the levee will be acquired in Fee Simple. The Channel Improvements Easement will be used for clearing and snagging work. Should a borrow site be required, the Borrow Easement will be used. The Temporary Work Area Easement will be used for staging or temporary work areas, and the Drainage Ditch Easement will be used as required. The estates recommended are standard estates.

FEE.

The fee simple title to (the land described in Schedule A) l/(Tracts Nos. ____, ____ and ___), subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

BORROW EASEMENT.

A (temporary) (perpetual and assignable) right and easement to clear, borrow, excavate and remove sand, soil, dirt, and other materials from (the land described in Schedule A) (Tracts Nos. _____, _____ and _____); subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines; reserving, however, to the landowners, their heirs and assigns, all such rights and privileges in said land as may be used without interfering with or abridging the rights and easement hereby acquired.

TEMPORARY WORK AREA EASEMENT.

A temporary easement and right-of-way in, on, over and across (the land described in Schedule A) (Tracts Nos. _____, _____ and _____), for a period not to exceed ___________________, beginning with date possession of the land is granted to the Project Sponsor, for use by the Project Sponsor, its representatives, agents, and contractors as a work area, including the right to deposit backfill, move, store and remove equipment and supplies, and erect and remove temporary structures on the land and to perform any other work necessary and incident to the construction of the ____________________ Project, together with the right to trim, cut, fell and remove there from all trees, underbrush, obstructions, and any other vegetation, structures, or obstacles within the limits of the right-of-way; reserving, however, to the landowners, their heirs and assigns, all such rights and privileges as may be used without interfering with or abridging the rights and easement hereby acquired; subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

CHANNEL IMPROVEMENT EASEMENT.

A perpetual and assignable right and easement to construct, operate, and maintain channel improvement works on, over and across (the land described in Schedule A) (Tracts Nos. _____, _____ and _____) for the purposes as authorized by the Act of Congress approved ____________, including the right to clear, cut, fell, remove and dispose of any and all timber, trees, underbrush, buildings, improvements and/or other obstructions there from; to excavate: dredge, cut away, and remove any or all of said land and to place thereon dredge or spoil material; and for such other purposes as may be required in connection with said work of improvement; reserving, however, to the owners, their heirs and assigns, all such rights and privileges as may be used without interfering with or abridging the rights and easement hereby acquired; subject, however, to existing easements far public roads and highways, public utilities, railroads and pipelines.

DRAINAGE DITCH EASEMENT.

A perpetual and assignable easement and right-of-way in, over and across (the land described in Schedule A) (Tracts Nos. ____, ____ and _____) to construct, maintain, repair, operate, patrol and replace a drainage ditch, reserving, however, to the owners, their heirs and assigns, all such rights and privileges in the land as may be used without interfering with or abridging the rights and easement hereby acquired; subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

3.3.5.17 Real Estate Estimate

A summary of the cost for each option is at Table 3.3.5.17-1. The real estate estimates at Tables 3.3.5.17-2 and 3.3.5.17-3 include the land cost for acquisition of land, relocation benefits to include a replacement housing payment and fixed rate move expenses, and Federal and non-Federal administrative costs. Administrative costs are those costs incurred for verifying ownership of lands, certification of those lands required for project purposes, legal opinions, analysis or other requirements that may be necessary, during PED. No cost is included for a borrow site or temporary work area. The requirement, if any, for a borrow site or temporary work area will be identified during PED. If further real estate requirements are identified during PED or if there is a significant increase in cost, a supplement to the Real Estate Appendix will be prepared. A 25% contingency is applied to the current estimate.

Table 3.3.5.17-1.
Real Estate Cost Summary

Option	Impacted Parcels	Relocations	Total Cost
Option A - 17.0	67	2	$2,571,000
Option B - 21.0	67	4	$2,649,000

Table 3.3.5.17-2.
LOD3 Harrison County Forrest Heights Levee, Gulfport - Option A 17.0 Estimate

a. Lands and Improvements/Permits				
18 Ownerships for Levee, 2 Improvements				219,740
1 Ownerships for Pond, 0 Improvements				13,392
48 Ownerships for Channel Improvement				245,520
67 Ownerships			Subtotal	478,652
b. Mineral Rights				0
c. Damages				0
d. P.L. 91-646 Relocation costs - 2 relocations				56,000
e. Administrative Cost				1,522,500
	Relocation	Acquisition	Total	
Federal	3,000	167,500	170,500	

Non-Federal	12,000	1,340,000	1,352,000	
	15,000	1,507,500	1,522,500	
Sub-Total				2,057,152
Contingencies (25%)				514,288
Totals				**2,571,440**
Rounded				**2,571,000**

Table 3.3.5.17-3.
LOD3 Harrison County Forrest Heights Levee, Gulfport - Option B 21.0 Estimate

a. Lands and Improvements/Permits				
18 Ownerships for Levee, 2 Improvements				281,800
1 Ownerships for Pond, 0 Improvements				13,392
48 Ownerships for Channel Improvement				245,520
67 Ownerships			Subtotal	540,712
b. Mineral Rights				0
c. Damages				0
d. P.L. 91-646 Relocation costs - 2 relocations				56,000
e. Administrative Cost				1,522,500
	Relocation	Acquisition	Total	
Federal	3,000	167,500	170,500	
Non-Federal	12,000	1,340,000	1,352,000	
	15,000	1,507,500	1,522,500	
Sub-Total				2,119,212
Contingencies (25%)				529,803
Totals				**2,649,015**
Rounded				**2,649,000**

3.3.5.18 Summary of Potential Real Estate Issues

The requirement for temporary work areas, disposal or borrow areas has not been identified. Should these areas be required, these would be considered as part of the LERRD requirements. Typically if disposal or borrow sites are required, Real estate would provide an analysis during PED to compare the cost of acquiring an these sites with the cost of using a commercial sites and make a determination which method is most cost effective. See Section 2.8 Borrow Areas on page 5.

Should drainage ditches, temporary work areas, disposal or borrow areas become a necessary real estate acquisition requirement, valuation of lands will be performed. Land costs associated with these areas, and administrative costs will be added to the Real Estate Cost Estimate. If further real estate requirements are identified during PED or if there is a significant increase in cost, a supplement to the Real Estate Appendix will be prepared.

Any requirements for relocation contracts pertaining to facilities/utilities will be identified and completed during PED.

Any requirement for mitigation lands will be identified during PED.

Should condemnation of any required real estate interest be necessary, it is the responsibility of the NFS. This issue is addressed during the Assessment of the Non-Federal Sponsor's Real Estate Acquisition Capability. However, if the real estate interest is one that the NFS does not have authority to condemn, the Federal Government can perform the condemnation on behalf of the NFS.

A relocation plan will need to be completed during PED to address potential relocation activity under P.L. 91-646. There are a number of factors pertaining to relocations that can impact the project both in cost and in schedule. Payments for Housing of Last Resort, which would exceed the standard housing replacement payments, are very likely due to the size of the project and the lack of available decent, safe and sanitary housing in the area. Another factor that could increase cost and impact schedule is the cost of business relocations. Depending on the type of business and the operation, this could involve moving equipment and machinery to new locations. It is necessary to interview each impacted individual and business during Pre-Construction, Engineering and Design Phase to determine the requirements for relocation and to estimate a cost for the relocation.

3.3.5.19 Chart of Accounts

The cost estimate for all Federal and non-Federal real estate activities necessary for implementation of the project after completion of the feasibility study for land acquisition, construction, LERRD, and other items are coded as delineated in the Cost Work Breakdown Structure (CWBS). This real estate cost estimate is then incorporated into the Total Current Working Estimate utilizing the Microcomputer Aided Cost Engineering System (MCACES). The Chart of Accounts at Tables 3.3.5.19-1 and 3.3.5.19-2 shows the CWBS for real estate activities.

Table 3.3.5.19-1.
Chart of Accounts - LOD3 Harrison County Forrest Heights Levee, Gulfport - Option A

01A	Project Planning	Federal	Non-Federal	Totals
	Other			
	Project Cooperation Agreement			
01AX	Contingencies (25%)			
	Subtotal			
01B	Lands and Damages/Permits			
01B40	Acquisition/Review of NFS	167,500		167,500
01B20	Acquisition by NFS		1,340,000	1,340,000
01BX	Contingencies (25%)	41,875	335,000	376,875
	Subtotal	209,375	1,675,000	1,884,375
01F	PL 91-646 Assistance			
01F20	By NFS		12,000	12,000
01FX	Contingencies (25%)		3,000	3,000
	Subtotal		15,000	15,000

01A	Project Planning	Federal	Non-Federal	Totals
01R	Real Estate Land Payments			
01R1B	Land Payments by NFS		478,652	478,652
01R2B	PL91-646 Relocation Payment by NFS		56,000	56,000
01R2D	Review of NFS	3,000		3,000
01RX	Contingencies (25%)	750	133,663	134,413
	Subtotal	3,750	668,315	672,065
	Totals	**213,125**	**2,358,315**	**2,571,440**
	Rounded			**2,571,000**

Table 3.3.5.19-2.
Chart of Accounts - LOD3 Harrison County Forrest Heights Levee, Gulfport - Option B

01A	Project Planning	Federal	Non-Federal	Totals
	Other			
	Project Cooperation Agreement			
01AX	Contingencies (25%)			
	Subtotal			
01B	Lands and Damages/Permits			
01B40	Acquisition/Review of NFS	167,500		167,500
01B20	Acquisition by NFS		1,340,000	1,340,000
01BX	Contingencies (25%)	41,875	335,000	376,875
	Subtotal	209,375	1,675,000	1,884,375
01F	PL 91-646 Assistance			
01F20	By NFS		12,000	12,000
01FX	Contingencies (25%)		3,000	3,000
	Subtotal		15,000	15,000
01R	Real Estate Land Payments			
01R1B	Land Payments by NFS		540,712	540,712
01R2B	PL91-646 Relocation Payment by NFS		56,000	56,000
01R2D	Review of NFS	3,000		3,000
01RX	Contingencies (25%)	750	149,178	149,928
	Subtotal	3,750	745,890	749,640
	Totals	**213,125**	**2,435,890**	**2,649,015**
	Rounded			**2,649,000**

3.3.6 *Jackson County, Elevated Roadway*

Residential and business areas along the coast in Jackson County are susceptible to storm surge damage. The city of Ocean Springs lies at the eastern side of the Back Bay of Biloxi. Ground elevations over most of the residential and business areas vary between elevations 16-24 ft NAVD88, with houses along the coast between 8-16 ft NAVD88. This option entails the raising of the Beach Road and the adjoining seawall to Elevation 11.00 from Highway 90 eastward to the Jackson County Marina. The project also provides for all utility infrastructures such as water, sewer, storm drain, gas and electric lines to be removed and reinstalled to meet the new grades. The project location is shown in Figure3.3.6-1 with the roadway in red.

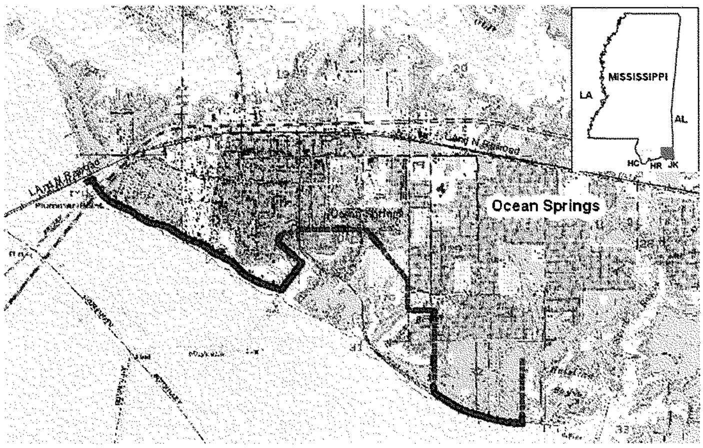

Figure 3.3.6-1.
Vicinity Map, Ocean Springs

3.3.6.1 Project Description

This option consists of raising the beach road to elevation 11 feet NAVD88 in Ocean Springs. The internal sub-basins and levee culvert/pump locations are shown on Figure 3.3.6.1-1. Drainage on the interior of the raised highway would be collected at the highway and channeled to culverts placed at locations shown below. Drainage Ditches along the toe of the highway will be required to assure that smaller basins can be drained to a culvert/pump site.

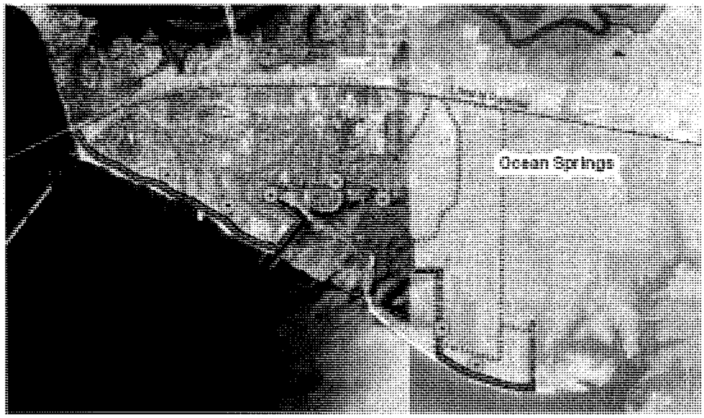

Figure 3.3.6.1-1.
Pump/Culvert/Sub-basin Site Location

The Line 3 defense elevates the roadway and accompanying seawall by extending the seaway at its present slope to grade, creating the roadway sub grade then, sloping the backside to one vertical to three horizontal side slopes with a twenty five foot toe width for access and drainage. All work areas to receive fill shall be cleared and grubbed of all trees and surface organics and all existing foundations, streets, utilities, etc. will be removed and the subsequent cavities backfilled and compacted. The embankment will be constructed of sand clay materials obtained from off site commercial sources, trucked to the work area. The final surface on the back side will be armored by the placement of 12 inch thick gabion mattress filled with small stone for erosion protection during an event that overtops the road. All non critical surface areas will be subsequently covered by grassing. Road crossings will incorporate ramping over the embankment where the surface elevation is near that of the crest elevation. Drainage on the interior of the raised roadway would be collected at the highway and channeled to culverts. 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 for control in the event the flap gate malfunctions. 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.

Operation and maintenance activities for this project will be required on an annual basis. All pumps and gates will be operated to assure proper working order. Debris and shoaled sediment will be removed. Vegetation on the levees will be cut to facilitate inspection and to prevent roots from causing weak levee locations.

3.3.6.2 Real Estate Requirements

Real Estate requirements for Line of Defense 3, Jackson County Elevated Road measure include lands, easements, rights-of-way and relocations, and disposal/borrow areas (LERRD), and the right to raise a road and construct an earthen levee, drainage ditches and 7 culvert/pump station facilities. Based on the project footprint, it was determined that approximately 137 parcels and 55 structures would be impacted. The acreage to be acquired is unknown. It is known that the 7 pump stations will require approximately 0.23 of an acre each for a total of 1.61 acres. Lands required for construction of the levee will be acquired in fee simple interest. Based on the number of structures being impacted, the assumption is that there will be 55 relocations.

Ditches that will be constructed to provide drainage for the levee are expected to be located within the footprint of the levee. Until final plans and specifications are completed, an assumption is made that the ditches will be constructed on the same lands acquired for construction of the levee. If any additional lands are required, this will be determined during PED.

Raising of the roadway and relocation of any utilities will most probably need to be accomplished through a relocation contract. This will be further investigated and confirmed during PED.

An assumption is made that excavated materials from clearing, snagging, and construction of ditches, etc. will be disposed of in county owned or commercial landfills. However, In the event that the excavated material is not suitable for a landfill a disposal site will have to be acquired. Typically if disposal sites are required, this would be considered as part of the LERRD requirement. Real Estate would provide an analysis during PED to compare the cost of acquiring an upland disposal site with the cost of using a commercial landfill and make a determination which method is most cost effective.

The recommended plan proposes to use material from an inventory of upland borrow sites to construct the project. A specific site has not been identified or confirmed for use at time of this report. Typically if borrow sites are required, this would be considered a part of the LERRD requirement. Real Estate would provide an analysis during PED to compare the cost of acquiring an upland borrow site with the cost of using a commercial borrow site and make a determination which method is most cost effective. The requirement for temporary work areas is unknown. Sponsor owned lands will be used if available. Otherwise, this may be an additional real estate requirement, and will be further defined during PED.

3.3.6.3 Utility/Facility Relocation

The plan calls for elevation of Highway 90. Some removal/relocation of utilities may be required. An assumption is made that this work will be accomplished under a relocation contract. This will be further investigated and confirmed during PED. See Chapter 2 Section 2.10 for more detailed discussion.

3.3.6.4 Existing Projects/Studies

Relevant projects and studies are found in the main report at Section 1.6, History of the Investigation and Section 1.7, Prior and On-Going Studies, Reports and Programs.

3.3.6.5 Environmental Impacts

See the Main Report, Chapter 6. Environmental Effects of Plans and the Environmental Appendix, for a full discussion on environmental effects.

3.3.6.6 Project Sponsor Responsibilities and Capabilities

The State of Mississippi will be the non-Federal Project Sponsor (NFS). The NFS has the responsibility to acquire all real estate interests required for the Project. The NFS shall accomplish all alterations and relocations of facilities, structures and improvements determined by the government to be necessary for construction of the Project.

Title to any acquired real estate will be retained by the Project Sponsor and will not be conveyed to the United States Government. Prior to advertisement of any construction contract, the NFS shall furnish to the government an Authorization for Entry for Construction (Exhibit "A" to the Real Estate Appendix) to all lands, easements and rights-of-way, as necessary. The NFS will also furnish to the government evidence supporting their legal authority to grant rights-of-way to such lands. The NFS shall comply with applicable provisions of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970, Public Law 91-646, approved 2 January 1971, and amended by Title IV of the Surface Transportation Uniform Relocation Assistance Act of 1987, Public Law 100-17, effective 2 April 1989, in acquiring real estate interests for the Project, and inform all affected persons of applicable benefits, policies, and procedures in connection with said Act(s). A form for the Assessment of the Non-Federal Sponsor's Capability to Acquire Real Estate is at Exhibit "B" to the Real Estate Appendix. The assessment will be made during PED phase.

The non-Federal sponsor is entitled to receive credit against its share of project costs for the value of lands it provides and the value of the relocations that are required for the project. Generally, for the purpose of determining the amount of credit to be afforded, the value of the LER is the fair market value of the real property interest, plus certain incidental costs of acquiring those interests, that the non-federal sponsor provided for the project as required by the Government. The NFS cannot receive credit for the value of any LER, including incidental costs, which were previously provided as an item of cooperation for another Federal project, including projects that preceded enactment of WRDA 1986.

3.3.6.7 Government Owned Property

There are no known Government owned lands within the proposed project.

3.3.6.8 Historical Significance

See the Main Report, Section 3.2.9 Cultural and Archaeological Resources, for a general discussion on cultural and archaeological resources.

3.3.6.9 Mineral Rights

There are no known mineral activities within the scope of the proposed project.

3.3.6.10 Hazardous, Toxic, and Radioactive Waste (HTRW)

Due to the extent of the project, no preliminary assessment was performed to identify the possibility of hazardous waste on the sites. These studies will be conducted during the next phase of work. See Sections 3.2.8 and 6.16 of the Main Report for a discussion on HTRW.

3.3.6.11 Public Law 91-646, Relocation Assistance Benefits

The Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970 establishes a uniform policy for fair and equitable treatment of persons displaced as a result of federal and federally assisted programs in order that such persons shall not suffer disproportionate injuries as a result of programs designed for the benefits of the public as a whole. A qualified displaced person may be entitled to certain relocation assistance benefits which include reimbursement of moving costs and a replacement housing benefit. Moving expense can be reimbursed either based on actual costs or a fixed moving cost schedule. The replacement housing payment is separated into 3 basic types - purchase supplement, rental assistance and down payment. All replacement housing must be decent, safe, and sanitary (DSS) before a replacement housing payment can be made.

It is estimated that there are approximately 55 relocations in this alternative. All estimates are based on information from county public records. The number of business relocations as compared to residential relocations is unknown. In order to accomplish the relocation activity in a timely manner, the plan set forth in Chapter 2. Section 2.5 can be used.

3.3.6.12 Attitude of Property Owners

Real Estate has not interviewed property owners or tenants during the study phase for the MsCIP. However, numerous public meetings have been held at different locations throughout the study area to inform stakeholders and property owners about the study and the protective measures under consideration for the Mississippi coastal area. A number of local newspapers have published articles that discuss the MsCIP study and the perceived positive effects as well as the negative impacts that may occur as a result of the project. Some of these articles can be found on web sites. While many of the locals may welcome the benefits of the proposed project, there are some who oppose the project.

3.3.6.13 Acquisition Schedule

An acquisition schedule will be developed when plans and specifications become available and more definite information is available pertaining to the specific areas and number of parcels for acquisition. The acquisition schedule will be developed during PED and will be a joint effort of the NFS, the project manager and Real Estate. The schedule will set forth a time line for title, survey, appraisal, negotiation, preparation of documents and closing activity. After acquisition activity is completed certification of lands acquired/owned by the sponsor will be necessary prior to advertisement for construction. The Certification of Real Estate can be accomplished within 30 - 60 days after acquisition. See Chapter 2. Section 2.5. for discussion on an acquisition implementation/management plan.

3.3.6.14 Estates for Proposed Project

All lands required for the levee will be acquired in Fee Simple. Should a borrow site be required, the Borrow Easement will be used. The Temporary Work Area Easement will be used for staging or temporary work areas, and the Drainage Ditch Easement will be used as required. The estates recommended are standard estates.

FEE.

The fee simple title to (the land described in Schedule A) l/(Tracts Nos. ____, ____ and ___), subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

BORROW EASEMENT.

A (temporary) (perpetual and assignable) right and easement to clear, borrow, excavate and remove sand, soil, dirt, and other materials from (the land described in Schedule A) (Tracts Nos. _____, _____ and _____); subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines; reserving, however, to the landowners, their heirs and assigns, all such rights and privileges in said land as may be used without interfering with or abridging the rights and easement hereby acquired.

TEMPORARY WORK AREA EASEMENT.

A temporary easement and right-of-way in, on, over and across (the land described in Schedule A) (Tracts Nos. _____, _____ and _____), for a period not to exceed __________________, beginning with date possession of the land is granted to the Project Sponsor, for use by the Project Sponsor, its representatives, agents, and contractors as a work area, including the right to deposit backfill, move, store and remove equipment and supplies, and erect and remove temporary structures on the land and to perform any other work necessary and incident to the construction of the ____________________ Project, together with the right to trim, cut, fell and remove there from all trees, underbrush, obstructions, and any other vegetation, structures, or obstacles within the limits of the right-of-way; reserving, however, to the landowners, their heirs and assigns, all such rights and privileges as may be used without interfering with or abridging the rights and easement hereby acquired; subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

DRAINAGE DITCH EASEMENT.

A perpetual and assignable easement and right-of-way in, over and across (the land described in Schedule A) (Tracts Nos. ____, ____ and _____) to construct, maintain, repair, operate, patrol and replace a drainage ditch, reserving, however, to the owners, their heirs and assigns, all such rights and privileges in the land as may be used without interfering with or abridging the rights and easement hereby acquired; subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

3.3.6.15 Real Estate Estimate

The real estate cost estimate at Table 3.3.6.15-1 includes the land cost for acquisition of land, relocation benefits to include a replacement housing payment and fixed rate move expenses, and Federal and non-Federal administrative costs. Administrative costs are those costs incurred for verifying ownership of lands, certification of those lands required for project purposes, legal opinions, analysis or other requirements that may be necessary, during PED. No cost is included for a borrow site or temporary work area. The requirement, if any, for a borrow site or temporary work area will be identified during PED. If further real estate requirements are identified during PED or if there is a significant increase in cost, a supplement to the Real Estate Appendix will be prepared. A 25% contingency is applied to the current estimate.

Table 3.3.6.15-1.
LOD3 Jackson County Elevated Road Estimate

a. Lands and Improvements/Permits		
130 Ownerships for Levee, 55 Improvements		25,914,583
7 Pump Stations		271,308
137 Ownerships	Subtotal	26,185,891
b. Mineral Rights		0
c. Damages		0
d. P.L. 91-646 Relocation costs – 55 relocations		1,523,200
e. Administrative Cost		3,495,000

	Relocation	Acquisition	Total
Federal	82,500	342,500	425,000
Non-Federal	330,000	2,740,000	3,070,000
	412,500	3,082,500	3,495,000

Subtotal	31,204,091
Contingencies (25%)	7,801,023
Totals	**39,005,114**
Rounded	**39,005,000**

3.3.6.16 Summary of Potential Real Estate Issues

The requirement for temporary work areas, disposal or borrow areas has not been identified. Should these areas be required, these would be considered as part of the LERRD requirements. Typically if disposal or borrow sites are required, Real estate would provide an analysis during PED to compare the cost of acquiring an these sites with the cost of using a commercial sites and make a determination which method is most cost effective. See Section 2.8 Borrow Areas on page 5.

Should drainage ditches, temporary work areas, disposal or borrow areas become a necessary real estate acquisition requirement, valuation of lands will be performed. Land costs associated with these areas, and administrative costs will be added to the Real Estate Cost Estimate. If further real estate requirements are identified during PED or if there is a significant increase in cost, a supplement to the Real Estate Appendix will be prepared.

Any requirements for relocation contracts pertaining to facilities/utilities will be identified and completed during PED.

Any requirement for mitigation lands will be identified during PED.

Should condemnation of any required real estate interest be necessary, it is the responsibility of the NFS. This issue is addressed during the Assessment of the Non-Federal Sponsor's Real Estate Acquisition Capability. However, if the real estate interest is one that the NFS does not have authority to condemn, the Federal Government can perform the condemnation on behalf of the NFS.

A relocation plan will need to be completed during PED to address potential relocation activity under P.L. 91-646. There are a number of factors pertaining to relocations that can impact the project both in cost and in schedule. Payments for Housing of Last Resort, which would exceed the standard housing replacement payments, are very likely due to the size of the project and the lack of available decent, safe and sanitary housing in the area. Another factor that could increase cost and impact schedule is the cost of business relocations. Depending on the type of business and the operation, this could involve moving equipment and machinery to new locations. It is necessary to interview each impacted individual and business during Pre-Construction, Engineering and Design Phase to determine the requirements for relocation and to estimate a cost for the relocation.

3.3.6.17 Chart of Accounts

The cost estimate for all Federal and non-Federal real estate activities necessary for implementation of the project after completion of the feasibility study for land acquisition, construction, LERRD, and other items are coded as delineated in the Cost Work Breakdown Structure (CWBS). This real estate cost estimate is then incorporated into the Total Current Working Estimate utilizing the Microcomputer Aided Cost Engineering System (MCACES). The Chart of Accounts at Table 3.3.6.17-1 shows the CWBS for real estate activities.

Table 3.3.6.17-1.
Chart of Accounts - LOD3 Jackson County Elevated Road

01A	Project Planning	Federal	Non-Federal	Totals
	Other			
	Project Cooperation Agreement			
01AX	Contingencies (25%)			
	Subtotal			
01B	Lands and Damage/Permits			
01B40	Acquisition/Review of NFS	342,500		342,500
01B20	Acquisition by NFS		2,740,000	2,740,000
01BX	Contingencies (25%)	85,625	685,000	770,625
	Subtotal	428,125	3,425,000	3,853,125
01F	PL 91-646 Assistance			
01F20	By NFS		330,000	330,000
01FX	Contingencies (25%)		82,500	82,500
	Subtotal		412,500	412,500
01R	Real Estate Land Payments			
01R1B	Land Payments by NFS		26,185,891	26,185,891
01R2B	PL91-646 Relocation Payment by NFS		1,523,200	1,523,200
01R2D	Review of NFS	82,500		82,500
01RX	Contingencies (25%)	20,625	6,927,273	6,947,898
	Subtotal	103,125	34,636,364	34,739,489
	Totals	**531,250**	**38,473,864**	**39,005,114**
	Rounded			**39,005,000**

3.3.7 Jackson County Ring Levees, Ocean Springs

Several high density residential and business areas in Jackson County were identified. They are Ocean Springs, Gulf Park, Belle Fontaine, Gautier and Pascagoula/Moss Point. The city of Ocean Springs is located in the western part of Jackson County and lies at the eastern side of the Back Bay of Biloxi as shown in Figure 3.3.7-1. Ground elevations over most of the residential and business areas vary between elevations 16-24 feet NAVD88, with houses along the coast at between 8-16 feet NAVD88. These areas are subject to damage from storm surges associated with hurricanes. For purposes of providing protection for future storm events, the construction of an earthen ring levee is evaluated. The options in this study are identified as Option A and Option B. The levees were evaluated at elevations 20 ft NAVD88 and 30 ft NAVD88. The top width was assumed 15 ft with side slopes of 1 vertical to 3 horizontal.

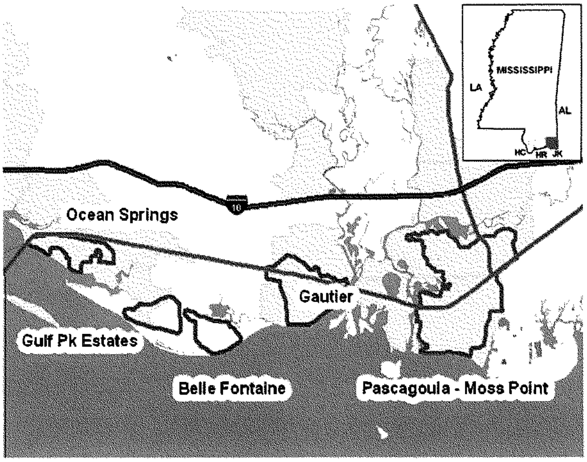

Figure 3.3.7-1.
Vicinity Map, Ocean Springs, MS

3.3.7.1 Option A - Elevation 20.0 ft NAVD88

This option consists of an earthen dike around the most densely populated areas of Ocean Springs along with the internal sub-basins and levee culvert/pump locations. The levee would have an elevation of 20.0 feet with a top width of 15 ft and slopes of 1 vertical to 3 horizontal.

3.3.7.2 Option B - Elevation 30.0 ft NAVD88

The alignment of the levee is the same as Option A, above but with an elevation of 30.0 feet. The only difference between the description of this option and preceding description of Option A is the height of the levee, pumping facilities, number of roadway and railroad intersections, and the length of the levee culverts.

3.3.7.3 Project Description

Figure 3.3.7.3-1 shows the location of the proposed project alternatives. As described above, the levee will be an earthen berm constructed either at elevation 20.0 feet or 30.0 feet along with the internal sub-basins and levee culvert/pump locations. Drainage on the interior of the ring levee would be collected at the levee and channeled to culverts placed in the levee. 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. In addition, pumps would be constructed near the outflow points to remove water from the interior during storm events occurring when the culverts are closed because of high water in the sound. Drainage ditches along the toe of the levee will be required to assure that smaller basins can be drained to a culvert/pump site. Figure 3.3.7.3-2 shows the proposed location of the pump/culvert sites. 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. Further studies will detail the requirement for the appropriate ponding areas, pump sizes, or buyouts in the affected areas.

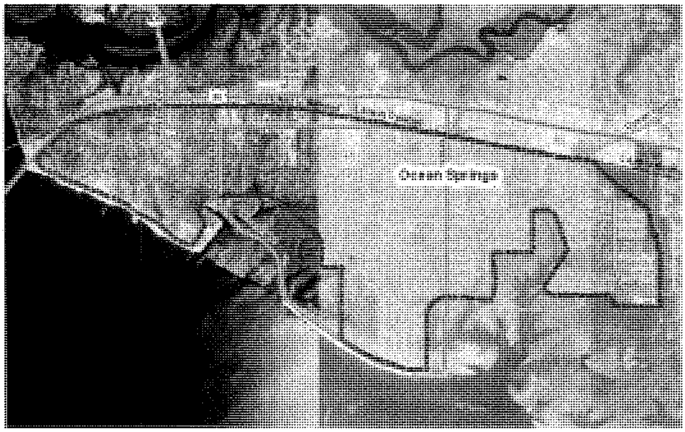

Figure 3.3.7.3-1.
Ocean Springs Ring Levee

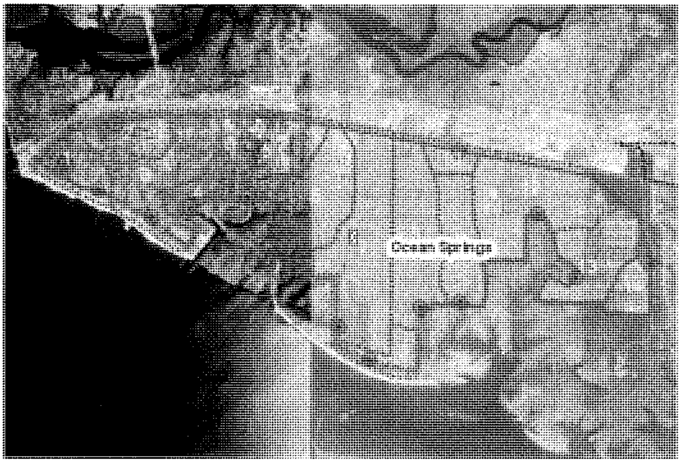

Figure 3.3.7.3-2.
Pump/Culvert/Sub-basin Site Locations

The inland barrier earthen levee section will have one vertical to three horizontal side slopes with a fifteen foot crest width. All work areas to receive fill shall be cleared and grubbed of all trees and surface organics and all existing foundations, streets, utilities, etc. will be removed and the subsequent cavities backfilled and compacted. The levee will be constructed of sand clay materials obtained from off site commercial sources, and trucked to the work area. The final surface will be armored by the placement of 24 inch thick gabion mattress filled with small stone for erosion protection during an event that overtops the levee. The armoring will be anchored on the front face by trenching and extend across the downstream slope and a 25 foot area beyond the toe. The front side of the levee and all non critical surface areas will be subsequently covered by grassing. In order to maintain the natural runoff patterns culverts would be inserted through the protection line at appropriate locations. Pump facilities are required at 14 locations. As any flood barrier is constructed the natural groundwater runoff would be inhibited. In order to maintain the natural runoff patterns culverts would be inserted through the protection line at appropriate locations. For this study these were configured as cast-in-place reinforced concrete box structures fitted with flap gates to minimize normal backflows and sluice gates to provide storm closure when needed.

Road crossings will incorporate small gate structures or ramping over the embankment where the surface elevation is near that of the crest elevation. The elevation relationship of the crest and the adjacent railroad will be a governing factor. At each point where a roadway crosses the protection line the decision must be made whether to maintain this artery and adapt the protection line to accommodate it, or to terminate the artery at the protection line and divert traffic to cross the protection line at another location. For this study it was assumed that all roadways and railways crossing the levee alignment would be retained except where it was very evident that traffic could be combined without undue congestion. Once the decision has been made to retain a particular roadway, it must then be determined how best to configure the artery to conduct traffic across the protection line. The simplest means of passing roadway traffic is to ramp the roadway over the protection line. This alternative is not always viable because of severe right-of-way restraints caused

by extreme levee height, urban congestion, etc. In such instances other methods can be used including partial ramping in combination with low profile roller gates. In more restricted areas full height gates which would leave the roadway virtually unaltered might be preferable, even though this alternative would usually be more costly than ramping. In some extreme circumstances where high levees are required to pass through very congested areas, installation of tunnels with closure gates may be required.

Because of the extreme gradient restrictions necessarily placed on railway construction, it is practically never acceptable to elevate a railway up and over a levee. Therefore, the available alternatives would include gated pass through structures. Because of the vertical clearance requirements of railroad traffic all railroad pass through structures for this study were configured having vertical walls on either side of the railway with double swing gates extending to the full height of the levee.

With the installation of a ring levee around the Ocean Springs area at Option A, elevation 20.0, 24 roadway intersections would have to be accommodated. For this study it was estimated that 6 roller gate structures and 18 would require swing gate structures would be required. At Option B, elevation 30.0, 76 roadway intersections would have to be accommodated, and it was estimated that 6 roller gate structures and 70 swing gate structures would be required

Operation and maintenance activities for this project will be required on an annual basis. All pumps and gates will be operated to assure proper working order. Debris and shoaled sediment will be removed. Vegetation on the levees will be cut to facilitate inspection and to prevent roots from causing weak levee locations. Rills will be filled and damaged revetment will be repaired.

3.3.7.4 Real Estate Requirements

Real Estate requirements for Line of Defense 3, Ocean Spring Ring Levees include lands, easements, rights-of-way and relocations, and disposal/borrow areas (LERRD), and the right to construct an earthen levee, drainage ditches and 14 culvert/pump station facilities.

Based on the footprint of the Option A 20.0 foot elevation, it was determined that approximately 197 parcels and 83 structures would be impacted. The acreage to be acquired for the levee is unknown. It is known that the 14 pump stations will require approximately 0.23 of an acre each for a total of 3.22 acres. Lands required for construction of the levee will be acquired in fee simple interest. Based on the number of structures being impacted, the assumption is that there will be 83 relocations.

Based on the footprint of the Option B 30.0 foot elevation, it was determined that 576 parcels and 312 structures are impacted. The acreage to be acquired for the levee is unknown. It is known that the 14 pump stations would require approximately 0.23 of an acre each for a total of 3.22 acres. Lands required for construction of the levee will be acquired in fee simple interest. Based on the number of structures being impacted, the assumption is that there will be 312 relocations.

Ditches that will be constructed to provide drainage for the interior of the ring levee are expected to be located within the footprint of the levee. Until final plans and specifications are completed, an assumption is made that the ditches will be constructed on the same lands acquired for construction of the levee. If any additional lands are required, this will be determined during PED.

Any modifications to the roadways and utilities will most probably need to be accomplished through a relocation contract. This will be further investigated and confirmed during PED.

An assumption is made that excavated materials from clearing, snagging, and construction of ditches, etc. will be disposed of in county owned or commercial landfills. However, In the event that the excavated material is not suitable for a landfill a disposal site will have to be acquired. Typically if disposal sites are required, this would be considered as part of the LERRD requirement. Real Estate would provide an analysis during PED to compare the cost of acquiring an upland disposal site with the cost of using a commercial landfill and make a determination which method is most cost effective.

The recommended plan proposes to use material from an inventory of upland borrow sites to construct the levee. A specific site has not been identified or confirmed for use at time of this report. Typically if borrow sites are required, this would be considered a part of the LERRD requirement. Real Estate would provide an analysis during PED to compare the cost of acquiring an upland borrow site with the cost of using a commercial borrow site and make a determination which method is most cost effective. The requirement for temporary work areas is unknown. Sponsor owned lands will be used if available. Otherwise, this may be an additional real estate requirement, and will be further defined during PED.

3.3.7.5 Utility/Facility Relocation

The plan calls for roads to be ramped over the proposed levee and possible relocation of utilities. An assumption is made that this work will be accomplished through a relocation contract. This will be further investigated and confirmed during PED. See Chapter 2 Section 2.10 for more detailed discussion.

3.3.7.6 Existing Projects/Studies

Relevant projects and studies are found in the main report at Section 1.6, History of the Investigation and Section 1.7, Prior and On-Going Studies, Reports and Programs.

3.3.7.7 Environmental Impacts

See the Main Report, Chapter 6. Environmental Effects of Plans and the Environmental Appendix, for a full discussion on environmental effects.

3.3.7.8 Project Sponsor Responsibilities and Capabilities

The State of Mississippi will be the non-Federal Project Sponsor (NFS). The NFS has the responsibility to acquire all real estate interests required for the Project. The NFS shall accomplish all alterations and relocations of facilities, structures and improvements determined by the government to be necessary for construction of the Project.

Title to any acquired real estate will be retained by the Project Sponsor and will not be conveyed to the United States Government. Prior to advertisement of any construction contract, the NFS shall furnish to the government an Authorization for Entry for Construction (Exhibit "A" to the Real Estate Appendix) to all lands, easements and rights-of-way, as necessary. The NFS will also furnish to the government evidence supporting their legal authority to grant rights-of-way to such lands. The NFS shall comply with applicable provisions of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970, Public Law 91-646, approved 2 January 1971, and amended by Title IV of the Surface Transportation Uniform Relocation Assistance Act of 1987, Public Law 100-17, effective 2 April 1989, in acquiring real estate interests for the Project, and inform all affected persons of applicable benefits, policies, and procedures in connection with said Act(s). A form for the Assessment of the Non-Federal Sponsor's Capability to Acquire Real Estate is at Exhibit "B" to the Real Estate Appendix. The assessment will be made during PED phase.

The non-Federal sponsor is entitled to receive credit against its share of project costs for the value of lands it provides and the value of the relocations that are required for the project. Generally, for the purpose of determining the amount of credit to be afforded, the value of the LER is the fair market value of the real property interest, plus certain incidental costs of acquiring those interests, that the non-federal sponsor provided for the project as required by the Government. The NFS cannot receive credit for the value of any LER, including incidental costs, which were previously provided as an item of cooperation for another Federal project, including projects that preceded enactment of WRDA 1986.

3.3.7.9 Government Owned Property

There 11 Government owned parcels within the footprint of the project. In viewing the footprint, it appears that these parcels will be minimally impacted by construction of the levee for the most part. Three of the parcels may be impacted to a greater degree. Land values are listed in the public records but no improvement values are listed. Ownership is listed in public records as US of America and United States of America. Specific impacts to Government owned lands will be determined during PED.

3.3.7.10 Historical Significance

See the Main Report, Section 3.2.9 Cultural and Archaeological Resources, for a general discussion on cultural and archaeological resources.

3.3.7.11 Mineral Rights

There are no known mineral activities within the scope of the proposed project.

3.3.7.12 Hazardous, Toxic, and Radioactive Waste (HTRW)

Due to the extent of the project, no preliminary assessment was performed to identify the possibility of hazardous waste on the sites. These studies will be conducted during the next phase of work. See Sections 3.2.8 and 6.16 of the Main Report for a discussion on HTRW.

3.3.7.13 Public Law 91-646, Relocation Assistance Benefits

The Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970 establishes a uniform policy for fair and equitable treatment of persons displaced as a result of federal and federally assisted programs in order that such persons shall not suffer disproportionate injuries as a result of programs designed for the benefits of the public as a whole. A qualified displaced person may be entitled to certain relocation assistance benefits which include reimbursement of moving costs and a replacement housing benefit. Moving expense can be reimbursed either based on actual costs or a fixed moving cost schedule. The replacement housing payment is separated into 3 basic types - purchase supplement, rental assistance and down payment. All replacement housing must be decent, safe, and sanitary (DSS) before a replacement housing payment can be made.

It is estimated that there are approximately 83 relocations in Option A and approximately 312 relocations in Option B. No relocation plan has been completed nor has a relocation survey been done. All estimates are based on information from county public records. The number of business relocations as compared to residential relocations is unknown. In order to accomplish the relocation activity in a timely manner, the plan set forth in Chapter 2. Section 2.5 can be used.

3.3.7.14 Attitude of Property Owners

Real Estate has not interviewed property owners or tenants during the study phase for the MsCIP. However, numerous public meetings have been held at different locations throughout the study area to inform stakeholders and property owners about the study and the protective measures under consideration for the Mississippi coastal area. A number of local newspapers have published articles that discuss the MsCIP study and the perceived positive effects as well as the negative impacts that may occur as a result of the project. Some of these articles can be found on web sites. While many of the locals may welcome the benefits of the proposed project, there are some who oppose the project.

3.3.7.15 Acquisition Schedule

An acquisition schedule will be developed when plans and specifications become available and more definite information is available pertaining to the specific areas and number of parcels for acquisition. The acquisition schedule will be developed during PED and will be a joint effort of the NFS, the project manager and Real Estate. The schedule will set forth a time line for title, survey, appraisal, negotiation, preparation of documents and closing activity. After acquisition activity is completed certification of lands acquired/owned by the sponsor will be necessary prior to advertisement for construction. The Certification of Real Estate can be accomplished within 30 - 60 days after acquisition. See Chapter 2. Section 2.5. for discussion on an acquisition implementation/management plan.

3.3.7.16 Estates for Proposed Project

All lands required for the levee will be acquired in Fee Simple. Should a borrow site be required, the Borrow Easement will be used. The Temporary Work Area Easement will be used for staging or temporary work areas, and the Drainage Ditch Easement will be used as required. The estates recommended are standard estates.

FEE.

The fee simple title to (the land described in Schedule A) l/(Tracts Nos. ____, ____ and ___), subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

BORROW EASEMENT.

A (temporary) (perpetual and assignable) right and easement to clear, borrow, excavate and remove sand, soil, dirt, and other materials from (the land described in Schedule A) (Tracts Nos. _____, _____ and _____); subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines; reserving, however, to the landowners, their heirs and assigns, all such rights and privileges in said land as may be used without interfering with or abridging the rights and easement hereby acquired.

TEMPORARY WORK AREA EASEMENT.

A temporary easement and right-of-way in, on, over and across (the land described in Schedule A) (Tracts Nos. _____, _____ and _____), for a period not to exceed ___________________, beginning with date possession of the land is granted to the Project Sponsor, for use by the Project Sponsor, its representatives, agents, and contractors as a work area, including the right to deposit backfill, move, store and remove equipment and supplies, and erect and remove temporary structures on the land and to perform any other work necessary and incident to the construction of the ___________________ Project, together with the right to trim, cut, fell and remove there from all trees, underbrush, obstructions, and any other vegetation, structures, or obstacles within the limits of the right-of-way; reserving, however, to the landowners, their heirs and assigns, all such rights and privileges as may be used without interfering with or abridging the rights and easement hereby acquired; subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

DRAINAGE DITCH EASEMENT.

A perpetual and assignable easement and right-of-way in, over and across (the land described in Schedule A) (Tracts Nos. ____, ____ and _____) to construct, maintain, repair, operate, patrol and replace a drainage ditch, reserving, however, to the owners, their heirs and assigns, all such rights and privileges in the land as may be used without interfering with or abridging the rights and easement hereby acquired; subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

3.3.7.17 Real Estate Estimate

A summary of the cost for each option is at Table 3.3.7.17-1. The real estate estimates at Tables 3.3.7.17-2 and 3.3.7.17-3 include the land cost for acquisition of land, relocation benefits to include a replacement housing payment and fixed rate move expenses, and Federal and non-Federal administrative costs. Administrative costs are those costs incurred for verifying ownership of lands, certification of those lands required for project purposes, legal opinions, analysis or other requirements that may be necessary, during PED. No cost is included for a borrow site or temporary work area. The requirement, if any, for a borrow site or temporary work area will be identified during PED. If further real estate requirements are identified during PED or if there is a significant increase in cost, a supplement to the Real Estate Appendix will be prepared. A 25% contingency is applied to the current estimate.

Table 3.3.7.17-1.
Real Estate Cost Summary

Option	Impacted Parcels	Relocations	Total Cost
Option A - 20.0	197	83	$43,609,000
Option B - 30.0	576	312	$119,542,000

Table 3.3.7.17-2.
LOD3 Jackson County Ring Levee, Ocean Springs - Option A 20.0 Estimate

a. Lands and Improvements/Permits		
183 Ownerships for Levee, 83 Improvements		26,959,933
14 Pump Stations		542,617
197 Ownerships	Subtotal	27,502,550
b. Mineral Rights		0
c. Damages		0

d. P.L. 91-646 Relocation costs – 83 relocations				2,329,600
e. Administrative Cost				5,055,000

	Relocation	Acquisition	Total
Federal	124,500	492,500	617,000
Non-Federal	498,000	3,940,000	4,438,000
	622,500	4,432,500	5,055,000

Subtotal		34,887,150
Contingencies (25%)		8,721,788
	Totals	**43,608,938**
	Rounded	**43,609,000**

Table 3.3.7.17-3.
LOD3 Jackson County Ring Levee, Ocean Springs - Option B 30.0 Estimate

a. Lands and Improvements/Permits		
562 Ownerships for Levee, 312 Improvements		71,055,087
14 Pump Stations		542,617
576 Ownerships	Subtotal	71,597,704
b. Mineral Rights		0
c. Damages		0
d. P.L. 91-646 Relocation costs – 312 relocations		8,736,000
e. Administrative Cost		15,300,000

	Relocation	Acquisition	Total
Federal	468,000	1,440,000	1,908,000
Non-Federal	1,872,000	11,520,000	13,392,000
	2,340,000	12,960,000	15,300,000

Subtotal		95,633,704
Contingencies (25%)		23,908,426
	Totals	**119,542,130**
	Rounded	**119,542,000**

3.3.7.18 Summary of Potential Real Estate Issues

The requirement for temporary work areas, disposal or borrow areas has not been identified. Should these areas be required, these would be considered as part of the LERRD requirements. Typically if disposal or borrow sites are required, Real estate would provide an analysis during PED to compare the cost of acquiring an these sites with the cost of using a commercial sites and make a determination which method is most cost effective. See Section 2.8 Borrow Areas on page 5.

Should drainage ditches, temporary work areas, disposal or borrow areas become a necessary real estate acquisition requirement, valuation of lands will be performed. Land costs associated with these areas, and administrative costs will be added to the Real Estate Cost Estimate. If further real estate requirements are identified during PED or if there is a significant increase in cost, a supplement to the Real Estate Appendix will be prepared.

Any requirements for relocation contracts pertaining to facilities/utilities will be identified and completed during PED.

Any requirement for mitigation lands will be identified during PED.

Should condemnation of any required real estate interest be necessary, it is the responsibility of the NFS. This issue is addressed during the Assessment of the Non-Federal Sponsor's Real Estate Acquisition Capability. However, if the real estate interest is one that the NFS does not have authority to condemn, the Federal Government can perform the condemnation on behalf of the NFS.

A relocation plan will need to be completed during PED to address potential relocation activity under P.L. 91-646. There are a number of factors pertaining to relocations that can impact the project both in cost and in schedule. Payments for Housing of Last Resort, which would exceed the standard housing replacement payments, are very likely due to the size of the project and the lack of available decent, safe and sanitary housing in the area. Another factor that could increase cost and impact schedule is the cost of business relocations. Depending on the type of business and the operation, this could involve moving equipment and machinery to new locations. It is necessary to interview each impacted individual and business during Pre-Construction, Engineering and Design Phase to determine the requirements for relocation and to estimate a cost for the relocation.

3.3.7.19 Chart of Accounts

The cost estimate for all Federal and non-Federal real estate activities necessary for implementation of the project after completion of the feasibility study for land acquisition, construction, LERRD, and other items are coded as delineated in the Cost Work Breakdown Structure (CWBS). This real estate cost estimate is then incorporated into the Total Current Working Estimate utilizing the Microcomputer Aided Cost Engineering System (MCACES). The Chart of Accounts at Tables 3.3.7.19-1 and 3.3.7.19-2 shows the CWBS for real estate activities.

Table 3.3.7.19-1.
Chart of Accounts - LOD3 Jackson County Ring Levee, Ocean Springs - Option A

01A	Project Planning	Federal	Non-Federal	Totals
	Other			
	Project Cooperation Agreement			
01AX	Contingencies (25%)			
	Subtotal			
01B	Lands and Damage/Permits			
01B40	Acquisition/Review of NFS	492,500		492,500
01B20	Acquisition by NFS		3,940,000	3,940,000
01BX	Contingencies (25%)	123,125	985,000	1,108,125
	Subtotal	615,625	4,925,000	5,540,625
01F	PL 91-646 Assistance			
01F20	By NFS		498,000	498,000
01FX	Contingencies (25%)		124,500	124,500
	Subtotal		622,500	622,500
01R	Real Estate Land Payments			
01R1B	Land Payments by NFS		27,502,550	27,502,550
01R2B	PL91-646 Relocation Payment by NFS		2,329,600	2,329,600
01R2D	Review of NFS	124,500		124,500
01RX	Contingencies (25%)	31,125	7,458,038	7,489,163
	Subtotal	155,625	37,290,188	37,445,813
	Totals	**771,250**	**42,837,688**	**43,608,938**
	Rounded			**43,609,000**

Table 3.3.7.19-2.
Chart of Accounts - LOD3 Jackson County Ring Levee, Ocean Springs - Option B

01A	Project Planning	Federal	Non-Federal	Totals
	Other			
	Project Cooperation Agreement			
01AX	Contingencies (25%)			
	Subtotal			
01B	Lands and Damage/Permits			
01B40	Acquisition/Review of NFS	1,440,000		1,440,000
01B20	Acquisition by NFS		11,520,000	11,520,000
01BX	Contingencies (25%)	360,000	2,880,000	3,240,000
	Subtotal	1,800,000	14,400,000	16,200,000
01F	PL 91-646 Assistance			
01F20	By NFS		1,872,000	1,872,000
01FX	Contingencies (25%)		468,000	468,000
	Subtotal		2,340,000	2,340,000
01R	Real Estate Land Payments			
01R1 B	Land Payments by NFS		71,597,704	71,597,704
01R2 B	PL91-646 Relocation Payment by NFS		8,736,000	8,736,000
01R2	Review of NFS	468,000		468,000

01A D	Project Planning	Federal	Non-Federal	Totals
01RX	Contingencies (25%)	117,000	20,083,426	20,200,426
	Subtotal	585,000	100,417,130	101,002,130
	Totals	**2,385,000**	**117,157,130**	**119,542,130**
	Rounded			**119,542,000**

3.3.8 Jackson County Ring Levees, Gulf Park

Several high density residential and business areas in Jackson County were identified. They are Ocean Springs, Gulf Park, Belle Fontaine, Gautier and Pascagoula/Moss Point. Gulf Park Estates Subdivision is located adjacent to and east of Ocean Springs. The area of study for the ring levee is bounded by Simmons Bayou on the north and the Mississippi Sound on the south. The location of the Gulf Park Estate ring levee is shown in Figure 3.3.8-1. Ground elevations over most of the residential areas vary between elevations 10-20 feet NAVD88. These areas are subject to damage from storm surges associated with hurricanes. For purposes of providing protection for future storm events, the construction of an earthen ring levee is evaluated. The options in this study are identified as Option A, Option B, Option C and Option D. The levees were evaluated at elevations 20 ft NAVD88 and 30 ft NAVD88. The top width was assumed 15 ft with side slopes of 1 vertical to 3 horizontal.

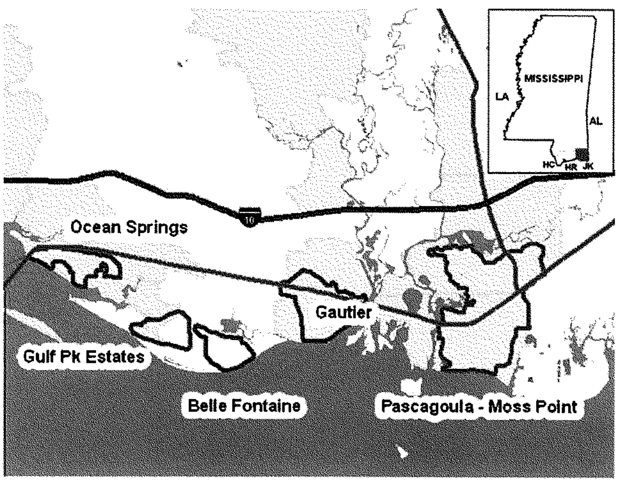

Figure 3.3.8-1.
Vicinity Map, Gulf Park Estates

3.3.8.1 Option A - Elevation 20.0 ft NAVD88

This option consists of an earthen dike around the most densely populated areas of Gulf Park Estates along with the internal sub-basins and levee culvert/pump locations. The levee would have an elevation of 20.0 feet with a top width of 15 ft and slopes of 1 vertical to 3 horizontal.

3.3.8.2 Option B - Elevation 30.0 ft NAVD88

The alignment of the levee is the same as Option A, above but with an elevation of 30.0 feet. The only difference between the description of this option and preceding description of Option A is the height of the levee, pumping facilities, number of roadway and railroad intersections, and the length of the levee culverts.

3.3.8.3 Option C - Alternate Alignment, Elevation 20.0 ft NAVD88

Option C consists of an earthen levee at elevation 20.0 feet in an alignment slightly different from the alignment for Options A and B. Additionally, the lands that lay between the alignment of Option A and the alternate alignment, Option C will be acquired as a buffer zone in this option.

3.3.8.4 Option D - Alternate Alignment, Elevation 30.0 ft NAVD88

The alignment of the levee is the same as Option C, above but with an elevation of 30.0 feet. The only difference between the description of this option and preceding description of Option C is the height of the levee, pumping facilities, number of roadway and railroad intersections, and the length of the levee culverts. As above, the buffer zone lands will be acquired.

3.3.8.5 Project Description

Figure 3.3.8.5-1 shows the location of the proposed project alternatives with the alternate alignment representing Options C and D. As described above, the levee will be an earthen berm constructed either at elevation 20.0 feet or 30.0 feet along with the internal sub-basins and levee culvert/pump locations. Drainage on the interior of the ring levee would be collected at the levee and channeled to culverts placed in the levee. 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. In addition, pumps would be constructed near the outflow points to remove water from the interior during storm events occurring when the culverts are closed because of high water in the sound. Drainage ditches along the toe of the levee will be required to assure that smaller basins can be drained to a culvert/pump site. Figure 3.3.8.5-2 shows the proposed location of the pump/culvert sites. 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. Further studies will detail the requirement for the appropriate ponding areas, pump sizes, or buyouts in the affected areas.

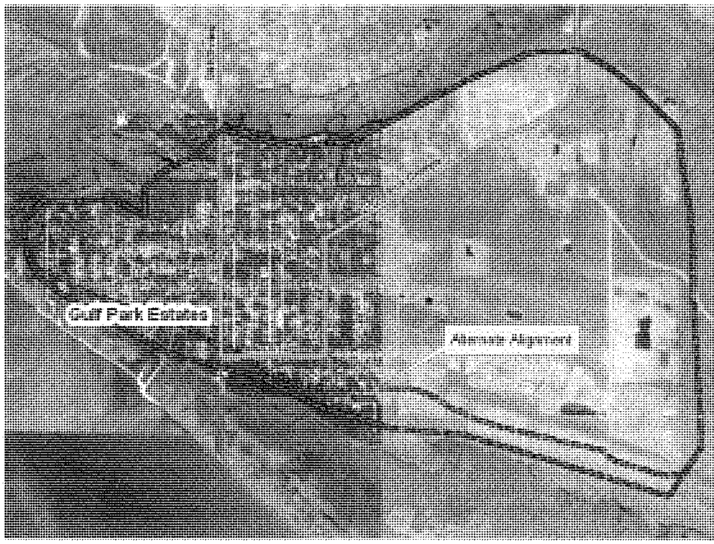

Figure 3.3.8.5-1.
Gulf Park Estates Ring Levee

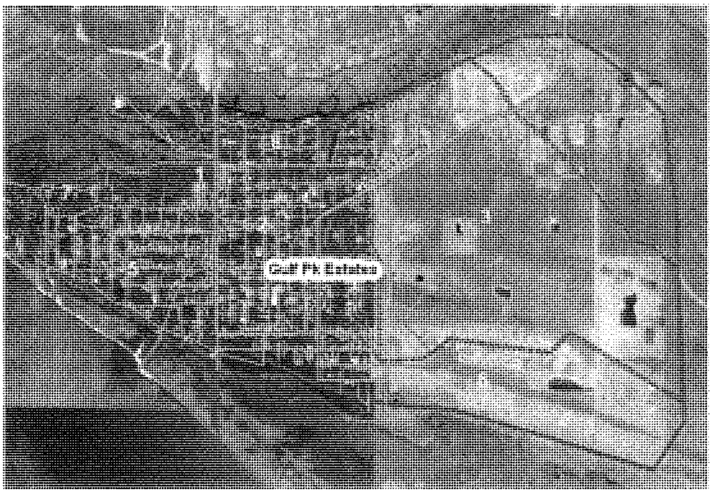

Figure 3.3.8.5-2.
Pump/Culvert/Sub-basin Site Locations

The inland barrier earthen levee section will have one vertical to three horizontal side slopes with a fifteen foot crest width. All work areas to receive fill shall be cleared and grubbed of all trees and surface organics and all existing foundations, streets, utilities, etc. will be removed and the subsequent cavities backfilled and compacted. The levee will be constructed of sand clay materials obtained from off site commercial sources, and trucked to the work area. The final surface will be armored by the placement of 24 inch thick gabion mattress filled with small stone for erosion protection during an event that overtops the levee. The armoring will be anchored on the front face by trenching and extend across the downstream slope and a 25 foot area beyond the toe. The front side of the levee and all non critical surface areas will be subsequently covered by grassing. In order to maintain the natural runoff patterns culverts would be inserted through the protection line at appropriate locations. For this study the culverts were configured as cast-in-place reinforced concrete box structures fitted with flap gates to minimize normal backflows and sluice gates to provide storm closure when needed. Pump facilities are required at 8 locations for Options A and B and at 9 locations for Options C and D.

Road crossings will incorporate small gate structures or ramping over the embankment where the surface elevation is near that of the crest elevation. The elevation relationship of the crest and the adjacent railroad will be a governing factor. At each point where a roadway crosses the protection line the decision must be made whether to maintain this artery and adapt the protection line to accommodate it, or to terminate the artery at the protection line and divert traffic to cross the protection line at another location. For this study it was assumed that all roadways and railways crossing the levee alignment would be retained except where it was very evident that traffic could be combined without undue congestion. Once the decision has been made to retain a particular roadway, it must then be determined how best to configure the artery to conduct traffic across the protection line. The simplest means of passing roadway traffic is to ramp the roadway over the protection line. This alternative is not always viable because of severe right-of-way restraints caused by extreme levee height, urban congestion, etc. In such instances other methods can be used including partial ramping in combination with low profile roller gates. In more restricted areas full height gates which would leave the roadway virtually unaltered might be preferable, even though this alternative would usually be more costly than ramping. In some extreme circumstances where high levees are required to pass through very congested areas, installation of tunnels with closure gates may be required.

Because of the extreme gradient restrictions necessarily placed on railway construction, it is practically never acceptable to elevate a railway up and over a levee. Therefore, the available alternatives would include gated pass through structures. Because of the vertical clearance requirements of railroad traffic all railroad pass through structures for this study were configured having vertical walls on either side of the railway with double swing gates extending to the full height of the levee.

With the installation of a ring levee around Gulf Park Estates at Option A, elevation 20.0, 20 roadway intersections would have to be accommodated. For this study it was estimated that 2 roller gate structures and 18 would require swing gate structures would be required. At Option B, elevation 30.0, 13 roadway intersections would have to be accommodated, and it was estimated that all 13 would require swing gate structures. At Option C, elevations 20.0, 18 roadway gates for intersections would have to be accommodated, and 14 would require swing gate structures with the remaining 4 requiring roller gates of varying heights. For Option D, elevation 30.0, 15 roadway intersections would have to be accommodated and all 15 would require swing gate structures.

Operation and maintenance activities for this project will be required on an annual basis. All pumps and gates will be operated to assure proper working order. Debris and shoaled sediment will be removed. Vegetation on the levees will be cut to facilitate inspection and to prevent roots from causing weak levee locations. Rills will be filled and damaged revetment will be repaired.

3.3.8.6 Real Estate Requirements

Real Estate requirements for Line of Defense 3, Gulf Park Estates Ring Levees include lands, easements, rights-of-way and relocations, and disposal/borrow areas (LERRD), and the right to acquire buffer zone lands, construct an earthen levee, drainage ditches and 8 - 9 culvert/pump station facilities depending on the option.

Based on the footprint of Option A, 20.0 foot elevation, it was determined that approximately 354 parcels and 62 structures would be impacted. The acreage to be acquired for the levee is unknown. It is known that the 8 pump stations will require approximately 0.23 of an acre each for a total of 1.84 acres. Lands required for construction of the levee will be acquired in fee simple interest, and lands for the drainage ditches that will be constructed outside the levee footprint will be acquired either in easement or fee as necessary. Based on the number of structures being impacted, the assumption is that there will be 62 relocations.

Based on the footprint of Option B, 30.0 foot elevation, it was determined that approximately 399 parcels and 66 structures would be impacted. The acreage to be acquired for the levee is unknown. It is known that the 8 pump stations will require approximately 0.23 of an acre each for a total of 1.84 acres. Lands required for construction of the levee will be acquired in fee simple interest, and lands for the drainage ditches that will be constructed outside the levee footprint will be acquired either in easement or fee as necessary. Based on the number of structures being impacted, the assumption is that there will be 66 relocations.

Based on the footprint of Option C, 20.0 foot elevation, it was determined that approximately 521 parcels and 134 structures would be impacted. This number includes acquisition of the buffer zone. The acreage to be acquired for the levee is unknown. It is known that the 9 pump stations will require approximately 0.23 of an acre each for a total of 2.07 acres. Lands required for construction of the levee will be acquired in fee simple interest, and lands for the drainage ditches that will be constructed outside the levee footprint will be acquired either in easement or fee as necessary. Based on the number of structures being impacted, the assumption is that there will be 134 relocations.

Based on the footprint of Option D, 30.0 foot elevation, it was determined that approximately 561 parcels and 144 structures would be impacted. This number includes acquisition of the buffer zone. The acreage to be acquired for the levee is unknown. It is known that the 9 pump stations will require approximately 0.23 of an acre each for a total of 2.07 acres. Lands required for construction of the levee will be acquired in fee simple interest, and lands for the drainage ditches that will be constructed outside the levee footprint will be acquired either in easement or fee as necessary. Based on the number of structures being impacted, the assumption is that there will be 141 relocations.

Any modifications to the roadways and utilities will most probably need to be accomplished through a relocation contract. This will be further investigated and confirmed during PED.

An assumption is made that excavated materials from clearing, snagging, and construction of ditches, etc. will be disposed of in county owned or commercial landfills. However, In the event that the excavated material is not suitable for a landfill a disposal site will have to be acquired. Typically if disposal sites are required, this would be considered as part of the LERRD requirement. Real Estate would provide an analysis during PED to compare the cost of acquiring an upland disposal site with the cost of using a commercial landfill and make a determination which method is most cost effective.

The recommended plan proposes to use material from an inventory of upland borrow sites to construct the levee. A specific site has not been identified or confirmed for use at time of this report. Typically if borrow sites are required, this would be considered a part of the LERRD requirement. Real Estate would provide an analysis during PED to compare the cost of acquiring an upland borrow site with the cost of using a commercial borrow site and make a determination which method is most cost effective. The requirement for temporary work areas is unknown. Sponsor owned lands will be used if available. Otherwise, this may be an additional real estate requirement, and will be further defined during PED.

3.3.8.7 Utility/Facility Relocation

The plan calls for roads to be ramped over the proposed levee and possible relocation of utilities. An assumption is made that this work will be accomplished through a relocation contract. This will be further investigated and confirmed during PED. See Chapter 2 Section 2.10 for more detailed discussion.

3.3.8.8 Existing Projects/Studies

Relevant projects and studies are found in the main report at Section 1.6, History of the Investigation and Section 1.7, Prior and On-Going Studies, Reports and Programs.

3.3.8.9 Environmental Impacts

See the Main Report, Chapter 6. Environmental Effects of Plans and the Environmental Appendix, for a full discussion on environmental effects.

3.3.8.10 Project Sponsor Responsibilities and Capabilities

The State of Mississippi will be the non-Federal Project Sponsor (NFS). The NFS has the responsibility to acquire all real estate interests required for the Project. The NFS shall accomplish all alterations and relocations of facilities, structures and improvements determined by the government to be necessary for construction of the Project.

Title to any acquired real estate will be retained by the Project Sponsor and will not be conveyed to the United States Government. Prior to advertisement of any construction contract, the NFS shall furnish to the government an Authorization for Entry for Construction (Exhibit "A" to the Real Estate Appendix) to all lands, easements and rights-of-way, as necessary. The NFS will also furnish to the government evidence supporting their legal authority to grant rights-of-way to such lands. The NFS shall comply with applicable provisions of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970, Public Law 91-646, approved 2 January 1971, and amended by Title IV of the Surface Transportation Uniform Relocation Assistance Act of 1987, Public Law 100-17, effective 2 April 1989, in acquiring real estate interests for the Project, and inform all affected persons of applicable benefits, policies, and procedures in connection with said Act(s). A form for the Assessment of the Non-Federal Sponsor's Capability to Acquire Real Estate is at Exhibit "B" to the Real Estate Appendix. The assessment will be made during PED phase.

The non-Federal sponsor is entitled to receive credit against its share of project costs for the value of lands it provides and the value of the relocations that are required for the project. Generally, for the purpose of determining the amount of credit to be afforded, the value of the LER is the fair market value of the real property interest, plus certain incidental costs of acquiring those interests, that the non-federal sponsor provided for the project as required by the Government. The NFS cannot receive credit for the value of any LER, including incidental costs, which were previously provided as an item of cooperation for another Federal project, including projects that preceded enactment of WRDA 1986.

3.3.8.11 Government Owned Property

There are no known Government owned lands within the proposed project.

3.3.8.12 Historical Significance

See the Main Report, Section 3.2.9 Cultural and Archaeological Resources, for a general discussion on cultural and archaeological resources.

3.3.8.13 Mineral Rights

There are no known mineral activities within the scope of the proposed project.

3.3.8.14 Hazardous, Toxic, and Radioactive Waste (HTRW)

Due to the extent of the project, no preliminary assessment was performed to identify the possibility of hazardous waste on the sites. These studies will be conducted during the next phase of work. See Sections 3.2.8 and 6.16 of the Main Report for a discussion on HTRW.

3.3.8.15 Public Law 91-646, Relocation Assistance Benefits

The Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970 establishes a uniform policy for fair and equitable treatment of persons displaced as a result of federal and federally assisted programs in order that such persons shall not suffer disproportionate injuries as a

result of programs designed for the benefits of the public as a whole. A qualified displaced person may be entitled to certain relocation assistance benefits which include reimbursement of moving costs and a replacement housing benefit. Moving expense can be reimbursed either based on actual costs or a fixed moving cost schedule. The replacement housing payment is separated into 3 basic types - purchase supplement, rental assistance and down payment. All replacement housing must be decent, safe, and sanitary (DSS) before a replacement housing payment can be made.

It is estimated that there are approximately 62 relocations in Option A, 66 relocations in Option B, 134 relocations in Option C, and 144 relocations in Option D. No relocation plan has been completed nor has a relocation survey been done. All estimates are based on information from county public records. The number of business relocations as compared to residential relocations is unknown. In order to accomplish the relocation activity in a timely manner, the plan set forth in Chapter 2. Section 2.5 can be used.

3.3.8.16 Attitude of Property Owners

Real Estate has not interviewed property owners or tenants during the study phase for the MsCIP. However, numerous public meetings have been held at different locations throughout the study area to inform stakeholders and property owners about the study and the protective measures under consideration for the Mississippi coastal area. A number of local newspapers have published articles that discuss the MsCIP study and the perceived positive effects as well as the negative impacts that may occur as a result of the project. Some of these articles can be found on web sites. While many of the locals may welcome the benefits of the proposed project, there are some who oppose the project.

3.3.8.17 Acquisition Schedule

An acquisition schedule will be developed when plans and specifications become available and more definite information is available pertaining to the specific areas and number of parcels for acquisition. The acquisition schedule will be developed during PED and will be a joint effort of the NFS, the project manager and Real Estate. The schedule will set forth a time line for title, survey, appraisal, negotiation, preparation of documents and closing activity. After acquisition activity is completed certification of lands acquired/owned by the sponsor will be necessary prior to advertisement for construction. The Certification of Real Estate can be accomplished within 30 - 60 days after acquisition. See Chapter 2. Section 2.5. for discussion on an acquisition implementation/management plan.

3.3.8.18 Estates for Proposed Project

All lands required for the levee will be acquired in Fee Simple. Should a borrow site be required, the Borrow Easement will be used. The Temporary Work Area Easement will be used for staging or temporary work areas, and the Drainage Ditch Easement will be used as required. The estates recommended are standard estates.

FEE.

The fee simple title to (the land described in Schedule A) I/(Tracts Nos. ____, ____ and ___), subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

BORROW EASEMENT.

A (temporary) (perpetual and assignable) right and easement to clear, borrow, excavate and remove sand, soil, dirt, and other materials from (the land described in Schedule A) (Tracts Nos. _____,

_____ and _____); subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines; reserving, however, to the landowners, their heirs and assigns, all such rights and privileges in said land as may be used without interfering with or abridging the rights and easement hereby acquired.

TEMPORARY WORK AREA EASEMENT.

A temporary easement and right-of-way in, on, over and across (the land described in Schedule A) (Tracts Nos. _____, _____ and _____), for a period not to exceed ____________________, beginning with date possession of the land is granted to the Project Sponsor, for use by the Project Sponsor, its representatives, agents, and contractors as a work area, including the right to deposit backfill, move, store and remove equipment and supplies, and erect and remove temporary structures on the land and to perform any other work necessary and incident to the construction of the ____________________ Project, together with the right to trim, cut, fell and remove there from all trees, underbrush, obstructions, and any other vegetation, structures, or obstacles within the limits of the right-of-way; reserving, however, to the landowners, their heirs and assigns, all such rights and privileges as may be used without interfering with or abridging the rights and easement hereby acquired; subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

DRAINAGE DITCH EASEMENT.

A perpetual and assignable easement and right-of-way in, over and across (the land described in Schedule A) (Tracts Nos. ____, ____ and _____) to construct, maintain, repair, operate, patrol and replace a drainage ditch, reserving, however, to the owners, their heirs and assigns, all such rights and privileges in the land as may be used without interfering with or abridging the rights and easement hereby acquired; subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

3.3.8.19 Real Estate Estimate

A summary of the cost for each option is at Table 3.3.8.19-1. The real estate estimates at Tables 3.3.8.19-2 through 3.3.8.19-5 include the land cost for acquisition of land, relocation benefits to include a replacement housing payment and fixed rate move expenses, and Federal and non-Federal administrative costs. Administrative costs are those costs incurred for verifying ownership of lands, certification of those lands required for project purposes, legal opinions, analysis or other requirements that may be necessary, during PED. No cost is included for a borrow site or temporary work area. The requirement, if any, for a borrow site or temporary work area will be identified during PED. If further real estate requirements are identified during PED or if there is a significant increase in cost, a supplement to the Real Estate Appendix will be prepared. A 25% contingency is applied to the current estimate.

Table 3.3.8.19-1.
Real Estate Cost Summary

Option	Impacted Parcels	Relocations	Total Cost
Option A - 20.0	354	62	$31,458,000
Option B - 30.0	399	66	$34,051,000
Option C - 20.0	521	134	$55,002,000
Option D - 30.0	561	144	$58,603,000

Table 3.3.8.19-2.
LOD3 Jackson County Ring Levee, Gulf Park - Option A 20.0 Estimate

a. Lands and Improvements/Permits					
312 Ownerships, 60 Improvements					13,792,587
34 Ownerships for Ditches, 2 Improvements					897,419
8 Pump Stations					310,067
354 Ownerships				Subtotal	15,000,073
b. Mineral Rights					0
c. Damages					0
d. P.L. 91-646 Relocation costs - 62 relocations					1,736,000
e. Administrative Cost					8,430,000
		Relocation	Acquisition	Total	
	Federal	93,000	885,000	978,000	
	Non-Federal	372,000	7,080,000	7,452,000	
		465,000	7,965,000	8,430,000	
Sub-Total					25,166,073
Contingencies (25%)					6,291,518
	Totals				**31,457,591**
	Rounded				**31,458,000**

Table 3.3.8.19-3.
LOD3 Jackson County Ring Levee, Gulf Park - Option B 30.0 Estimate

a. Lands and Improvements/Permits					
357 Ownerships for Levee, 64 Improvements					14,712,847
34 Ownerships for Ditches, 2 Improvements					897,419
8 Pump Stations					310,067
399 Ownerships				Subtotal	15,920,333
b. Mineral Rights					0
c. Damages					0
d. P.L. 91-646 Relocation costs - 66 relocations					1,848,000
e. Administrative Cost					9,472,500
		Relocation	Acquisition	Total	
	Federal	99,000	997,500	1,096,500	
	Non-Federal	396,000	7,980,000	8,376,000	
		495,000	8,977,500	9,472,500	
Sub-Total					27,240,833
Contingencies (25%)					6,810,208
	Totals				**34,051,041**
	Rounded				**34,051,000**

Table 3.3.8.19-4.
LOD3 Jackson County Ring Levee, Gulf Park - Option C, Alternate Alignment, Elevation 20.0 Estimate

a. Lands and Improvements/Permits					
365 Ownerships for Levee, 121 Improvements					23,289,789
113 Ownerships for Buffer, 11 Improvements					2,969,418
34 Ownerships for Ditches, 2 Improvements					897,419
9 Ownerships for Pump Stations					348,825
521 Ownerships				Subtotal	27,505,451
b. Mineral Rights					0
c. Damages					0
d. P.L. 91-646 Relocation costs - 134 relocations					3,768,800
e. Administrative Cost					12,727,500
	Relocation	Acquisition	Total		
Federal	201,000	1,302,500	1,503,500		
Non-Federal	804,000	10,420,000	11,224,000		
	1,005,000	11,722,500	12,727,500		
Sub-Total					44,001,751
Contingencies (25%)					11,000,438
Totals					**55,002,189**
Rounded					**55,002,000**

Table 3.3.8.19-5.
LOD3 Jackson County Ring Levee, Gulf Park - Option D Alternate Alignment
Elevation 30.0 Estimate

a. Lands and Improvements/Permits				
418 Ownerships for Levee, 135 Improvements				25,624,634
100 Ownerships for Buffer, 7 Improvements				2,271,308
34 Ownerships for Ditches, 2 Improvements				897,419
9 Ownerships for Pump Stations				348,825
561 Ownerships			Subtotal	29,142,186
b. Mineral Rights				0
c. Damages				0
d. P.L. 91-646 Relocation costs - 144 relocations				4,037,600
e. Administrative Cost				13,702,500
	Relocation	Acquisition	Total	
Federal	216,000	1,402,500	1,618,500	
Non-Federal	864,000	11,220,000	12,084,000	
	1,080,000	12,622,500	13,702,500	
Sub-Total				46,882,286
Contingencies (25%)				11,720,572
Totals				**58,602,858**
Rounded				**58,603,000**

3.3.8.20 Summary of Potential Real Estate Issues

The requirement for temporary work areas, disposal or borrow areas has not been identified. Should these areas be required, these would be considered as part of the LERRD requirements. Typically if disposal or borrow sites are required, Real estate would provide an analysis during PED to compare the cost of acquiring an these sites with the cost of using a commercial sites and make a determination which method is most cost effective. See Section 2.8 Borrow Areas on page 5.

Should drainage ditches, temporary work areas, disposal or borrow areas become a necessary real estate acquisition requirement, valuation of lands will be performed. Land costs associated with these areas, and administrative costs will be added to the Real Estate Cost Estimate. If further real estate requirements are identified during PED or if there is a significant increase in cost, a supplement to the Real Estate Appendix will be prepared.

Any requirements for relocation contracts pertaining to facilities/utilities will be identified and completed during PED.

Any requirement for mitigation lands will be identified during PED.

Should condemnation of any required real estate interest be necessary, it is the responsibility of the NFS. This issue is addressed during the Assessment of the Non-Federal Sponsor's Real Estate

Acquisition Capability. However, if the real estate interest is one that the NFS does not have authority to condemn, the Federal Government can perform the condemnation on behalf of the NFS.

A relocation plan will need to be completed during PED to address potential relocation activity under P.L. 91-646. There are a number of factors pertaining to relocations that can impact the project both in cost and in schedule. Payments for Housing of Last Resort, which would exceed the standard housing replacement payments, are very likely due to the size of the project and the lack of available decent, safe and sanitary housing in the area. Another factor that could increase cost and impact schedule is the cost of business relocations. Depending on the type of business and the operation, this could involve moving equipment and machinery to new locations. It is necessary to interview each impacted individual and business during Pre-Construction, Engineering and Design Phase to determine the requirements for relocation and to estimate a cost for the relocation.

3.3.8.21 Chart of Accounts

The cost estimate for all Federal and non-Federal real estate activities necessary for implementation of the project after completion of the feasibility study for land acquisition, construction, LERRD, and other items are coded as delineated in the Cost Work Breakdown Structure (CWBS). This real estate cost estimate is then incorporated into the Total Current Working Estimate utilizing the Microcomputer Aided Cost Engineering System (MCACES). The Chart of Accounts at Tables 3.3.8.21-1 through 3.3.8.21-4 shows the CWBS for real estate activities.

Table 3.3.8.21-1.
Chart of Accounts - LOD3 Jackson County Ring Levee, Gulf Park - Option A

01A	Project Planning	Federal	Non-Federal	Totals
	Other			
	Project Cooperation Agreement			
01AX	Contingencies (25%)			
	Subtotal			
01B	Lands and Damages/Permits			
01B40	Acquisition/Review of NFS	885,000		885,000
01B20	Acquisition by NFS		7,080,000	7,080,000
01BX	Contingencies (25%)	221,250	1,770,000	1,991,250
	Subtotal	1,106,250	8,850,000	9,956,250
01F	PL 91-646 Assistance			
01F20	By NFS		372,000	372,000
01FX	Contingencies (25%)		93,000	93,000
	Subtotal		465,000	465,000
01R	Real Estate Land Payments			
01R1B	Land Payments by NFS		15,000,073	15,000,073
01R2B	PL91-646 Relocation Payment by NFS		1,736,000	1,736,000
01R2D	Review of NFS	93,000		93,000
01RX	Contingencies (25%)	23,250	4,184,018	4,207,268
	Subtotal	116,250	20,920,091	21,036,341
	Totals	**1,222,500**	**30,235,091**	**31,457,591**
	Rounded			**31,458,000**

Table 3.3.8.21-2.
Chart of Accounts - LOD3 Jackson County Ring Levee, Gulf Park - Option B

01A	Project Planning	Federal	Non-Federal	Totals
	Other			
	Project Cooperation Agreement			
01AX	Contingencies (25%)			
	Subtotal			
01B	Lands and Damages/Permits			
01B40	Acquisition/Review of NFS	997,500		997,500
01B20	Acquisition by NFS		7,980,000	7,980,000
01BX	Contingencies (25%)	249,375	1,995,000	2,244,375
	Subtotal	1,246,875	9,975,000	11,221,875
01F	PL 91-646 Assistance			
01F20	By NFS		396,000	396,000
01FX	Contingencies (25%)		99,000	99,000
	Subtotal		495,000	495,000
01R	Real Estate Land Payments			
01R1B	Land Payments by NFS		15,920,333	15,920,333
01R2B	PL91-646 Relocation Payment by NFS		1,848,000	1,848,000
01R2D	Review of NFS	99,000		99,000
01RX	Contingencies (25%)	24,750	4,442,083	4,466,833
	Subtotal	123,750	22,210,416	22,334,166
	Totals	**1,370,625**	**32,680,416**	**34,051,041**
	Rounded			**34,051,000**

Table 3.3.8.21-3.
Chart of Accounts - LOD3 Jackson County Ring Levee, Gulf Park - Option C Alternate Alignment

01A	Project Planning	Federal	Non-Federal	Totals
	Other			
	Project Cooperation Agreement			
01AX	Contingencies (25%)			
	Subtotal			
01B	Lands and Damages/Permits			
01B40	Acquisition/Review of NFS	1,302,500		1,302,500
01B20	Acquisition by NFS		10,420,000	10,420,000
01BX	Contingencies (25%)	325,625	2,605,000	2,930,625
	Subtotal	1,628,125	13,025,000	14,653,125
01F	PL 91-646 Assistance			
01F20	By NFS		804,000	804,000
01FX	Contingencies (25%)		201,000	201,000
	Subtotal		1,005,000	1,005,000
01R	Real Estate Land Payments			
01R1B	Land Payments by NFS		27,505,451	27,505,451
01R2B	PL91-646 Relocation Payment by NFS		3,768,800	3,768,800
01R2D	Review of NFS	201,000		201,000
01RX	Contingencies (25%)	50,250	7,818,563	7,868,813
	Subtotal	251,250	39,092,814	39,344,064
	Totals	**1,879,375**	**53,122,814**	**55,002,189**
	Rounded			**55,002,000**

Table 3.3.8.21-4.
Chart of Accounts - LOD3 Jackson County Ring Levee, Gulf Park - Option D Alternate Alignment

01A	Project Planning	Federal	Non-Federal	Totals
	Other			
	Project Cooperation Agreement			
01AX	Contingencies (25%)			
	Subtotal			
01B	Lands and Damages/Permits			
01B40	Acquisition/Review of NFS	1,402,500		1,402,500
01B20	Acquisition by NFS		11,220,000	11,220,000
01BX	Contingencies (25%)	350,625	2,805,000	3,155,625
	Subtotal	1,753,125	14,025,000	15,778,125
01F	PL 91-646 Assistance			
01F20	By NFS		864,000	864,000
01FX	Contingencies (25%)		216,000	216,000
	Subtotal		1,080,000	1,080,000
01R	Real Estate Land Payments			
01R1B	Land Payments by NFS		29,142,186	29,142,186
01R2B	PL91-646 Relocation Payment by NFS		4,037,600	4,037,600
01R2D	Review of NFS	216,000		216,000
01RX	Contingencies (25%)	54,000	8,294,947	8,348,947
	Subtotal	270,000	41,474,733	41,744,733
	Totals	**2,023,125**	**56,579,733**	**58,602,858**
	Rounded			**58,603,000**

3.3.9 Jackson County Ring Levees, Belle Fontaine

Several high density residential and business areas in Jackson County were identified. They are Ocean Springs, Gulf Park, Belle Fontaine, Gautier, and Pascagoula/Moss Point. The subdivision of Belle Fontaine is located just west of Gautier along the gulf coast on Mississippi Sound. The location of the Belle Fontaine ring levee is shown in Figure 3.3.9-1. The northeastern part of the subdivision is near elevation 10-14 feet NAVD88 and very flat. Ground elevations over the southwestern part of the area vary between elevations 16-20 feet NAVD88. These areas are subject to damage from storm surges associated with hurricanes. For purposes of providing protection for future storm events, the construction of an earthen ring levee is evaluated. The options in this study are identified as Option A, Option B, Option C and Option D. The levees were evaluated at elevations 20 ft NAVD88 and 30 ft NAVD88. The top width was assumed 15 ft with side slopes of 1 vertical to 3 horizontal.

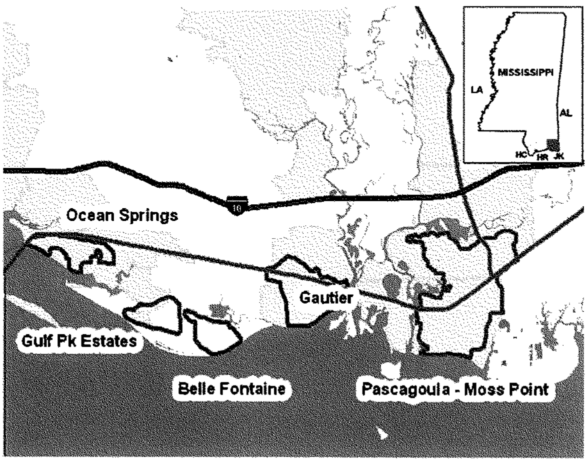

Figure 3.3.9-1.
Vicinity Map, Belle Fontaine

3.3.9.1 Option A - Elevation 20.0 ft NAVD88

This option consists of an earthen dike around the subdivision of Belle Fontaine along with the internal sub-basins and levee culvert/pump locations. The levee would have an elevation of 20.0 feet with a top width of 15 ft and slopes of 1 vertical to 3 horizontal.

3.3.9.2 Option B - Elevation 30.0 ft NAVD88

The alignment of the levee is the same as Option A, above but with an elevation of 30.0 feet. The only difference between the description of this option and preceding description of Option A is the height of the levee, pumping facilities, number of roadway and railroad intersections, and the length of the levee culverts.

3.3.9.3 Option C - Alternate Alignment, Elevation 20.0 ft NAVD88

Option C consists of an earthen levee at elevation 20.0 feet in an alignment slightly different from the alignment for Options A and B. Additionally, the lands that lay between the alignment of Option A and the alternate alignment Option C will be acquired as a buffer zone in this option.

3.3.9.4 Option D - Alternate Alignment, Elevation 30.0 ft NAVD88

The alignment of the levee is the same as Option C, above but with an elevation of 30.0 feet. The only difference between the description of this option and preceding description of Option C is the height of the levee, pumping facilities, number of roadway and railroad intersections, and the length of the levee culverts. As above, the buffer zone lands will be acquired.

3.3.9.5 *Project Description*

Figure 3.3.9.5-1 shows the location of the proposed project alternatives with the alternate alignment representing Options C and D. As described above, the levee will be an earthen berm constructed either at elevation 20.0 feet or 30.0 feet along with the internal sub-basins and levee culvert/pump locations. Drainage on the interior of the ring levee would be collected at the levee and channeled to culverts placed in the levee. 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. In addition, pumps would be constructed near the outflow points to remove water from the interior during storm events occurring when the culverts are closed because of high water in the sound. Drainage ditches along the toe of the levee will be required to assure that smaller basins can be drained to a culvert/pump site. Figure 3.3.9.5-2 shows the proposed location of the pump/culvert sites. 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. Further studies will detail the requirement for the appropriate ponding areas, pump sizes, or buyouts in the affected areas.

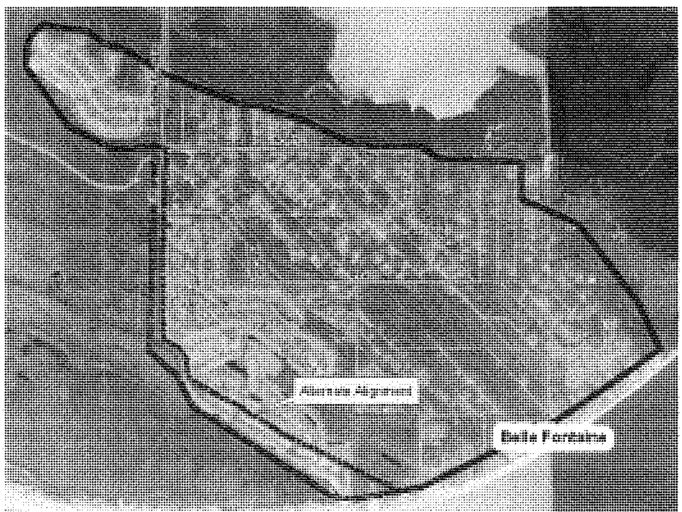

Figure 3.3.9.5-1.
Belle Fontaine Ring Levee

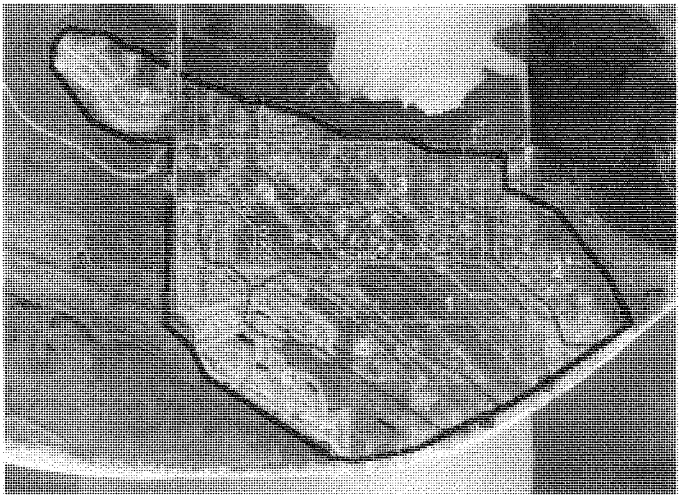

Figure 3.3.9.5-2.
Pump/Culvert/Sub-basin Site Locations

The inland barrier earthen levee section will have one vertical to three horizontal side slopes with a fifteen foot crest width. All work areas to receive fill shall be cleared and grubbed of all trees and surface organics and all existing foundations, streets, utilities, etc. will be removed and the subsequent cavities backfilled and compacted. The levee will be constructed of sand clay materials obtained from off site commercial sources, and trucked to the work area. The final surface will be armored by the placement of 24 inch thick gabion mattress filled with small stone for erosion protection during an event that overtops the levee. The armoring will be anchored on the front face by trenching and extend across the downstream slope and a 25 foot area beyond the toe. The front side of the levee and all non critical surface areas will be subsequently covered by grassing. In order to maintain the natural runoff patterns culverts would be inserted through the protection line at appropriate locations. For this study these were configured as cast-in-place reinforced concrete box structures fitted with flap gates to minimize normal backflows and sluice gates to provide storm closure when needed. Pump facilities are required at 7 locations.

Road crossings will incorporate small gate structures or ramping over the embankment where the surface elevation is near that of the crest elevation. The elevation relationship of the crest and the adjacent railroad will be a governing factor. At each point where a roadway crosses the protection line the decision must be made whether to maintain this artery and adapt the protection line to accommodate it, or to terminate the artery at the protection line and divert traffic to cross the protection line at another location. For this study it was assumed that all roadways and railways crossing the levee alignment would be retained except where it was very evident that traffic could be combined without undue congestion. Once the decision has been made to retain a particular roadway, it must then be determined how best to configure the artery to conduct traffic across the protection line. The simplest means of passing roadway traffic is to ramp the roadway over the protection line. This alternative is not always viable because of severe right-of-way restraints caused

by extreme levee height, urban congestion, etc. In such instances other methods can be used including partial ramping in combination with low profile roller gates. In more restricted areas full height gates which would leave the roadway virtually unaltered might be preferable, even though this alternative would usually be more costly than ramping. In some extreme circumstances where high levees are required to pass through very congested areas, installation of tunnels with closure gates may be required.

Because of the extreme gradient restrictions necessarily placed on railway construction, it is practically never acceptable to elevate a railway up and over a levee. Therefore, the available alternatives would include gated pass through structures. Because of the vertical clearance requirements of railroad traffic all railroad pass through structures for this study were configured having vertical walls on either side of the railway with double swing gates extending to the full height of the levee.

With the installation of a ring levee around Belle Fontaine at Option A, elevation 20.0, 10 roadway intersections would have to be accommodated. For this study it was estimated that 5 roller gate structures and 5 swing gate structures would be required. At Option B, elevation 30.0, 13roadway intersections would have to be accommodated, and it was estimated that all 13 would require swing gate structures. At Option C, elevation 20.0, 13 roadway intersections would have to be accommodated and it was estimated that 5 of these would require swing gate structures with the remaining five requiring roller gates of varying heights. At Option D, elevation 30.0, 11 roadway intersections would have to be accommodated and it was estimated that all 11 would require swing gate structures.

Operation and maintenance activities for this project will be required on an annual basis. All pumps and gates will be operated to assure proper working order. Debris and shoaled sediment will be removed. Vegetation on the levees will be cut to facilitate inspection and to prevent roots from causing weak levee locations. Rills will be filled and damaged revetment will be repaired.

3.3.9.6 Real Estate Requirements

Real Estate requirements for Line of Defense 3, Belle Fontaine Ring Levee include lands, easements, rights-of-way and relocations, and disposal/borrow areas (LERRD), and the right to acquire buffer zone lands, construct an earthen levee, drainage ditches and 7 culvert/pump station facilities.

Based on the footprint of Option A, 20.0 foot elevation, it was determined that approximately 228 parcels and 30 structures would be impacted. The acreage to be acquired for the levee is unknown. It is known that the 7 pump stations will require approximately 0.23 of an acre each for a total of 1.61 acres. Lands required for construction of the levee will be acquired in fee simple interest. Based on the number of structures being impacted, the assumption is that there will be 30 relocations.

Based on the footprint of Option B, 30.0 foot elevation, it was determined that 297 parcels and 38 structures are impacted. The acreage to be acquired for the levee is unknown. It is known that the 7 pump stations would require approximately 0.23 of an acre each for a total of 1.61 acres. Lands required for construction of the levee will be acquired in fee simple interest. Based on the number of structures being impacted, the assumption is that there will be 28 relocations.

Based on the footprint of Option C, 20.0 foot elevation, it was determined that 286 parcels and 45 structures would be impacted. This number includes acquisition of the buffer zone lands. The acreage to be acquired for the levee is unknown. It is known that the 7 pump stations will require approximately 0.23 of an acre each for a total of 1.61 acres. Lands required for construction of the levee will be acquired in fee simple interest. Based on the number of structures being impacted, the assumption is that there will be 45 relocations.

Based on the footprint of Option D, 30.0 foot elevation, it was determined that 359 parcels and 54 structures would be impacted. This includes acquisition of the buffer zone lands. The acreage to be acquired for the levee is unknown. It is known that the 7 pump stations will require approximately 0.23 of an acre each for a total of 1.61 acres. Lands required for construction of the levee will be acquired in fee simple interest. Based on the number of structures being impacted, the assumption is that there will be 54 relocations.

Ditches that will be constructed to provide drainage for the interior of the ring levee are expected to be located within the footprint of the levee. Until final plans and specifications are completed, an assumption is made that the ditches will be constructed on the same lands acquired for construction of the levee. If any additional lands are required, this will be determined during PED.

Any modifications to the roadways and utilities will most probably need to be accomplished through a relocation contract. This will be further investigated and confirmed during PED.

An assumption is made that excavated materials from clearing, snagging, and construction of ditches, etc. will be disposed of in county owned or commercial landfills. However, In the event that the excavated material is not suitable for a landfill a disposal site will have to be acquired. Typically if disposal sites are required, this would be considered as part of the LERRD requirement. Real Estate would provide an analysis during PED to compare the cost of acquiring an upland disposal site with the cost of using a commercial landfill and make a determination which method is most cost effective.

The recommended plan proposes to use material from an inventory of upland borrow sites to construct the levee. A specific site has not been identified or confirmed for use at time of this report. Typically if borrow sites are required, this would be considered a part of the LERRD requirement. Real Estate would provide an analysis during PED to compare the cost of acquiring an upland borrow site with the cost of using a commercial borrow site and make a determination which method is most cost effective. The requirement for temporary work areas is unknown. Sponsor owned lands will be used if available. Otherwise, this may be an additional real estate requirement, and will be further defined during PED.

3.3.9.7 Utility/Facility Relocation

The plan calls for roads to be ramped over the proposed levee and possible relocation of utilities. An assumption is made that this work will be accomplished through a relocation contract. This will be further investigated and confirmed during PED. See Chapter 2 Section 2.10 for more detailed discussion.

3.3.9.8 Existing Projects/Studies

Relevant projects and studies are found in the main report at Section 1.6, History of the Investigation and Section 1.7, Prior and On-Going Studies, Reports and Programs.

3.3.9.9 Environmental Impacts

See the Main Report, Chapter 6. Environmental Effects of Plans and the Environmental Appendix, for a full discussion on environmental effects.

3.3.9.10 Project Sponsor Responsibilities and Capabilities

The State of Mississippi will be the non-Federal Project Sponsor (NFS). The NFS has the responsibility to acquire all real estate interests required for the Project. The NFS shall accomplish all alterations and relocations of facilities, structures and improvements determined by the government to be necessary for construction of the Project.

Title to any acquired real estate will be retained by the Project Sponsor and will not be conveyed to the United States Government. Prior to advertisement of any construction contract, the NFS shall furnish to the government an Authorization for Entry for Construction (Exhibit "A" to the Real Estate Appendix) to all lands, easements and rights-of-way, as necessary. The NFS will also furnish to the government evidence supporting their legal authority to grant rights-of-way to such lands. The NFS shall comply with applicable provisions of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970, Public Law 91-646, approved 2 January 1971, and amended by Title IV of the Surface Transportation Uniform Relocation Assistance Act of 1987, Public Law 100-17, effective 2 April 1989, in acquiring real estate interests for the Project, and inform all affected persons of applicable benefits, policies, and procedures in connection with said Act(s). A form for the Assessment of the Non-Federal Sponsor's Capability to Acquire Real Estate is at Exhibit "B" to the Real Estate Appendix. The assessment will be made during PED phase.

The non-Federal sponsor is entitled to receive credit against its share of project costs for the value of lands it provides and the value of the relocations that are required for the project. Generally, for the purpose of determining the amount of credit to be afforded, the value of the LER is the fair market value of the real property interest, plus certain incidental costs of acquiring those interests, that the non-federal sponsor provided for the project as required by the Government. The NFS cannot receive credit for the value of any LER, including incidental costs, which were previously provided as an item of cooperation for another Federal project, including projects that preceded enactment of WRDA 1986.

3.3.9.11 Government Owned Property

There are no known Government owned lands within the proposed project.

3.3.9.12 Historical Significance

See the Main Report, Section 3.2.9 Cultural and Archaeological Resources, for a general discussion on cultural and archaeological resources.

3.3.9.13 Mineral Rights

There are no known mineral activities within the scope of the proposed project.

3.3.9.14 Hazardous, Toxic, and Radioactive Waste (HTRW)

Due to the extent of the project, no preliminary assessment was performed to identify the possibility of hazardous waste on the sites. These studies will be conducted during the next phase of work. See Sections 3.2.8 and 6.16 of the Main Report for a discussion on HTRW.

3.3.9.15 Public Law 91-646, Relocation Assistance Benefits

The Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970 establishes a uniform policy for fair and equitable treatment of persons displaced as a result of federal and federally assisted programs in order that such persons shall not suffer disproportionate injuries as a

result of programs designed for the benefits of the public as a whole. A qualified displaced person may be entitled to certain relocation assistance benefits which include reimbursement of moving costs and a replacement housing benefit. Moving expense can be reimbursed either based on actual costs or a fixed moving cost schedule. The replacement housing payment is separated into 3 basic types - purchase supplement, rental assistance and down payment. All replacement housing must be decent, safe, and sanitary (DSS) before a replacement housing payment can be made.

It is estimated that there are approximately 30 relocations in Option A, 38 relocations in Option B, 45 relocations in Option C, and 54 relocations in Option D. No relocation plan has been completed nor has a relocation survey been done. All estimates are based on information from county public records. The number of business relocations as compared to residential relocations is unknown. In order to accomplish the relocation activity in a timely manner, the plan set forth in Chapter 2. Section 2.5 can be used.

3.3.9.16 Attitude of Property Owners

Real Estate has not interviewed property owners or tenants during the study phase for the MsCIP. However, numerous public meetings have been held at different locations throughout the study area to inform stakeholders and property owners about the study and the protective measures under consideration for the Mississippi coastal area. A number of local newspapers have published articles that discuss the MsCIP study and the perceived positive effects as well as the negative impacts that may occur as a result of the project. Some of these articles can be found on web sites. While many of the locals may welcome the benefits of the proposed project, there are some who oppose the project.

3.3.9.17 Acquisition Schedule

An acquisition schedule will be developed when plans and specifications become available and more definite information is available pertaining to the specific areas and number of parcels for acquisition. The acquisition schedule will be developed during PED and will be a joint effort of the NFS, the project manager and Real Estate. The schedule will set forth a time line for title, survey, appraisal, negotiation, preparation of documents and closing activity. After acquisition activity is completed certification of lands acquired/owned by the sponsor will be necessary prior to advertisement for construction. The Certification of Real Estate can be accomplished within 30 - 60 days after acquisition. See Chapter 2. Section 2.5. for discussion on an acquisition implementation/management plan.

3.3.9.18 Estates for Proposed Project

All lands required for the levee will be acquired in Fee Simple. Should a borrow site be required, the Borrow Easement will be used. The Temporary Work Area Easement will be used for staging or temporary work areas and the Drainage Ditch Easement will be used as required. The estates recommended are standard estates.

FEE.

The fee simple title to (the land described in Schedule A) I/(Tracts Nos. ____, ____ and ___), subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

BORROW EASEMENT.

A (temporary) (perpetual and assignable) right and easement to clear, borrow, excavate and remove sand, soil, dirt, and other materials from (the land described in Schedule A) (Tracts Nos. _____,

_____ and _____); subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines; reserving, however, to the landowners, their heirs and assigns, all such rights and privileges in said land as may be used without interfering with or abridging the rights and easement hereby acquired.

TEMPORARY WORK AREA EASEMENT.

A temporary easement and right-of-way in, on, over and across (the land described in Schedule A) (Tracts Nos. _____, _____ and _____), for a period not to exceed ___________________, beginning with date possession of the land is granted to the Project Sponsor, for use by the Project Sponsor, its representatives, agents, and contractors as a work area, including the right to deposit backfill, move, store and remove equipment and supplies, and erect and remove temporary structures on the land and to perform any other work necessary and incident to the construction of the ___________________ Project, together with the right to trim, cut, fell and remove there from all trees, underbrush, obstructions, and any other vegetation, structures, or obstacles within the limits of the right-of-way; reserving, however, to the landowners, their heirs and assigns, all such rights and privileges as may be used without interfering with or abridging the rights and easement hereby acquired; subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

DRAINAGE DITCH EASEMENT.

A perpetual and assignable easement and right-of-way in, over and across (the land described in Schedule A) (Tracts Nos. ____, ____ and _____) to construct, maintain, repair, operate, patrol and replace a drainage ditch, reserving, however, to the owners, their heirs and assigns, all such rights and privileges in the land as may be used without interfering with or abridging the rights and easement hereby acquired; subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

3.3.9.19 Real Estate Estimate

A summary of the cost for each option is at Table 3.3.9.19-1. The real estate estimates at Tables 3.3.9.19-2 through 3.3.9.19-5 include the land cost for acquisition of land, relocation benefits to include a replacement housing payment and fixed rate move expenses, and Federal and non-Federal administrative costs. Administrative costs are those costs incurred for verifying ownership of lands, certification of those lands required for project purposes, legal opinions, analysis or other requirements that may be necessary, during PED. No cost is included for a borrow site or temporary work area. The requirement, if any, for a borrow site or temporary work area will be identified during PED. If further real estate requirements are identified during PED or if there is a significant increase in cost, a supplement to the Real Estate Appendix will be prepared. A 25% contingency is applied to the current estimate.

Table 3.3.9.19-1.
Real Estate Cost Summary

Option	Impacted Parcels	Relocations	Total Cost
Option A - 20.0	228	30	$19,366,000
Option B - 30.0	297	38	$25,774,000
Option C - 20.0	286	45	$26,711,000
Option D - 30.0	359	54	$33,260,000

Table 3.3.9.19-2.
LOD3 Jackson County Ring Levee, Belle Fontaine - Option A 20.0 Estimate

a. Lands and Improvements/Permits				
221 Ownerships for Levee, 30 Improvements				9,015,200
7 Pump Stations				271,308
228 Ownerships				
			Subtotal	9,286,508
b. Mineral Rights				0
c. Damages				0
30 relocations				
d. P.L. 91-646 Relocation costs – 30 relocations				851,200
e. Administrative Cost				5,355,000
	Relocation	Acquisition	Total	
Federal	45,000	570,000	615,000	
Non-Federal	180,000	4,560,000	4,740,000	
	225,000	5,130,000	5,355,000	
Subtotal				15,492,708
Contingencies (25%)				3,873,177
Totals				**19,365,885**
Rounded				**19,366,000**

Table 3.3.9.19-3.
LOD3 Jackson County Ring Levee, Belle Fontaine - Option B 30.0 Estimate

a. Lands and Improvements/Permits				
290 Ownerships for Levee, 38 Improvements				12,327,474
7 Pump Stations				271,308
297 Ownerships			Subtotal	12,598,782
b. Mineral Rights				0
c. Damages				0
d. P.L. 91-646 Relocation costs – 38 relocations				1,052,800
e. Administrative Cost				6,967,500
	Relocation	Acquisition	Total	
Federal	57,000	742,500	799,500	
Non-Federal	228,000	5,940,000	6,168,000	
	285,000	6,682,500	6,967,500	
Subtotal				20,619,082
Contingencies (25%)				5,154,771
Totals				**25,773,853**
Rounded				**25,774,000**

Table 3.3.9.19-4.
LOD3 Jackson County Ring Levee, Belle Fontaine - Option C Alternate Alignment, Elevation 20.0 Estimate

a. Lands and Improvements/Permits				
251 Ownerships for Levee, 43 Improvements				11,442,807
28 Ownerships for Buffer, 2 Improvements				1,314,250
7 Ownerships for Pump Stations				271,308
286 Ownerships			Subtotal	13,028,365
b. Mineral Rights				0
c. Damages				0
d. P.L. 91-646 Relocation costs - 45 relocations				1,568,000
e. Administrative Cost				6,772,500
	Relocation	Acquisition	Total	
Federal	67,500	715,000	782,500	
Non-Federal	270,000	5,720,000	5,990,000	
	337,500	6,435,000	6,772,500	
Sub-Total				21,368,865
Contingencies (25%)				5,342,216
Totals				**26,711,081**
Rounded				**26,711,000**

Table 3.3.9.19-5.
LOD3 Jackson County Ring Levee, Belle Fontaine - Option D Alternate Alignment, Elevation 30.0 Estimate

a. Lands and Improvements/Permits				
335 Ownerships for Levee, 54 Improvements				15,586,002
17 Ownerships for Buffer, 0 Improvements				745,255
7 Ownerships for Pump Stations				271,308
359 Ownerships			Subtotal	16,602,565
b. Mineral Rights				0
c. Damages				0
d. P.L. 91-646 Relocation costs - 54 relocations				1,523,200
e. Administrative Cost				8,482,500
	Relocation	Acquisition	Total	
Federal	81,000	897,500	978,500	
Non-Federal	324,000	7,180,000	7,504,000	
	405,000	8,077,500	8,482,500	
Sub-Total				26,608,265
Contingencies (25%)				6,652,066
Totals				**33,260,331**
Rounded				**33,260,000**

3.3.9.20 Summary of Potential Real Estate Issues

The requirement for temporary work areas, disposal or borrow areas has not been identified. Should these areas be required, these would be considered as part of the LERRD requirements. Typically if disposal or borrow sites are required, Real estate would provide an analysis during PED to compare the cost of acquiring an these sites with the cost of using a commercial sites and make a determination which method is most cost effective. See Section 2.8 Borrow Areas on page 5.

Should drainage ditches, temporary work areas, disposal or borrow areas become a necessary real estate acquisition requirement, valuation of lands will be performed. Land costs associated with these areas, and administrative costs will be added to the Real Estate Cost Estimate. If further real estate requirements are identified during PED or if there is a significant increase in cost, a supplement to the Real Estate Appendix will be prepared.

Any requirements for relocation contracts pertaining to facilities/utilities will be identified and completed during PED.

Any requirement for mitigation lands will be identified during PED.

Should condemnation of any required real estate interest be necessary, it is the responsibility of the NFS. This issue is addressed during the Assessment of the Non-Federal Sponsor's Real Estate Acquisition Capability. However, if the real estate interest is one that the NFS does not have authority to condemn, the Federal Government can perform the condemnation on behalf of the NFS.

A relocation plan will need to be completed during PED to address potential relocation activity under P.L. 91-646. There are a number of factors pertaining to relocations that can impact the project both in cost and in schedule. Payments for Housing of Last Resort, which would exceed the standard housing replacement payments, are very likely due to the size of the project and the lack of available decent, safe and sanitary housing in the area. Another factor that could increase cost and impact schedule is the cost of business relocations. Depending on the type of business and the operation, this could involve moving equipment and machinery to new locations. It is necessary to interview each impacted individual and business during Pre-Construction, Engineering and Design Phase to determine the requirements for relocation and to estimate a cost for the relocation.

3.3.9.21 Chart of Accounts

The cost estimate for all Federal and non-Federal real estate activities necessary for implementation of the project after completion of the feasibility study for land acquisition, construction, LERRD, and other items are coded as delineated in the Cost Work Breakdown Structure (CWBS). This real estate cost estimate is then incorporated into the Total Current Working Estimate utilizing the Microcomputer Aided Cost Engineering System (MCACES). The Chart of Accounts at Tables 3.3.9.21-1 through 3.3.9.21-4 shows the CWBS for real estate activities.

Table 3.3.9.21-1.
Chart of Accounts - LOD3 Jackson County Ring Levee, Belle Fontaine - Option A

01A	Project Planning	Federal	Non-Federal	Totals
	Other			
	Project Cooperation Agreement			
01AX	Contingencies (25%)			
	Subtotal			
01B	Lands and Damage/Permits			
01B40	Acquisition/Review of NFS	570,000		570,000
01B20	Acquisition by NFS		4,560,000	4,560,000
01BX	Contingencies (25%)	142,500	1,140,000	1,282,500
	Subtotal	712,500	5,700,000	6,412,500
01F	PL 91-646 Assistance			
01F20	By NFS		180,000	180,000
01FX	Contingencies (25%)		45,000	45,000
	Subtotal		225,000	225,000
01R	Real Estate Land Payments			
01R1 B	Land Payments by NFS		9,286,508	9,286,508
01R2 B	PL91-646 Relocation Payment by NFS		851,200	851,200
01R2 D	Review of NFS	45,000		45,000
01RX	Contingencies (25%)	11,250	2,534,427	2,545,677
	Subtotal	56,250	12,672,135	12,728,385
	Totals	**768,750**	**18,597,135**	**19,365,885**
	Rounded			**19,366,000**

Table 3.3.9.21-2.

Chart of Accounts - LOD3 Jackson County Ring Levee, Belle Fontaine - Option B

01A	Project Planning	Federal	Non-Federal	Totals
	Other			
	Project Cooperation Agreement			
01AX	Contingencies (25%)			
	Subtotal			
01B	Lands and Damage/Permits			
01B40	Acquisition/Review of NFS	742,500		742,500
01B20	Acquisition by NFS		5,940,000	5,940,000
01BX	Contingencies (25%)	185,625	1,485,000	1,670,625
	Subtotal	928,125	7,425,000	8,353,125
01F	PL 91-646 Assistance			
01F20	By NFS		228,000	228,000
01FX	Contingencies (25%)		57,000	57,000
	Subtotal		285,000	285,000
01R	Real Estate Land Payments			
01R1 B	Land Payments by NFS		12,598,782	12,598,782
01R2 B	PL91-646 Relocation Payment by NFS		1,052,800	1,052,800
01R2 D	Review of NFS	57,000		57,000
01RX	Contingencies (25%)	14,250	3,412,896	3,427,146
	Subtotal	71,250	17,064,478	17,135,728
	Totals	**999,375**	**24,774,478**	**25,773,853**
	Rounded			**25,774,000**

Table 3.3.9.21-3.
Chart of Accounts - LOD3 Jackson County Ring Levee, Belle Fontaine - Option C Alternate Alignment

01A	Project Planning	Federal	Non-Federal	Totals
	Other			
	Project Cooperation Agreement			
01AX	Contingencies (25%)			
	Subtotal			
01B	Lands and Damages/Permits			
01B40	Acquisition/Review of NFS	715,000		715,000
01B20	Acquisition by NFS		5,720,000	5,720,000
01BX	Contingencies (25%)	178,750	1,430,000	1,608,750
	Subtotal	893,750	7,150,000	8,043,750
01F	PL 91-646 Assistance			
01F20	By NFS		270,000	270,000
01FX	Contingencies (25%)		67,500	67,500
	Subtotal		337,500	337,500
01R	Real Estate Land Payments			
01R1B	Land Payments by NFS		13,028,365	13,028,365
01R2B	PL91-646 Relocation Payment by NFS		1,568,000	1,568,000
01R2D	Review of NFS	67,500		67,500
01RX	Contingencies (25%)	16,875	3,649,091	3,665,966
	Subtotal	84,375	18,245,456	18,329,831
	Totals	**978,125**	**25,732,956**	**26,711,081**
	Rounded			**26,711,000**

Table 3.3.9.21-4.
Chart of Accounts - LOD3 Jackson County Ring Levee, Belle Fontaine - Option D Alternate Alignment

01A	Project Planning	Federal	Non-Federal	Totals
	Other			
	Project Cooperation Agreement			
01AX	Contingencies (25%)			
	Subtotal			
01B	Lands and Damages/Permits			
01B40	Acquisition/Review of NFS	897,500		897,500
01B20	Acquisition by NFS		7,180,000	7,180,000
01BX	Contingencies (25%)	224,375	1,795,000	2,019,375
	Subtotal	1,121,875	8,975,000	10,096,875
01F	PL 91-646 Assistance			
01F20	By NFS		324,000	324,000
01FX	Contingencies (25%)		81,000	81,000
	Subtotal		405,000	405,000
01R	Real Estate Land Payments			
01R1B	Land Payments by NFS		16,602,565	16,602,565
01R2B	PL91-646 Relocation Payment by NFS		1,523,200	1,523,200
01R2D	Review of NFS	81,000		81,000
01RX	Contingencies (25%)	20,250	4,531,441	4,551,691
	Subtotal	101,250	22,657,206	22,758,456
	Totals	**1,223,125**	**32,037,206**	**33,260,331**
	Rounded			**33,260,000**

3.3.10 Jackson County Ring Levees, Gautier

Several high density residential and business areas in Jackson County were identified. They are Ocean Springs, Gulf Park, Belle Fontaine, Gautier and Pascagoula/Moss Point. Gautier is located on the west side of the Pascagoula River delta at the mouth of the West Pascagoula River at the Mississippi Sound. The location of the Gautier ring levee is shown in Figure 3.3.10-1. Ground elevations over most of the residential and business areas vary between elevations 10-20 feet NAVD88. These areas are subject to damage from storm surges associated with hurricanes. For purposes of providing protection for future storm events, the construction of an earthen ring levee is evaluated. The options in this study are identified as Option A and Option B. The levees were evaluated at elevations 20 ft NAVD88 and 30 ft NAVD88. The top width was assumed 15 ft with side slopes of 1 vertical to 3 horizontal.

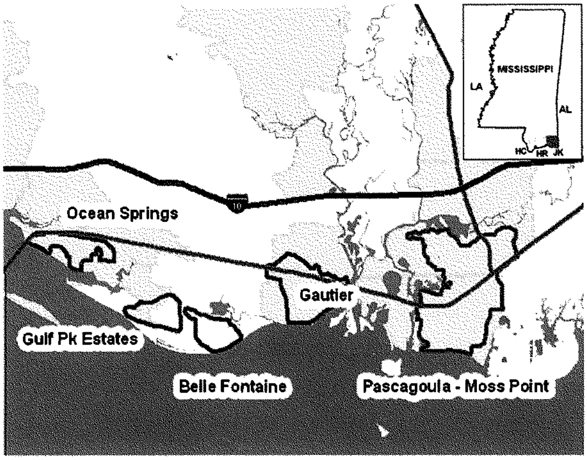

Figure 3.3.10-1.
Vicinity Map, Gautier

3.3.10.1 Option A - Elevation 20.0 ft NAVD88

This option consists of an earthen dike around the most densely populated areas of Gautier along with the internal sub-basins and levee culvert/pump locations. The levee would have an elevation of 20.0 feet with a top width of 15 ft and slopes of 1 vertical to 3 horizontal.

3.3.10.2 Option B - Elevation 30.0 ft NAVD88

The alignment of the levee is the same as Option A, above but with an elevation of 30.0 feet. The only difference between the description of this option and preceding description of Option A is the height of the levee, pumping facilities, number of roadway and railroad intersections, and the length of the levee culverts.

3.3.10.3 Project Description

Figure 3.3.10.3-1 shows the location of the proposed project alternatives. As described above, the levee will be an earthen berm constructed either at elevation 20.0 feet or 30.0 feet along with the internal sub-basins and levee culvert/pump locations. Drainage on the interior of the ring levee would be collected at the levee and channeled to culverts placed in the levee. The culverts would have tidal 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 manual control in the event the tidal gate malfunctions. In addition, pumps would be constructed near the outflow points to remove water from the interior during storm events occurring when the culverts are closed because of high water in the sound. Drainage ditches along the toe of the levee will be required to assure that smaller basins can be drained to a culvert/pump site. Figure 3.3.10.3-2 shows the proposed location of the pump/culvert sites. 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. Further studies will detail the requirement for the appropriate ponding areas, pump sizes, or buyouts in the affected areas.

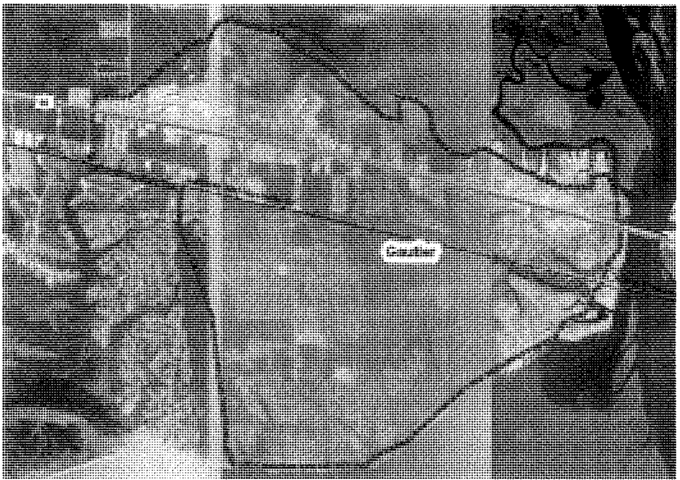

Figure 3.3.10.3-1.
Gautier Ring Levee

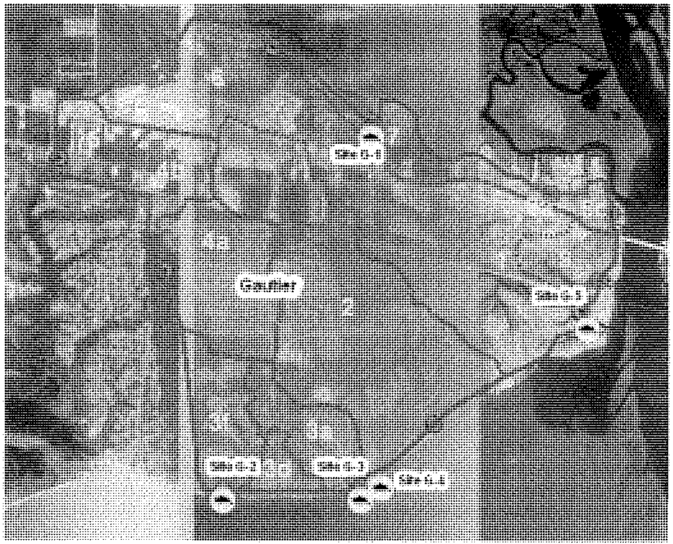

Figure 3.3.10.3-2.
Pump/Culvert/Sub-basin/Boat Access Site Locations

The inland barrier earthen levee section will have one vertical to three horizontal side slopes with a fifteen foot crest width. All work areas to receive fill shall be cleared and grubbed of all trees and surface organics and all existing foundations, streets, utilities, etc. will be removed and the subsequent cavities backfilled and compacted. The levee will be constructed of sand clay materials obtained from off site commercial sources, and trucked to the work area. The final surface will be armored by the placement of 24 inch thick gabion mattress filled with small stone for erosion protection during an event that overtops the levee. The armoring will be anchored on the front face by trenching and extend across the downstream slope and a 25 foot area beyond the toe. The front side of the levee and all non critical surface areas will be subsequently covered by grassing. In order to maintain the natural runoff patterns culverts would be inserted through the protection line at appropriate locations. For this study the culverts were configured as cast-in-place reinforced concrete box structures fitted with flap gates to minimize normal backflows and sluice gates to provide closure when needed. Pump facilities are required at 11 locations.

Road crossings will incorporate small gate structures or ramping over the embankment where the surface elevation is near that of the crest elevation. The elevation relationship of the crest and the adjacent railroad will be a governing factor. At each point where a roadway crosses the protection line the decision must be made whether to maintain this artery and adapt the protection line to accommodate it, or to terminate the artery at the protection line and divert traffic to cross the protection line at another location. For this study it was assumed that all roadways and railways crossing the levee alignment would be retained except where it was very evident that traffic could be combined without undue congestion. Once the decision has been made to retain a particular roadway, it must then be determined how best to configure the artery to conduct traffic across the protection line. The simplest means of passing roadway traffic is to ramp the roadway over the protection line. This alternative is not always viable because of severe right-of-way restraints caused by extreme levee height, urban congestion, etc. In such instances other methods can be used including partial ramping in combination with low profile roller gates. In more restricted areas full height gates which would leave the roadway virtually unaltered might be preferable, even though this alternative would usually be more costly than ramping. In some extreme circumstances where high levees are required to pass through very congested areas, installation of tunnels with closure gates may be required.

Because of the extreme gradient restrictions necessarily placed on railway construction, it is practically never acceptable to elevate a railway up and over a levee. Therefore, the available alternatives would include gated pass through structures. Because of the vertical clearance requirements of railroad traffic all railroad pass through structures for this study were configured having vertical walls on either side of the railway with double swing gates extending to the full height of the levee.

With the installation of a ring levee around Gautier at Option A, elevation 20.0, 20 roadway intersections would have to be accommodated. For this study it was estimated that 11 roller gate structures and 11 swing gate structures would be required. At Option B, elevation 30.0, 23 roadway intersections would have to be accommodated, and it was estimated that all 23 would require swing gate structures.

Operation and maintenance activities for this project will be required on an annual basis. All pumps and gates will be operated to assure proper working order. Debris and shoaled sediment will be removed. Vegetation on the levees will be cut to facilitate inspection and to prevent roots from causing weak levee locations. Rills will be filled and damaged revetment will be repaired.

3.3.10.4 Real Estate Requirements

Real Estate requirements for Line of Defense 3, Gautier Ring Levee include lands, easements, rights-of-way and relocations, and disposal/borrow areas (LERRD), and the right to construct an earthen levee, drainage ditches and 11 culvert/pump station facilities.

Based on the footprint of the Option A 20.0 foot elevation, it was determined that approximately 313 parcels and 139 structures would be impacted. The acreage to be acquired for the levee is unknown. It is known that the 11 pump stations will require approximately 0.23 of an acre each for a total of 2.53 acres. Lands required for construction of the levee will be acquired in fee simple interest. Based on the number of structures being impacted, the assumption is that there will be 139 relocations.

Based on the footprint of the Option B 30.0 foot elevation, it was determined that 354 parcels and 161 structures would be impacted. The acreage to be acquired for the levee is unknown. It is known that the 11 pump stations will require approximately 0.23 of an acre each for a total of 2.53 acres. Lands required for construction of the levee will be acquired in fee simple interest. Based on the number of structures being impacted, the assumption is that there will be 161 relocations.

Ditches that will be constructed to provide drainage for the interior of the ring levee are expected to be located within the footprint of the levee. Until final plans and specifications are completed, an assumption is made that the ditches will be constructed on the same lands acquired for construction of the levee. If any additional lands are required, this will be determined during PED.

Any modifications to the roadways and utilities will most probably need to be accomplished through a relocation contract. This will be further investigated and confirmed during PED.

In some areas the levee alignment would cross a moderately sized water course where it is apparent that boats currently traverse the area. To allow continued free boat access to areas behind the levee these water courses will be fitted with a scaled down adaptation of the larger rising sector gate structure used for the bay barriers at Biloxi and Bay St. Louis. A small boat access structure is shown at the mouth of multiple basins in the project footprint. Rising sector gates will be provided at these gates allowing shallow draft traffic most of the time. The gates will be closed prior to hurricane storm surge. No additional real estate interest is identified for boat access points as they fall within the footprint of the project and impacted parcels are included in the total that is projected. For those lands required for construction that lay below the mean high water mark, navigation servitude will apply.

An assumption is made that excavated materials from clearing, snagging, and construction of ditches, etc. will be disposed of in county owned or commercial landfills. However, In the event that the excavated material is not suitable for a landfill a disposal site will have to be acquired. Typically if disposal sites are required, this would be considered as part of the LERRD requirement. Real Estate would provide an analysis during PED to compare the cost of acquiring an upland disposal site with the cost of using a commercial landfill and make a determination which method is most cost effective.

An assumption is made that excavated materials from clearing, snagging, and construction of ditches, etc. will be disposed of in county owned or commercial landfills. However, In the event that the excavated material is not suitable for a landfill a disposal site will have to be acquired. Typically if disposal sites are required, this would be considered as part of the LERRD requirement. Real Estate would provide an analysis during PED to compare the cost of acquiring an upland disposal site with the cost of using a commercial landfill and make a determination which method is most cost effective.

The recommended plan proposes to use material from an inventory of upland borrow sites to construct the levee. A specific site has not been identified or confirmed for use at time of this report. Typically if borrow sites are required, this would be considered a part of the LERRD requirement. Real Estate would provide an analysis during PED to compare the cost of acquiring an upland borrow site with the cost of using a commercial borrow site and make a determination which method is most cost effective. The requirement for temporary work areas is unknown. Sponsor owned lands will be used if available. Otherwise, this may be an additional real estate requirement, and will be further defined during PED.

3.3.10.5 Utility/Facility Relocation

The plan calls for roads to be ramped over the proposed levee and possible relocation of utilities. An assumption is made that this work will be accomplished through a relocation contract. This will be further investigated and confirmed during PED. See Chapter 2 Section 2.10 for more detailed discussion.

3.3.10.6 Existing Projects/Studies

Relevant projects and studies are found in the main report at Section 1.6, History of the Investigation and Section 1.7, Prior and On-Going Studies, Reports and Programs.

3.3.10.7 Environmental Impacts

See the Main Report, Chapter 6. Environmental Effects of Plans and the Environmental Appendix, for a full discussion on environmental effects.

3.3.10.8 Project Sponsor Responsibilities and Capabilities

The State of Mississippi will be the non-Federal Project Sponsor (NFS). The NFS has the responsibility to acquire all real estate interests required for the Project. The NFS shall accomplish all alterations and relocations of facilities, structures and improvements determined by the government to be necessary for construction of the Project.

Title to any acquired real estate will be retained by the Project Sponsor and will not be conveyed to the United States Government. Prior to advertisement of any construction contract, the NFS shall furnish to the government an Authorization for Entry for Construction (Exhibit "A" to the Real Estate Appendix) to all lands, easements and rights-of-way, as necessary. The NFS will also furnish to the government evidence supporting their legal authority to grant rights-of-way to such lands. The NFS shall comply with applicable provisions of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970, Public Law 91-646, approved 2 January 1971, and amended by Title IV of the Surface Transportation Uniform Relocation Assistance Act of 1987, Public Law 100-17, effective 2 April 1989, in acquiring real estate interests for the Project, and inform all affected persons of applicable benefits, policies, and procedures in connection with said Act(s). A form for the Assessment of the Non-Federal Sponsor's Capability to Acquire Real Estate is at Exhibit "B" to the Real Estate Appendix. The assessment will be made during PED phase.

The non-Federal sponsor is entitled to receive credit against its share of project costs for the value of lands it provides and the value of the relocations that are required for the project. Generally, for the purpose of determining the amount of credit to be afforded, the value of the LER is the fair market value of the real property interest, plus certain incidental costs of acquiring those interests, that the non-federal sponsor provided for the project as required by the Government. The NFS cannot receive credit for the value of any LER, including incidental costs, which were previously provided as an item of cooperation for another Federal project, including projects that preceded enactment of WRDA 1986.

3.3.10.9 Government Owned Property

There are no known Government owned lands within the proposed project.

3.3.10.10 Historical Significance

See the Main Report, Section 3.2.9 Cultural and Archaeological Resources, for a general discussion on cultural and archaeological resources.

3.3.10.11 Mineral Rights

There are no known mineral activities within the scope of the proposed project.

3.3.10.12 Hazardous, Toxic, and Radioactive Waste (HTRW)

Due to the extent of the project, no preliminary assessment was performed to identify the possibility of hazardous waste on the sites. These studies will be conducted during the next phase of work. See Sections 3.2.8 and 6.16 of the Main Report for a discussion on HTRW.

3.3.10.13 Public Law 91-646, Relocation Assistance Benefits

The Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970 establishes a uniform policy for fair and equitable treatment of persons displaced as a result of federal and federally assisted programs in order that such persons shall not suffer disproportionate injuries as a

result of programs designed for the benefits of the public as a whole. A qualified displaced person may be entitled to certain relocation assistance benefits which include reimbursement of moving costs and a replacement housing benefit. Moving expense can be reimbursed either based on actual costs or a fixed moving cost schedule. The replacement housing payment is separated into 3 basic types - purchase supplement, rental assistance and down payment. All replacement housing must be decent, safe, and sanitary (DSS) before a replacement housing payment can be made.

It is estimated that there are approximately 139 relocations in Option A and approximately 161 relocations in Option B. No relocation plan has been completed nor has a relocation survey been done. All estimates are based on information from county public records. The number of business relocations as compared to residential relocations is unknown. In order to accomplish the relocation activity in a timely manner, the plan set forth in Chapter 2. Section 2.5 can be used.

3.3.10.14 Attitude of Property Owners

Real Estate has not interviewed property owners or tenants during the study phase for the MsCIP. However, numerous public meetings have been held at different locations throughout the study area to inform stakeholders and property owners about the study and the protective measures under consideration for the Mississippi coastal area. A number of local newspapers have published articles that discuss the MsCIP study and the perceived positive effects as well as the negative impacts that may occur as a result of the project. Some of these articles can be found on web sites. While many of the locals may welcome the benefits of the proposed project, there are some who oppose the project.

3.3.10.15 Acquisition Schedule

An acquisition schedule will be developed when plans and specifications become available and more definite information is available pertaining to the specific areas and number of parcels for acquisition. The acquisition schedule will be developed during PED and will be a joint effort of the NFS, the project manager and Real Estate. The schedule will set forth a time line for title, survey, appraisal, negotiation, preparation of documents and closing activity. After acquisition activity is completed certification of lands acquired/owned by the sponsor will be necessary prior to advertisement for construction. The Certification of Real Estate can be accomplished within 30 - 60 days after acquisition. See Chapter 2. Section 2.5. for discussion on an acquisition implementation/management plan.

3.3.10.16 Estates for Proposed Project

All lands required for the levee will be acquired in Fee Simple. Should a borrow site be required, the Borrow Easement will be used. The Temporary Work Area Easement will be used for staging or temporary work areas, and the Drainage Ditch Easement will be used as required. The estates recommended are standard estates.

FEE.

The fee simple title to (the land described in Schedule A) l/(Tracts Nos. ____, ____ and ___), subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

BORROW EASEMENT.

A (temporary) (perpetual and assignable) right and easement to clear, borrow, excavate and remove sand, soil, dirt, and other materials from (the land described in Schedule A) (Tracts Nos. _____, _____ and _____); subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines; reserving, however, to the landowners, their heirs and assigns, all such rights and privileges in said land as may be used without interfering with or abridging the rights and easement hereby acquired.

TEMPORARY WORK AREA EASEMENT.

A temporary easement and right-of-way in, on, over and across (the land described in Schedule A) (Tracts Nos. _____, _____ and _____), for a period not to exceed ____________________, beginning with date possession of the land is granted to the Project Sponsor, for use by the Project Sponsor, its representatives, agents, and contractors as a work area, including the right to deposit backfill, move, store and remove equipment and supplies, and erect and remove temporary structures on the land and to perform any other work necessary and incident to the construction of the ____________________ Project, together with the right to trim, cut, fell and remove there from all trees, underbrush, obstructions, and any other vegetation, structures, or obstacles within the limits of the right-of-way; reserving, however, to the landowners, their heirs and assigns, all such rights and privileges as may be used without interfering with or abridging the rights and easement hereby acquired; subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

DRAINAGE DITCH EASEMENT.

A perpetual and assignable easement and right-of-way in, over and across (the land described in Schedule A) (Tracts Nos. ____, ____ and _____) to construct, maintain, repair, operate, patrol and replace a drainage ditch, reserving, however, to the owners, their heirs and assigns, all such rights and privileges in the land as may be used without interfering with or abridging the rights and easement hereby acquired; subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

3.3.10.17 Real Estate Estimate

A summary of the cost for each option is at Table 3.3.10.17-1. The real estate estimates at Table 3.3.10.17-2 and 3.3.10.17-3 include the land cost for acquisition of land, relocation benefits to include a replacement housing payment and fixed rate move expenses, and Federal and non-Federal administrative costs. Administrative costs are those costs incurred for verifying ownership of lands, certification of those lands required for project purposes, legal opinions, analysis or other requirements that may be necessary, during PED. No cost is included for a borrow site or temporary work area. The requirement, if any, for a borrow site or temporary work area will be identified during PED. If further real estate requirements are identified during PED or if there is a significant increase in cost, a supplement to the Real Estate Appendix will be prepared. A 25% contingency is applied to the current estimate.

Table 3.3.10.17-1.
Real Estate Cost Summary

Option	Impacted Parcels	Relocations	Total Cost
Option A - 20.0	313	139	$56,977,000
Option B - 30.0	354	161	$66,585,000

Table 3.3.10.17-2.
LOD3 Jackson County Ring Levee, Gautier - Option A 20.0 Estimate

a. Lands and Improvements/Permits				
302 Ownerships for Levee, 139 Improvements				33,172,344
11 Pump Stations				426,342
313 Ownerships			Subtotal	33,598,686
b. Mineral Rights				0
c. Damages				0
d. P.L. 91-646 Relocation costs – 139 relocations				3,897,600
e. Administrative Cost				8,085,000
	Relocation	Acquisition	Total	
Federal	208,500	782,500	991,000	
Non-Federal	834,000	6,260,000	7,094,000	
	1,042,500	7,042,500	8,085,000	
Subtotal				45,581,286
Contingencies (25%)				11,395,322
Totals				**56,976,608**
Rounded				**56,977,000**

Table 3.3.10.17-3.
LOD3 Jackson County Ring Levee, Gautier - Option B 30.0 Estimate

a. Lands and Improvements/Permits				
343 Ownerships for Levee, 161 Improvements				39,166,820
11 Pump Stations				426,342
354 Ownerships			Subtotal	39,593,162
b. Mineral Rights				0
c. Damages				0
d. P.L. 91-646 Relocation costs – 161 relocations				4,502,400
e. Administrative Cost				9,172,500
	Relocation	Acquisition	Total	
Federal	241,500	885,000	1,126,500	
Non-Federal	966,000	7,080,000	8,046,000	
	1,207,500	7,965,000	9,172,500	
Subtotal				53,268,062
Contingencies (25%)				13,317,016
Totals				**66,585,078**
Rounded				**66,585,000**

3.3.10.18 Summary of Potential Real Estate Issues

The requirement for temporary work areas, disposal or borrow areas has not been identified. Should these areas be required, these would be considered as part of the LERRD requirements. Typically if disposal or borrow sites are required, Real estate would provide an analysis during PED to compare the cost of acquiring an these sites with the cost of using a commercial sites and make a determination which method is most cost effective. See Section 2.8 Borrow Areas on page 5.

Should drainage ditches, temporary work areas, disposal or borrow areas become a necessary real estate acquisition requirement, valuation of lands will be performed. Land costs associated with these areas, and administrative costs will be added to the Real Estate Cost Estimate. If further real estate requirements are identified during PED or if there is a significant increase in cost, a supplement to the Real Estate Appendix will be prepared.

Any requirements for relocation contracts pertaining to facilities/utilities will be identified and completed during PED.

Any requirement for mitigation lands will be identified during PED.

Should condemnation of any required real estate interest be necessary, it is the responsibility of the NFS. This issue is addressed during the Assessment of the Non-Federal Sponsor's Real Estate Acquisition Capability. However, if the real estate interest is one that the NFS does not have authority to condemn, the Federal Government can perform the condemnation on behalf of the NFS.

A relocation plan will need to be completed during PED to address potential relocation activity under P.L. 91-646. There are a number of factors pertaining to relocations that can impact the project both in cost and in schedule. Payments for Housing of Last Resort, which would exceed the standard housing replacement payments, are very likely due to the size of the project and the lack of available decent, safe and sanitary housing in the area. Another factor that could increase cost and impact schedule is the cost of business relocations. Depending on the type of business and the operation, this could involve moving equipment and machinery to new locations. It is necessary to interview each impacted individual and business during Pre-Construction, Engineering and Design Phase to determine the requirements for relocation and to estimate a cost for the relocation.

3.3.10.19 Chart of Accounts

The cost estimate for all Federal and non-Federal real estate activities necessary for implementation of the project after completion of the feasibility study for land acquisition, construction, LERRD, and other items are coded as delineated in the Cost Work Breakdown Structure (CWBS). This real estate cost estimate is then incorporated into the Total Current Working Estimate utilizing the Microcomputer Aided Cost Engineering System (MCACES). The Chart of Accounts at Tables 3.3.10.19-1 and 3.3.10.19-2 shows the CWBS for real estate activities.

Table 3.3.10.19-1.
Chart of Accounts - LOD3 Jackson County Ring Levee, Gautier - Option A

01A	Project Planning	Federal	Non-Federal	Totals
	Other			
	Project Cooperation Agreement			
01AX	Contingencies (25%)			
	Subtotal			
01B	Lands and Damage/Permits			
01B40	Acquisition/Review of NFS	782,500		782,500

01A	Project Planning	Federal	Non-Federal	Totals
01B20	Acquisition by NFS		6,260,000	6,260,000
01BX	Contingencies (25%)	195,625	1,565,000	1,760,625
	Subtotal	978,125	7,825,000	8,803,125
01F	PL 91-646 Assistance			
01F20	By NFS		834,000	834,000
01FX	Contingencies (25%)		208,500	208,500
	Subtotal		1,042,500	1,042,500
01R	Real Estate Land Payments			
01R1B	Land Payments by NFS		33,598,686	33,598,686
01R2B	PL91-646 Relocation Payment by NFS		3,897,600	3,897,600
01R2D	Review of NFS	208,500		208,500
01RX	Contingencies (25%)	52,125	9,374,072	9,426,197
	Subtotal	260,625	46,870,358	47,130,983
	Totals	**1,238,750**	**55,737,858**	**56,976,608**
	Rounded			**56,977,000**

Table 3.3.10.19-2.
Chart of Accounts - LOD3 Jackson County Ring Levee, Gautier - Option B

01A	Project Planning	Federal	Non-Federal	Totals
	Other			
	Project Cooperation Agreement			
01AX	Contingencies (25%)			
	Subtotal			
01B	Lands and Damage/Permits			
01B40	Acquisition/Review of NFS	885,000		885,000
01B20	Acquisition by NFS		7,080,000	7,080,000
01BX	Contingencies (25%)	221,250	1,770,000	1,991,250
	Subtotal	1,106,250	8,850,000	9,956,250
01F	PL 91-646 Assistance			
01F20	By NFS		966,000	966,000
01FX	Contingencies (25%)		241,500	241,500
	Subtotal		1,207,500	1,207,500
01R	Real Estate Land Payments			
01R1B	Land Payments by NFS		39,593,162	39,593,162
01R2B	PL91-646 Relocation Payment by NFS		4,502,400	4,502,400
01R2D	Review of NFS	241,500		241,500
01RX	Contingencies (25%)	60,375	11,023,891	11,084,266
	Subtotal	301,875	55,119,453	55,421,328
	Totals	**1,408,125**	**65,176,953**	**66,585,078**
	Rounded			**66,585,000**

3.3.11 Jackson County Ring Levees, Pascagoula/Moss Point

Several high density residential and business areas in Jackson County were identified. They are Ocean Springs, Gulf Park, Belle Fontaine, Gautier and Pascagoula/Moss Point. The cities of Moss Point and Pascagoula lie at the confluence of the Escatawpa and Pascagoula Rivers along the gulf coast on Mississippi Sound as shown on Figure 3.3.11-1. Both the northern part of Moss Point and the southern Part of Pascagoula are very flat. Ground elevations over most of the residential and business areas vary between elevations 10-12 feet NAVD88 in the southern part of the area (Pascagoula) and 14-20 feet NAVD88 in the northern part (Moss Point). These areas are subject to damage from storm surges associated with hurricanes. For purposes of providing protection for future storm events, the construction of an earthen ring levee is evaluated. The options in this study are identified as Options A through H. The levees were evaluated at elevations 20 ft NAVD88 and 30 ft NAVD88. The top width was assumed 15 ft with side slopes of 1 vertical to 3 horizontal.

3.3.11.1 Option A - Elevation 20.0 ft NAVD88

This option consists of an earthen dike around the most densely populated areas of Moss Point and Pascagoula along with the internal sub-basins and levee culvert/pump locations. The levee would have an elevation of 20.0 feet with a top width of 15 ft and slopes of 1 vertical to 3 horizontal. This is the basic alignment and is the most extensive, covering the main residential areas in Pascagoula and Moss Point.

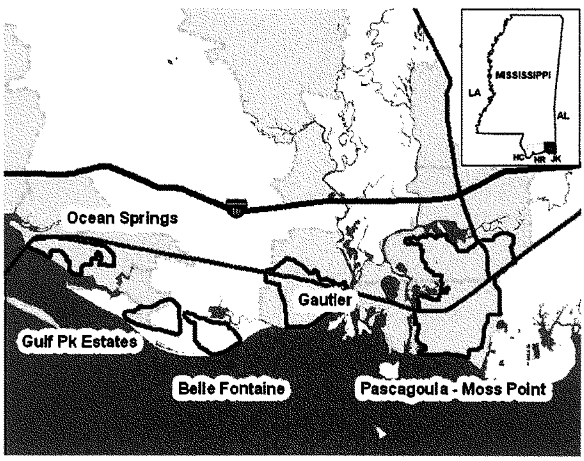

Figure 3.3.11-1.
Vicinity Map, Pascagoula/Moss Point

3.3.11.2 Option B - Elevation 30.0 ft NAVD88

The alignment of the levee is the same as Option A, above but with an elevation of 30.0 feet. The only difference between the description of this option and preceding description of Option A is the height of the levee, pumping facilities, number of roadway and railroad intersections, and the length of the levee culverts.

3.3.11.3 Option C - Washington Avenue Alternate Alignment, Elevation 20.0 ft NAVD88

The alignment of the Option C levee is the same as Option A, except that it follows Washington Avenue on the southernmost leg of the levee. Additionally the lands that lay between the alignment of Option A and the alternate alignment Option C will be acquired as buffer zone in this option.

3.3.11.4 Option D - Washington Avenue Alternate Alignment, Elevation 30.0 ft NAVD88

The alignment of the levee is the same as Option C above. The only difference between the description of this option and preceding description of Option C is the height of the levee, pumping facilities, number of roadway and railroad intersections, and the length of the levee culverts. As above, the buffer zone lands will be acquired

3.3.11.5 Option E - Moss point Alternate Alignment, Elevation 20.0 ft NAVD88

The alignment of the Option E levee is the same as Option A, except that it follows a modified alignment through Moss Point along higher ground on the north leg of the levee. Additionally the lands that lay between the alignment of Option A and the alternate alignment Option E will be acquired as a buffer zone in this option.

3.3.11.6 Option F - Moss Point Alternate Alignment, Elevation 30.0 ft NAVD88

The alignment of the levee is the same as Option E above. The only difference between the description of this option and preceding description of Option C is the height of the levee, pumping facilities, number of roadway and railroad intersections, and the length of the levee culverts. As above, the buffer zone lands will be acquired.

3.3.11.7 Option G - Combined Washington Avenue and Moss Point Alterative Alignments, Elevation 20.0 ft NAVD88

The alignment of the levee is the same as Option A, above, except that is follows the same modified alignment along Washington Ave as for Options C and D on the south, and the modified alignment in Moss Point as for Options E and F along the north leg of the levee. Additionally, the lands that lay between the alignment of Option A and the alternate alignments Option C and Option E will be acquired as buffer zones in this option.

3.3.11.8 Option H - Combined Washington Avenue and Moss Point Alterative Alignments, Elevation 30.0 ft NAVD88

The alignment of the levee is the same as Option G above. The only difference between the description of this option and preceding description of Option G is the height of the levee, pumping facilities, number of roadway and railroad intersections, and the length of the levee culverts. As above, the buffer zone lands will be acquired.

3.3.11.9 Project Description

Figure 3.3.11.9-1 shows the location of the proposed project alternatives with the alternate alignments representing Options C-H. As described above, the levee will be an earthen berm constructed either at elevation 20.0 feet or 30.0 feet along with the internal sub-basins and levee culvert/pump locations. Drainage on the interior of the ring levee would be collected at the levee and channeled to culverts placed in the levee. 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. In addition, pumps would be constructed near the outflow points to remove water from the interior during storm events occurring when the culverts are closed because of high water in the sound. Drainage ditches along the toe of the levee will be required to assure that smaller basins can be drained to a culvert/pump site. Figure 3.3.11.9-2 shows the proposed location of the pump/culvert sites. 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. Further studies will detail the requirement for the appropriate ponding areas, pump sizes, or buyouts in the affected areas.

The inland barrier earthen levee section will have one vertical to three horizontal side slopes with a fifteen foot crest width. All work areas to receive fill shall be cleared and grubbed of all trees and surface organics and all existing foundations, streets, utilities, etc. will be removed and the subsequent cavities backfilled and compacted. The levee will be constructed of sand clay materials obtained from off site commercial sources, and trucked to the work area. The final surface will be armored by the placement of 24 inch thick gabion mattress filled with small stone for erosion protection during an event that overtops the levee. The armoring will be anchored on the front face by trenching and extend across the downstream slope and a 25 foot area beyond the toe. The front side of the levee and all non critical surface areas will be subsequently covered by grassing. In order to maintain the natural runoff patterns culverts would be inserted through the protection line at appropriate locations. For this study these were configured as cast-in-place reinforced concrete box structures fitted with flap gates to minimize normal backflows and sluice gates to provide storm closure when needed. Pump facilities are required at 23-28 locations with variance depending on the option.

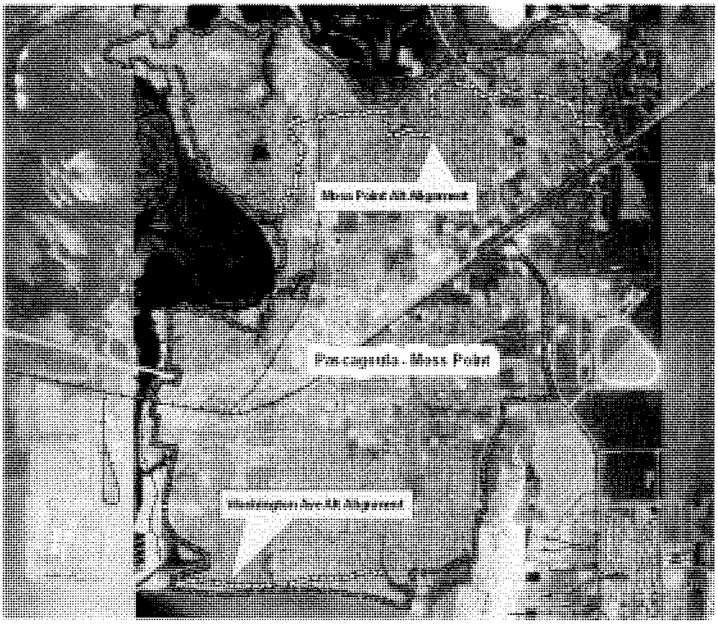

Figure 3.3.11.9-1.
Pascagoula/Moss Point Levee

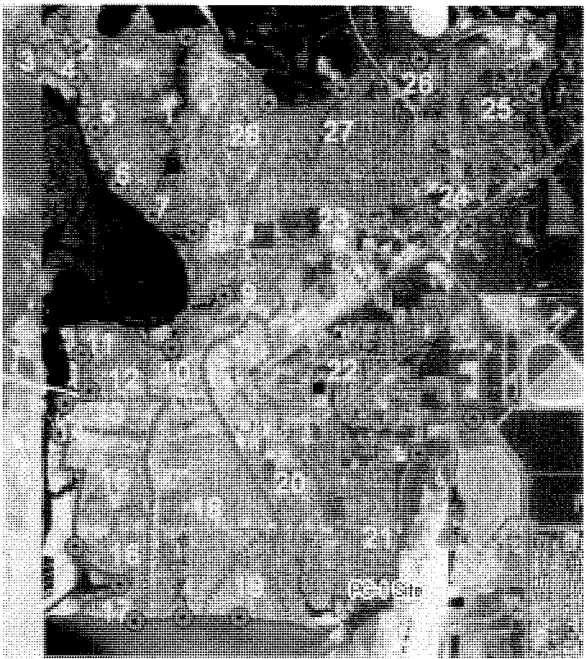

Figure 3.3.11.9-2.
Pump/Culvert/Sub-basin/Boat Access Site Locations

Road crossings will incorporate small gate structures or ramping over the embankment where the surface elevation is near that of the crest elevation. The elevation relationship of the crest and the adjacent railroad will be a governing factor. At each point where a roadway crosses the protection line the decision must be made whether to maintain this artery and adapt the protection line to accommodate it, or to terminate the artery at the protection line and divert traffic to cross the protection line at another location. For this study it was assumed that all roadways and railways crossing the levee alignment would be retained except where it was very evident that traffic could be combined without undue congestion. Once the decision has been made to retain a particular roadway, it must then be determined how best to configure the artery to conduct traffic across the protection line. The simplest means of passing roadway traffic is to ramp the roadway over the protection line. This alternative is not always viable because of severe right-of-way restraints caused by extreme levee height, urban congestion, etc. In such instances other methods can be used including partial ramping in combination with low profile roller gates. In more restricted areas full height gates which would leave the roadway virtually unaltered might be preferable, even though this alternative would usually be more costly than ramping. In some extreme circumstances where high levees are required to pass through very congested areas, installation of tunnels with closure gates may be required.

Because of the extreme gradient restrictions necessarily placed on railway construction, it is practically never acceptable to elevate a railway up and over a levee. Therefore, the available alternatives would include gated pass through structures. Because of the vertical clearance requirements of railroad traffic all railroad pass through structures for this study were configured having vertical walls on either side of the railway with double swing gates extending to the full height of the levee.

Table 3.3.11.9-1 summarizes the number of roadway/railway intersections impacted by the various options. The number of roller gate, swing gate and railroad gate structures are listed for each option.

Table 3.3.11.9-1.
Levee and Roadway/Railway Intersections

Option	Roadway/Railway Intersections	Roller Gates	Swing Gates	Railroad Gates
Option A	68	29	35	8
Option B	79	1	73	5
Option C	76	24	108	14
Option D	87	1	180	18
Option E	43	15	56	10
Option F	75		75	14
Option G	48	15	72	10
Option H	79		79	14

Operation and maintenance activities for this project will be required on an annual basis. All pumps and gates will be operated to assure proper working order. Debris and shoaled sediment will be removed. Vegetation on the levees will be cut to facilitate inspection and to prevent roots from causing weak levee locations. Rills will be filled and damaged revetment will be repaired.

3.3.11.10 Real Estate Requirements

Real Estate requirements for Line of Defense 3, Pascagoula/Moss Point Ring Levee include lands, easements, rights-of-way and relocations, and disposal/borrow areas (LERRD), and the right to acquire buffer zone lands, construct an earthen levee, drainage ditches and 23 - 28 culvert/pump station facilities depending on the option.

Based on the footprint of the Option A, 20.0 foot elevation, it was determined that approximately 1075 parcels and 536 structures would be impacted. The acreage to be acquired for the levee is unknown. It is known that the 28 pump stations will require approximately 0.23 of an acre each for a total of 6.44 acres. Lands required for construction of the levee will be acquired in fee simple interest, and lands for the drainage ditches that will be constructed outside the levee footprint will be acquired either in easement or fee as necessary. Based on the number of structures being impacted, the assumption is that there will be 536 relocations.

Based on the footprint of the Option B, 30.0 foot elevation, it was determined that 1203 parcels and 602 structures would be impacted. The acreage to be acquired for the levee is unknown. It is known that the 28 pump stations will require approximately 0.23 of an acre each for a total of 6.44 acres. Lands required for construction of the levee will be acquired in fee simple interest, and lands for the drainage ditches that will be constructed outside the levee footprint will be acquired either in easement or fee as necessary. Based on the number of structures being impacted, the assumption is that there will be 602 relocations.

Based on the footprint of the Option C, 20.0 foot elevation, it was determined that 1175 parcels and 550 structures would be impacted. Lands for the buffer zone are included in this number. The acreage to be acquired for the levee is unknown. It is known that the 27 pump stations will require approximately 0.23 of an acre each for a total of 6.21 acres. Lands required for the buffer zone and for construction of the levee will be acquired in fee simple interest, and lands for the drainage ditches that will be constructed outside the levee footprint will be acquired either in easement or fee as necessary. Based on the number of structures being impacted, the assumption is that there will be 550 relocations.

Based on the footprint of the Option D, 30.0 foot elevation, it was determined that 1321 parcels and 623 structures would be impacted. Lands for the buffer zone are included in this number. The acreage to be acquired for the levee is unknown. It is known that the 27 pump stations will require approximately 0.23 of an acre each for a total of 6.21 acres. Lands required for the buffer zone and for construction of the levee will be acquired in fee simple interest, and lands for the drainage ditches that will be constructed outside the levee footprint will be acquired either in easement or fee as necessary. Based on the number of structures being impacted, the assumption is that there will be 623 relocations.

Based on the footprint of the Option E, 20.0 foot elevation, it was determined that 2964 parcels and 1870 structures would be impacted. Lands for the buffer zone are included in this number. The acreage to be acquired for the levee is unknown. It is known that the 24 pump stations will require approximately 0.23 of an acre each for a total of 5.52 acres. Lands required for the buffer zone and for construction of the levee will be acquired in fee simple interest, and lands for the drainage ditches that will be constructed outside the levee footprint will be acquired either in easement or fee as necessary. Based on the number of structures being impacted, the assumption is that there will be 1870 relocations.

Based on the footprint of the Option F, 30.0 foot elevation, it was determined that 3076 parcels and 1926 structures would be impacted. Lands for the buffer zone are included in this number. The acreage to be acquired for the levee is unknown. It is known that the 24 pump stations will require approximately 0.23 of an acre each for a total of 5.52 acres. Lands required for the buffer zone and for construction of the levee will be acquired in fee simple interest, and lands for the drainage ditches that will be constructed outside the levee footprint will be acquired either in easement or fee as necessary. Based on the number of structures being impacted, the assumption is that there will be 1926 relocations.

Based on the footprint of the Option G 20.0 foot elevation, it was determined that 3138 parcels and 1939 structures would be impacted. Lands for the buffer zone are included in this number. The acreage to be acquired for the levee is unknown. It is known that the 23 pump stations will require approximately 0.23 of an acre each for a total of 5.29 acres. Lands required for the buffer zone and for construction of the levee will be acquired in fee simple interest, and lands for the drainage ditches that will be constructed outside the levee footprint will be acquired either in easement or fee as necessary. Based on the number of structures being impacted, the assumption is that there will be 1939 relocations.

Based on the footprint of the Option H, 30.0 foot elevation, it was determined that 3253 parcels and 1994 structures would be impacted. The acreage to be acquired for the levee is unknown. It is known that the 23 pump stations will require approximately 0.23 of an acre each for a total of 5.29 acres. Lands required for the buffer zone and for construction of the levee will be acquired in fee simple interest, and lands for the drainage ditches that will be constructed outside the levee footprint will be acquired either in easement or fee as necessary. Based on the number of structures being impacted, the assumption is that there will be 1994 relocations. Table 3.3.11.10-1 below summarizes the real estate requirements for the various alternatives.

Table 3.3.11.10-1.
Real Estate Requirements - LOD3 Pascagoula/Moss Point Alternatives

Option	Impacted Parcels	Impacted Structures	# Pump Stations/AC	Relocations
Option A	1,075	536	28 6.44 AC	536
Option B	1,203	602	28 6.44 AC	602
Option C	1,175	550	27 6.21 AC	550
Option D	1,321	623	27 6.21 AC	623
Option E	2,964	1,870	24 5.52 AC	1870
Option F	3,076	1,926	24 5.52 AC	1926
Option G	3,138	1,939	23 5.29 AC	1939
Option H	3,253	1,994	23 5.29 AC	1994

Any modifications to the roadways and utilities will most probably need to be accomplished through a relocation contract. This will be further investigated and confirmed during PED.

In some areas the levee alignment would cross a moderately sized water course where it is apparent that boats currently traverse the area. To allow continued free boat access to areas behind the levee these water courses will be fitted with a scaled down adaptation of the larger rising sector gate structure used for the bay barriers at Biloxi and Bay St. Louis. A small boat access structure is shown at the mouth of one basin in the project footprint. Rising sector gates will be provided at this gate allowing shallow draft traffic most of the time. The gate will be closed prior to hurricane storm surge. No additional real estate interest is identified for boat access points as they fall within the footprint of the project and impacted parcels are included in the total that is projected. For those lands required for construction that lay below the mean high water mark, navigation servitude will apply.

An assumption is made that excavated materials from clearing, snagging, and construction of ditches, etc. will be disposed of in county owned or commercial landfills. However, In the event that the excavated material is not suitable for a landfill a disposal site will have to be acquired. Typically if disposal sites are required, this would be considered as part of the LERRD requirement. Real Estate would provide an analysis during PED to compare the cost of acquiring an upland disposal site with the cost of using a commercial landfill and make a determination which method is most cost effective.

The recommended plan proposes to use material from an inventory of upland borrow sites to construct the levee. A specific site has not been identified or confirmed for use at time of this report. Typically if borrow sites are required, this would be considered a part of the LERRD requirement. Real Estate would provide an analysis during PED to compare the cost of acquiring an upland borrow site with the cost of using a commercial borrow site and make a determination which method is most cost effective. The requirement for temporary work areas is unknown. Sponsor owned lands will be used if available. Otherwise, this may be an additional real estate requirement, and will be further defined during PED.

3.3.11.11 Utility/Facility Relocation

The plan calls for roads to be ramped over the proposed levee and possible relocation of utilities. An assumption is made that this work will be accomplished through a relocation contract. This will be further investigated and confirmed during PED. See Chapter 2 Section 2.10 for more detailed discussion.

3.3.11.12 Existing Projects/Studies

Relevant projects and studies are found in the main report at Section 1.6, History of the Investigation and Section 1.7, Prior and On-Going Studies, Reports and Programs.

3.3.11.13 Environmental Impacts

See the Main Report, Chapter 6. Environmental Effects of Plans and the Environmental Appendix, for a full discussion on environmental effects.

3.3.11.14 Project Sponsor Responsibilities and Capabilities

The State of Mississippi will be the non-Federal Project Sponsor (NFS). The NFS has the responsibility to acquire all real estate interests required for the Project. The NFS shall accomplish all alterations and relocations of facilities, structures and improvements determined by the government to be necessary for construction of the Project.

Title to any acquired real estate will be retained by the Project Sponsor and will not be conveyed to the United States Government. Prior to advertisement of any construction contract, the NFS shall furnish to the government an Authorization for Entry for Construction (Exhibit "A" to the Real Estate Appendix) to all lands, easements and rights-of-way, as necessary. The NFS will also furnish to the government evidence supporting their legal authority to grant rights-of-way to such lands. The NFS shall comply with applicable provisions of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970, Public Law 91-646, approved 2 January 1971, and amended by Title IV of the Surface Transportation Uniform Relocation Assistance Act of 1987, Public Law 100-17, effective 2 April 1989, in acquiring real estate interests for the Project, and inform all affected persons of applicable benefits, policies, and procedures in connection with said Act(s). A form for the Assessment of the Non-Federal Sponsor's Capability to Acquire Real Estate is at Exhibit "B" to the Real Estate Appendix. The assessment will be made during PED phase.

The non-Federal sponsor is entitled to receive credit against its share of project costs for the value of lands it provides and the value of the relocations that are required for the project. Generally, for the purpose of determining the amount of credit to be afforded, the value of the LER is the fair market value of the real property interest, plus certain incidental costs of acquiring those interests, that the non-federal sponsor provided for the project as required by the Government. The NFS cannot receive credit for the value of any LER, including incidental costs, which were previously provided as an item of cooperation for another Federal project, including projects that preceded enactment of WRDA 1986.

3.3.11.15 Government Owned Property

One (1) Government owned parcel is within the footprint of the project. In viewing the footprint, it appears that approximately 30% of the parcel will be impacted by construction of the levee. Land value is listed as $131,090 and improvement value is listed as $427,020. Ownership is listed in public records as US Govt (Pasc Fishery Lab). Specific impacts to this particular parcel and/or structure will be determined during PED.

3.3.11.16 Historical Significance

See the Main Report, Section 3.2.9 Cultural and Archaeological Resources, for a general discussion on cultural and archaeological resources.

3.3.11.17 Mineral Rights

There are no known mineral activities within the scope of the proposed project.

3.3.11.18 Hazardous, Toxic, and Radioactive Waste (HTRW)

Due to the extent of the project, no preliminary assessment was performed to identify the possibility of hazardous waste on the sites. These studies will be conducted during the next phase of work. See Sections 3.2.8 and 6.16 of the Main Report for a discussion on HTRW.

3.3.11.19 Public Law 91-646, Relocation Assistance Benefits

The Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970 establishes a uniform policy for fair and equitable treatment of persons displaced as a result of federal and federally assisted programs in order that such persons shall not suffer disproportionate injuries as a result of programs designed for the benefits of the public as a whole. A qualified displaced person may be entitled to certain relocation assistance benefits which include reimbursement of moving costs and a replacement housing benefit. Moving expense can be reimbursed either based on actual costs or a fixed moving cost schedule. The replacement housing payment is separated into 3 basic types - purchase supplement, rental assistance and down payment. All replacement housing must be decent, safe, and sanitary (DSS) before a replacement housing payment can be made.

Table 3.3.11.19-1 shows the number of expected relocations for each Option. No relocation plan has been completed nor has a relocation survey been done. All estimates are based on information from county public records. The number of business relocations as compared to residential relocations is unknown. In order to accomplish the relocation activity in a timely manner, the plan set forth in Chapter 2. Section 2.5 can be used.

Table 3.3.11.19-1.
PL 91-646 - Relocation Assistance

Option	Number of Relocations
Option A	536
Option B	602
Option C	550
Option D	623
Option E	1870
Option F	1926
Option G	1939
Option H	1994

3.3.11.20 Attitude of Property Owners

Real Estate has not interviewed property owners or tenants during the study phase for the MsCIP. However, numerous public meetings have been held at different locations throughout the study area to inform stakeholders and property owners about the study and the protective measures under consideration for the Mississippi coastal area. A number of local newspapers have published articles that discuss the MsCIP study and the perceived positive effects as well as the negative impacts that may occur as a result of the project. Some of these articles can be found on web sites. While many of the locals may welcome the benefits of the proposed project, there are some who oppose the project.

3.3.11.21 Acquisition Schedule

An acquisition schedule will be developed when plans and specifications become available and more definite information is available pertaining to the specific areas and number of parcels for acquisition. The acquisition schedule will be developed during PED and will be a joint effort of the NFS, the project manager and Real Estate. The schedule will set forth a time line for title, survey, appraisal, negotiation, preparation of documents and closing activity. After acquisition activity is completed certification of lands acquired/owned by the sponsor will be necessary prior to advertisement for construction. The Certification of Real Estate can be accomplished within 30 - 60 days after acquisition. See Chapter 2. Section 2.5. for discussion on an acquisition implementation/management plan.

3.3.11.22 Estates for Proposed Project

All lands required for the levee will be acquired in Fee Simple. Should a borrow site be required, the Borrow Easement will be used. The Temporary Work Area Easement will be used for staging or temporary work areas, and for drainage ditches constructed outside the footprint of the levee, fee or the Drainage Ditch Easement will be used as appropriate. The estates recommended are standard estates.

FEE.

The fee simple title to (the land described in Schedule A) l/(Tracts Nos. ____, ____ and ___), subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

BORROW EASEMENT.

A (temporary) (perpetual and assignable) right and easement to clear, borrow, excavate and remove sand, soil, dirt, and other materials from (the land described in Schedule A) (Tracts Nos. _____, _____ and _____); subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines; reserving, however, to the landowners, their heirs and assigns, all such rights and privileges in said land as may be used without interfering with or abridging the rights and easement hereby acquired.

TEMPORARY WORK AREA EASEMENT.

A temporary easement and right-of-way in, on, over and across (the land described in Schedule A) (Tracts Nos. _____, _____ and _____), for a period not to exceed ___________________, beginning with date possession of the land is granted to the Project Sponsor, for use by the Project Sponsor, its representatives, agents, and contractors as a work area, including the right to deposit backfill, move, store and remove equipment and supplies, and erect and remove temporary structures on the land and to perform any other work necessary and incident to the construction of the ________________ Project, together with the right to trim, cut, fell and remove there from all trees, underbrush, obstructions, and any other vegetation, structures, or obstacles within the limits of the right-of-way; reserving, however, to the landowners, their heirs and assigns, all such rights and privileges as may be used without interfering with or abridging the rights and easement hereby acquired; subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

DRAINAGE DITCH EASEMENT.

A perpetual and assignable easement and right-of-way in, over and across (the land described in Schedule A) (Tracts Nos. ____, ____ and _____) to construct, maintain, repair, operate, patrol and replace a drainage ditch, reserving, however, to the owners, their heirs and assigns, all such rights and privileges in the land as may be used without interfering with or abridging the rights and easement hereby acquired; subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

3.3.11.23 Real Estate Estimate

A summary of cost for each option is at Table 3.3.11.23-1. The real estate estimates at Tables 3.3.11.23-2 through 3.3.11.23-9 include the land cost for acquisition of land, relocation benefits to include a replacement housing payment and fixed rate move expenses, and Federal and non-Federal administrative costs. Administrative costs are those costs incurred for verifying ownership of lands, certification of those lands required for project purposes, legal opinions, analysis or other requirements that may be necessary, during PED. No cost is included for a borrow site or temporary work area. The requirement, if any, for a borrow site or temporary work area will be identified during PED. If further real estate requirements are identified during PED or if there is a significant increase in cost, a supplement to the Real Estate Appendix will be prepared. A 25% contingency is applied to the current estimate.

Table 3.3.11.23-1.
Real Estate Cost Summary

Option	Impacted Parcels	Relocations	Total Cost
Option A - 20.0	1,075	536	$237,004,000
Option B - 30.0	1,203	602	$256,517,000
Option C - 20.0	1,175	550	$278,147,000
Option D - 30.0	1,321	623	$297,899,000
Option E - 20.0	2,964	1,870	$520,145,000
Option F - 30.0	3,076	1,926	$533,059,000
Option G - 20.0	3,138	1,939	$574,040,000
Option H - 30.0	3,253	1,994	$584,742,000

Table 3.3.11.23-2.
LOD3 Jackson County Ring Levee, Pascagoula/Moss Point - Option A
20.0 Estimate

a. Lands and Improvements/Permits					
954 Ownerships for Levee, 474 Improvements					137,828,453
93 Ownerships for Ditches, 62 Improvements					7,463,013
28 Pump Stations					1,085,233
1,075 Ownerships				Subtotal	146,376,699
b. Mineral Rights					0
c. Damages					0
d. P.L. 91-646 Relocation costs - 536 relocations					15,019,200
e. Administrative Cost					28,207,500
		Relocation	Acquisition	Total	
	Federal	804,000	2,687,500	3,491,500	
	Non-Federal	3,216,000	21,500,000	24,716,000	
		4,020,000	24,187,500	28,207,500	
Sub-Total					189,603,399
Contingencies (25%)					47,400,850
	Totals				**237,004,249**
	Rounded				**237,004,000**

Table 3.3.11.23-3.
LOD3 Jackson County Ring Levee, Pascagoula/Moss Point - Option B
30.0 Estimate

a. Lands and Improvements/Permits				
1,104 Ownerships for Levee, 557 Improvements				150,053,939
71 Ownerships for Ditches, 45 Improvements				5,641,239
28 Pump Stations				1,085,233
1,203 Ownerships			subtotal	156,780,411
b. Mineral Rights				0
c. Damages				0
d. P.L. 91-646 Relocation costs - 602 relocations				16,850,400
e. Administrative Cost				31,582,500
	Relocation	Acquisition	Total	
Federal	903,000	3,007,500	3,910,500	
Non-Federal	3,612,000	24,060,000	27,672,000	
	4,515,000	27,067,500	31,582,500	
Sub-Total				205,213,311
Contingencies (25%)				51,303,328
Totals				**256,516,639**
Rounded				**256,517,000**

Table 3.3.11.23-4.
LOD3 Jackson County Ring Levee, Washington Avenue Alternate Alignment - Option C 20.0 Estimate

a. Lands and Improvements/Permits		
926 Ownerships for Levee, 464 Improvements		128,375,987
168 Ownerships for Buffer, 58 Improvements		43,205,925
54 Ownerships for Ditches, 28 Improvements		3,926,389
27 Pump Stations		1,046,475
1,175 Ownerships	Subtotal	176,554,776
b. Mineral Rights		0
c. Damages		0
d. P.L. 91-646 Relocation costs - 550 relocations		15,400,000
e. Administrative Cost		30,562,500

	Relocation	Acquisition	Total
Federal	825,000	2,937,500	3,762,500
Non-Federal	3,300,000	23,500,000	26,800,000
	4,125,000	26,437,500	30,562,500

Sub-Total		222,517,276
Contingencies (25%)		55,629,319
	Totals	**278,146,595**
	Rounded	**278,147,000**

Table 3.3.11.23-5.
LOD3 Jackson County Ring Levee, Washington Avenue Alternate Alignment - Option D 30.0 Estimate

a. Lands and Improvements/Permits		
1,099 Ownerships for Levee, 548 Improvements		142,777,351
141 Ownerships for Buffer, 47 Improvements		38,729,810
54 Ownerships for Ditches, 28 Improvements		3,926,389
27 Pump Stations		1,046,475
1,321 Ownerships	Subtotal	186,480,025
b. Mineral Rights		0
c. Damages		0
d. P. L. 91-646 Relocation costs - 623 relocations		17,444,000
e. Administrative Cost		34,395,000

	Relocation	Acquisition	Total
Federal	934,500	3,302,500	4,237,000
Non-Federal	3,738,000	26,420,000	30,158,000
	4,672,500	29,722,500	34,395,000

Sub-Total		238,319,025
Contingencies (25%)		59,579,756
	Totals	**297,898,781**
	Rounded	**297,899,000**

Table 3.3.11.23-6.
LOD3 Jackson County Ring Levee, Moss Point Alternate Alignment - Option E 20.0 Estimate

a. Lands and Improvements/Permits					
850 Ownerships for Levee, 385 Improvements					110,203,673
2,001 Ownerships for Buffer, 1,444 Improvements					168,271,915
89 Ownerships for Ditches, 41 Improvements					3,634,894
24 Pump Stations					930,200
2,964 Ownerships				Subtotal	283,040,682
b. Mineral Rights					0
c. Damages					0
d. P.L. 91-646 Relocation costs - 1,870 relocations					52,360,000
e. Administrative Cost					80,715,000
		Relocation	Acquisition	Total	
	Federal	2,805,000	7,410,000	10,215,000	
	Non-Federal	11,220,000	59,280,000	70,500,000	
		14,025,000	66,690,000	80,715,000	
Sub-Total					416,115,682
Contingencies (25%)					104,028,921
	Totals				**520,144,603**
	Rounded				**520,145,000**

Table 3.3.11.23-7.
LOD3 Jackson County Ring Levee, Moss Point Alternate Alignment - Option F 30.0 Estimate

a. Lands and Improvements/Permits					
997 Ownerships for Levee, 464 Improvements					118,287,317
1,987 Ownerships for Buffer, 1,433 Improvements					166,979,295
68 Ownerships for Ditches, 29 Improvements					2,667,427
24 Pump Stations					930,200
3,076 Ownerships				Subtotal	288,864,239
b. Mineral Rights					0
c. Damages					0
d. P.L. 91-646 Relocation costs - 1,926 relocations					53,928,000
e. Administrative Cost					83,655,000
		Relocation	Acquisition	Total	
	Federal	2,889,000	7,690,000	10,579,000	
	Non-Federal	11,556,000	61,520,000	73,076,000	
		14,445,000	69,210,000	83,655,000	
Sub-Total					426,447,239
Contingencies (25%)					106,611,810
		Totals			**533,059,049**
		Rounded			**533,059,000**

Table 3.3.11.23-8.
LOD3 Jackson County Ring Levee, Combined Washington Avenue and Moss Point Alternate Alignment - Option G 20.0 Estimate

a. Lands and Improvements/Permits		
819 Ownerships for Levee, 384 Improvements		100,728,605
2,169 Ownerships for Buffer, 1,502 Improvements		211,477,840
127 Ownerships for Ditches, 53 Improvements		6,694,928
23 Pump Stations		891,442
3,138 Ownerships	Subtotal	319,792,815
b. Mineral Rights		0
c. Damages		0
d. P.L. 91-646 Relocation costs - 1,939 relocations		54,292,000
e. Administrative Cost		85,147,500

	Relocation	Acquisition	Total
Federal	2,908,500	7,845,000	10,753,500
Non-Federal	11,634,000	62,760,000	74,394,000
	14,542,500	70,605,000	85,147,500

Sub-Total	459,232,315
Contingencies (25%)	114,808,079
Totals	**574,040,394**
Rounded	**574,040,000**

Table 3.3.11.23-9.
LOD3 Jackson County Ring Levee, Combined Washington Avenue and Moss Point Alternate Alignment - Option H 30.0 Estimate

a. Lands and Improvements/Permits		
991 Ownerships for Levee, 467 Improvements		111,202,627
2,128 Ownerships for Buffer, 1,480 Improvements		205,709,105
111 Ownerships for Ditches, 47 Improvements		6,010,699
23 Pump Stations		891,442
3,253 Ownerships	Subtotal	323,813,873
b. Mineral Rights		0
c. Damages		0
d. P.L. 91-646 Relocation costs - 1,994 relocations		55,832,000
e. Administrative Cost		88,147,500

	Relocation	Acquisition	Total
Federal	2,991,000	8,132,500	11,123,500
Non-Federal	11,964,000	65,060,000	77,024,000
	14,955,000	73,192,500	88,147,500

Sub-Total	467,793,373
Contingencies (25%)	116,948,343
Totals	**584,741,716**
Rounded	**584,742,000**

3.3.11.24 Summary of Potential Real Estate Issues

The requirement for temporary work areas, disposal or borrow areas has not been identified. Should these areas be required, these would be considered as part of the LERRD requirements. Typically if disposal or borrow sites are required, Real estate would provide an analysis during PED to compare the cost of acquiring an these sites with the cost of using a commercial sites and make a determination which method is most cost effective. See Section 2.8 Borrow Areas on page 5.

Should drainage ditches, temporary work areas, disposal or borrow areas become a necessary real estate acquisition requirement, valuation of lands will be performed. Land costs associated with these areas, and administrative costs will be added to the Real Estate Cost Estimate. If further real estate requirements are identified during PED or if there is a significant increase in cost, a supplement to the Real Estate Appendix will be prepared.

Any requirements for relocation contracts pertaining to facilities/utilities will be identified and completed during PED.

Any requirement for mitigation lands will be identified during PED.

Should condemnation of any required real estate interest be necessary, it is the responsibility of the NFS. This issue is addressed during the Assessment of the Non-Federal Sponsor's Real Estate

Acquisition Capability. However, if the real estate interest is one that the NFS does not have authority to condemn, the Federal Government can perform the condemnation on behalf of the NFS.

A relocation plan will need to be completed during PED to address potential relocation activity under P.L. 91-646. There are a number of factors pertaining to relocations that can impact the project both in cost and in schedule. Payments for Housing of Last Resort, which would exceed the standard housing replacement payments, are very likely due to the size of the project and the lack of available decent, safe and sanitary housing in the area. Another factor that could increase cost and impact schedule is the cost of business relocations. Depending on the type of business and the operation, this could involve moving equipment and machinery to new locations. It is necessary to interview each impacted individual and business during Pre-Construction, Engineering and Design Phase to determine the requirements for relocation and to estimate a cost for the relocation.

3.3.11.25 Chart of Accounts

The cost estimate for all Federal and non-Federal real estate activities necessary for implementation of the project after completion of the feasibility study for land acquisition, construction, LERRD, and other items are coded as delineated in the Cost Work Breakdown Structure (CWBS). This real estate cost estimate is then incorporated into the Total Current Working Estimate utilizing the Microcomputer Aided Cost Engineering System (MCACES). The Chart of Accounts at Tables 3.3.11.25-1 through 3.3.11.25-8 shows the CWBS for real estate activities.

Table 3.3.11.25-1.
Chart of Accounts - LOD3 Jackson County Ring Levee, Pascagoula/Moss Point - Option A

01A	Project Planning	Federal	Non-Federal	Totals
	Other			
	Project Cooperation Agreement			
01AX	Contingencies (25%)			
	Subtotal			
01B	Lands and Damages/Permits			
01B40	Acquisition/Review of NFS	2,687,500		2,687,500
01B20	Acquisition by NFS		21,500,000	21,500,000
01BX	Contingencies (25%)	671,875	5,375,000	6,046,875
	Subtotal	3,359,375	26,875,000	30,234,375
01F	PL 91-646 Assistance			
01F20	By NFS		3,216,000	3,216,000
01FX	Contingencies (25%)		804,000	804,000
	Subtotal		4,020,000	4,020,000
01R	Real Estate Land Payments			
01R1B	Land Payments by NFS		146,376,699	146,376,699
01R2B	PL91-646 Relocation Payment by NFS		15,019,200	15,019,200
01R2D	Review of NFS	804,000		804,000
01RX	Contingencies (25%)	201,000	40,348,975	40,549,975
	Subtotal	1,005,000	201,744,874	202,749,874
	Totals	**4,364,375**	**232,639,874**	**237,004,249**
	Rounded			**237,004,000**

Table 3.3.11.25-2.
Chart of Accounts - LOD3 Jackson County Ring Levee, Pascagoula/Moss Point - Option B

01A	Project Planning	Federal	Non-Federal	Totals
	Other			
	Project Cooperation Agreement			
01AX	Contingencies (25%)			
	Subtotal			
01B	Lands and Damages/Permits			
01B40	Acquisition/Review of NFS	3,007,500		3,007,500
01B20	Acquisition by NFS		24,060,000	24,060,000
01BX	Contingencies (25%)	751,875	6,015,000	6,766,875
	Subtotal	3,759,375	30,075,000	33,834,375
01F	PL 91-646 Assistance			
01F20	By NFS		3,612,000	3,612,000
01FX	Contingencies (25%)		903,000	903,000
	Subtotal		4,515,000	4,515,000
01R	Real Estate Land Payments			
01R1B	Land Payments by NFS		156,780,411	156,780,411
01R2B	PL91-646 Relocation Payment by NFS		16,850,400	16,850,400
01R2D	Review of NFS	903,000		903,000
01RX	Contingencies (25%)	225,750	43,407,703	43,633,453
	Subtotal	1,128,750	217,038,514	218,167,264
	Totals	**4,888,125**	**251,628,514**	**256,516,639**
	Rounded			**256,517,000**

Table 3.3.11.25-3.
Chart of Accounts - LOD3 Jackson County Ring Levee, Washington Avenue Alternate Alignment - Option C

01A	Project Planning	Federal	Non-Federal	Totals
	Other			
	Project Cooperation Agreement			
01AX	Contingencies (25%)			
	Subtotal			
01B	Lands and Damages/Permits			
01B40	Acquisition/Review of NFS	2,937,500		2,937,500
01B20	Acquisition by NFS		23,500,000	23,500,000
01BX	Contingencies (25%)	734,375	5,875,000	6,609,375
	Subtotal	3,671,875	29,375,000	33,046,875
01F	PL 91-646 Assistance			
01F20	By NFS		3,300,000	3,300,000
01FX	Contingencies (25%)		825,000	825,000
	Subtotal		4,125,000	4,125,000
01R	Real Estate Land Payments			
01R1B	Land Payments by NFS		176,554,776	176,554,776
01R2B	PL91-646 Relocation Payment by NFS		15,400,000	15,400,000
01R2D	Review of NFS	825,000		825,000
01RX	Contingencies (25%)	206,250	47,988,694	48,194,944
	Subtotal	1,031,250	239,943,470	240,974,720
	Totals	**4,703,125**	**273,443,470**	**278,146,595**
	Rounded			**278,147,000**

Table 3.3.11.25-4.
Chart of Accounts - LOD3 Jackson County Ring Levee, Washington Avenue Alternate Alignment - Option D

01A	Project Planning	Federal	Non-Federal	Totals
	Other			
	Project Cooperation Agreement			
01AX	Contingencies (25%)			
	Subtotal			
01B	Lands and Damages/Permits			
01B40	Acquisition/Review of NFS	3,302,500		3,302,500
01B20	Acquisition by NFS		26,420,000	26,420,000
01BX	Contingencies (25%)	825,625	6,605,000	7,430,625
	Subtotal	4,128,125	33,025,000	37,153,125
01F	PL 91-646 Assistance			
01F20	By NFS		3,738,000	3,738,000
01FX	Contingencies (25%)		934,500	934,500
	Subtotal		4,672,500	4,672,500
01R	Real Estate Land Payments			
01R1B	Land Payments by NFS		186,480,025	186,480,025
01R2B	PL91-646 Relocation Payment by NFS		17,444,000	17,444,000
01R2D	Review of NFS	934,500		934,500
01RX	Contingencies (25%)	233,625	50,981,006	51,214,631
	Subtotal	1,168,125	254,905,031	256,073,156
	Totals	**5,296,250**	**292,602,531**	**297,898,781**
	Rounded			**297,899,000**

Table 3.3.11.25-5.
Chart of Accounts - LOD3 Jackson County Ring Levee, Moss Point Alternate Alignment - Option E

01A	Project Planning	Federal	Non-Federal	Totals
	Other			
	Project Cooperation Agreement			
01AX	Contingencies (25%)			
	Subtotal			
01B	Lands and Damages/Permits			
01B40	Acquisition/Review of NFS	7,410,000		7,410,000
01B20	Acquisition by NFS		59,280,000	59,280,000
01BX	Contingencies (25%)	1,852,500	14,820,000	16,672,500
	Subtotal	9,262,500	74,100,000	83,362,500
01F	PL 91-646 Assistance			
01F20	By NFS		11,220,000	11,220,000
01FX	Contingencies (25%)		2,805,000	2,805,000
	Subtotal		14,025,000	14,025,000
01R	Real Estate Land Payments			
01R1B	Land Payments by NFS		283,040,682	283,040,682
01R2B	PL91-646 Relocation Payment by NFS		52,360,000	52,360,000
01R2D	Review of NFS	2,805,000		2,805,000
01RX	Contingencies (25%)	701,250	83,850,171	84,551,421
	Subtotal	3,506,250	419,250,853	422,757,103
	Totals	**12,768,750**	**507,375,853**	**520,144,603**
	Rounded			**520,145,000**

Table 3.3.11.25-6.
Chart of Accounts - LOD3 Jackson County Ring Levee, Moss Point
Alternate Alignment -
Option F

01A	Project Planning	Federal	Non-Federal	Totals
	Other			
	Project Cooperation Agreement			
01AX	Contingencies (25%)			
	Subtotal			
01B	Lands and Damages/Permits			
01B40	Acquisition/Review of NFS	7,690,000		7,690,000
01B20	Acquisition by NFS		61,520,000	61,520,000
01BX	Contingencies (25%)	1,922,500	15,380,000	17,302,500
	Subtotal	9,612,500	76,900,000	86,512,500
01F	PL 91-646 Assistance			
01F20	By NFS		11,556,000	11,556,000
01FX	Contingencies (25%)		2,889,000	2,889,000
	Subtotal		14,445,000	14,445,000
01R	Real Estate Land Payments			
01R1B	Land Payments by NFS		288,864,239	288,864,239
01R2B	PL91-646 Relocation Payment by NFS		53,928,000	53,928,000
01R2D	Review of NFS	2,889,000		2,889,000
01RX	Contingencies (25%)	722,250	85,698,060	86,420,310
	Subtotal	3,611,250	428,490,299	432,101,549
	Totals	**13,223,750**	**519,835,299**	**533,059,049**
	Rounded			**533,059,000**

Table 3.3.11.25-7.
Chart of Accounts - LOD3 Jackson County Ring Levee, Combined Washington Avenue and Moss Point Alternate Alignment - Option G

01A	Project Planning	Federal	Non-Federal	Totals
	Other			
	Project Cooperation Agreement			
01AX	Contingencies (25%)			
	Subtotal			
01B	Lands and Damages/Permits			
01B40	Acquisition/Review of NFS	7,845,000		7,845,000
01B20	Acquisition by NFS		62,760,000	62,760,000
01BX	Contingencies (25%)	1,961,250	15,690,000	17,651,250
	Subtotal	9,806,250	78,450,000	88,256,250
01F	PL 91-646 Assistance			
01F20	By NFS		11,634,000	11,634,000
01FX	Contingencies (25%)		2,908,500	2,908,500
	Subtotal		14,542,500	14,542,500
01R	Real Estate Land Payments			
01R1B	Land Payments by NFS		319,792,815	319,792,815
01R2B	PL91-646 Relocation Payment by NFS		54,292,000	54,292,000
01R2D	Review of NFS	2,908,500		2,908,500
01RX	Contingencies (25%)	727,125	93,521,204	94,248,329
	Subtotal	3,635,625	467,606,019	471,241,644
	Totals	**13,441,875**	**560,598,519**	**574,040,394**
	Rounded			**574,040,394**

Table 3.3.11.25-8.
Chart of Accounts - LOD3 Jackson County Ring Levee, Combined Washington Avenue and Moss Point Alternate Alignment - Option H

01A	Project Planning	Federal	Non-Federal	Totals
	Other			
	Project Cooperation Agreement			
01AX	Contingencies (25%)			
	Subtotal			
01B	Lands and Damages/Permits			
01B40	Acquisition/Review of NFS	8,132,500		8,132,500
01B20	Acquisition by NFS		65,060,000	65,060,000
01BX	Contingencies (25%)	2,033,125	16,265,000	18,298,125
	Subtotal	10,165,625	81,325,000	91,490,625
01F	PL 91-646 Assistance			
01F20	By NFS		11,964,000	11,964,000
01FX	Contingencies (25%)		2,991,000	2,991,000
	Subtotal		14,955,000	14,955,000
01R	Real Estate Land Payments			
01R1B	Land Payments by NFS		323,813,873	323,813,873
01R2B	PL91-646 Relocation Payment by NFS		55,832,000	55,832,000
01R2D	Review of NFS	2,991,000		2,991,000
01RX	Contingencies (25%)	747,750	94,911,468	95,659,218
	Subtotal	3,738,750	474,557,341	478,296,091
	Totals	**13,904,375**	**570,837,341**	**584,741,716**
	Rounded			**584,742,000**

3.4 Line of Defense 4 - Inland Barrier and Surge Gates

To preserve the shoreline environment as much as possible, a 4th line of defense for very large storms is envisioned that would be inland from the coast. This line of defense would be the highest line and could contain a larger storm surge up to that associated with a "Maximum Possible Intensity" (MPI) hurricane. Storms that will be modeled against this line will vary from a Camille type storm up to the MPI. This alignment would follow the same path as the railway that crosses the state near the coast but not cross either the Pearl River in Hancock County to the west or the Pascagoula River in Jackson County to the east. In Harrison County, this pathway is through heavily populated and commercial zones. The first major watershed divide west of the Pascagoula River was selected to turn the barrier north and extend it to a location beyond the extent of the storm surge associated with a MPI event. Similarly to the west in Hancock County, LOD-4 follows the railway to a watershed divide that is located east of the Pearl River where it follows the divide north to the MPI line. Both of these northward extensions will cross the path of Interstate 10 and may dictate some modifications to the highway depending on the selected top elevation of the line.

In order to protect much of the developed areas around Biloxi and St. Louis Bays, LOD-4 would have to include a structural surge barrier that would also cross the mouth of these bays. These surge barriers, when closed, would prevent storm surge from moving in through the inlets of the bays. The structural barriers across the bays could be similar to designs used in Europe for storm surge protection.

LOD-4 could also be designed to have roadways, even major highways on top if desired. This line would be the highest defense, but would not protect structures seaward from the larger storms that might overtop Line 3. All facilities seaward of Line 4 would be prone to flooding in a large storm, so flood-proofing would be necessary in this zone. As described prior, this barrier would extend from high ground east of the Pearl River to high ground west of the Pascagoula River for a distance of approximately 57 miles. It would not cross either of these river systems.

3.4.1 Hancock County Inland Barrier

Several high density residential and business areas are located in Hancock County. These are subject to damage from storm surges associated with hurricanes. Earthen levees were evaluated for protection of these areas. The levees were evaluated at elevations 20 ft NAVD88 and 30 ft NAVD88 and 40 ft NAVD88. The top width was assumed 15 ft with side-slopes of 1 vertical to 3 horizontal. These alternatives are Identified as Option A, Option B and Option C. Storm surge gates across St Louis Bay are also included to prevent flooding from hurricanes.

Hancock County is located on the west side of the Mississippi coast of Mississippi Sound as shown in Figure 3.4.1-1. The main residential and business areas are at Bay St Louis and Waveland. Ground elevations over the areas behind the levee vary between elevations 10-20 ft NAVD88 at low areas to as low as 5 ft NAVD88 in the Shoreline Park area. The area drains to the south along the coast to Mississippi Sound, to the north and east to St Louis Bay, and on the far west to Pearl River. The location of the levee in Hancock County is parallel to the CSX Railroad and the coast and turns northward across I-10 to tie into the corresponding elevation.

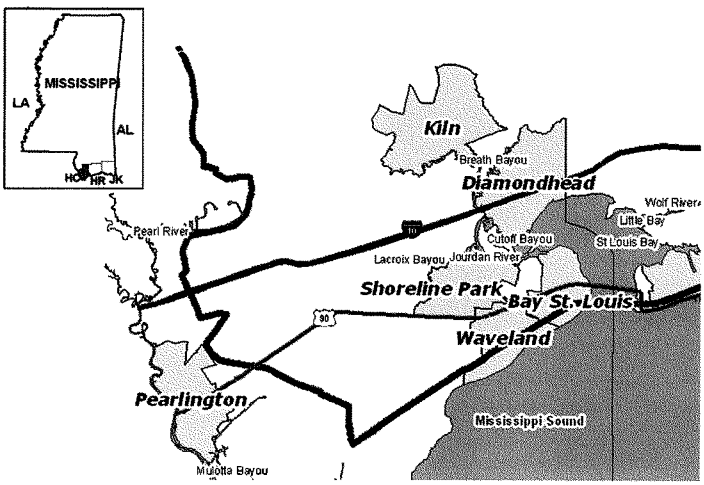

Figure 3.4.1-1
Vicinity Map Hancock County, MS

3.4.1.1 Option A - Elevation 20.0 ft NAVD88

This option consists of an earthen dike across the high ground of the county along with the internal sub-basins and levee culvert/pump locations. The levee would have a top width of 15 ft and slopes of 1 vertical to 3 horizontal. The levee is located mostly along high ground so ponding at the levee would be minimal. However, some ditching for drainage would be required on the outside of the levee.

3.4.1.2 Option B - Elevation 30.0 ft NAVD88

The alignment of the levee is the same as Option A, above but with an elevation of 30.0 feet. The only difference between the description of this option and preceding description of Option A is the height of the levee, pumping facilities, number of roadway and railroad intersections, and the length of the levee culverts.

3.4.1.3 Option C - Elevation 40.0 ft NAVD88

The alignment of the levee is the same as Option A, above but with an elevation of 40.0 feet. The only difference between the description of this option and preceding description of Option A is the height of the levee, pumping facilities, number of roadway and railroad intersections, and the length of the levee culverts.

3.4.1.4 Project Description

Figures 3.4.1.4-1 through 3.4.1.4-3 show the location of the proposed project alternatives. As described above, the inland barrier will be an earthen levee constructed either at elevation 20.0 feet, 30.0 or 40.0 feet along with the internal sub-basins and levee culvert/pump locations. Drainage on the interior of the ring levee would be collected at the levee and channeled to culverts placed in the levee. 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. In addition, pumps would be constructed near the outflow points to remove water from the interior during storm events occurring when the culverts are closed because of high water in the sound. Drainage ditches along the toe of the levee will be required to assure that smaller basins can be drained to a culvert/pump site. Figures 3.4.1.4-4 through 3.4.1.4-6 show the proposed locations of the pump/culvert sites. 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. Further studies will detail the requirement for the appropriate ponding areas, pump sizes, or buyouts in the affected areas.

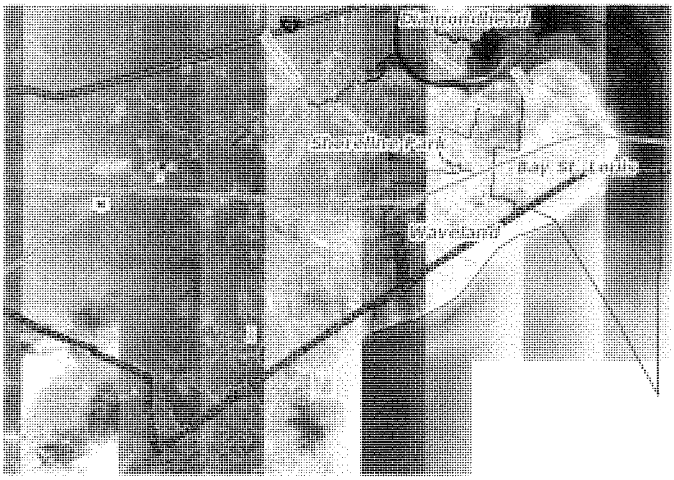

Figure 3.4.1.4-1.
Hancock County Inland Barrier

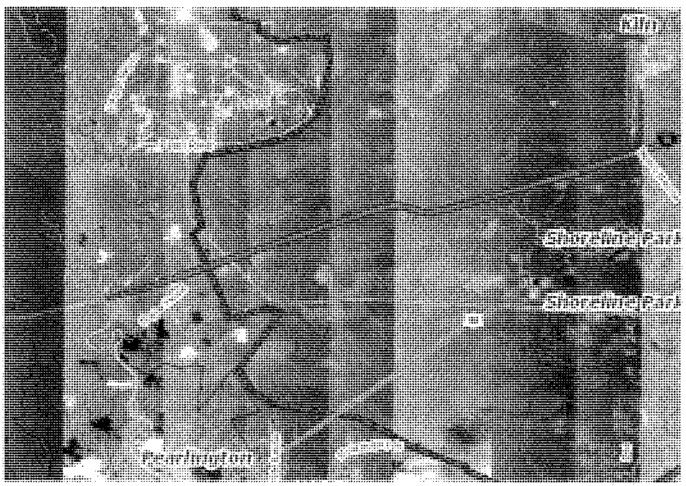

Figure 3.4.1.4-2.
Hancock County Inland Barrier

Figure 3.4.1.4-3.
Hancock County Inland Barrier

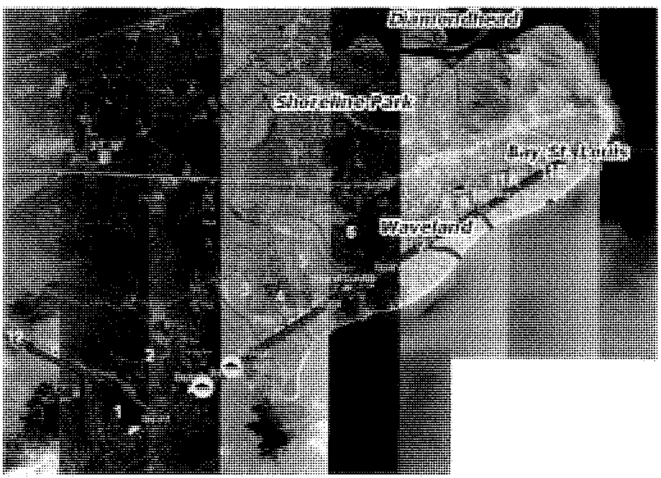

Figure 3.4.1.4-4.
Pump/Culvert/Sub-basins/Boat Access Site Locations

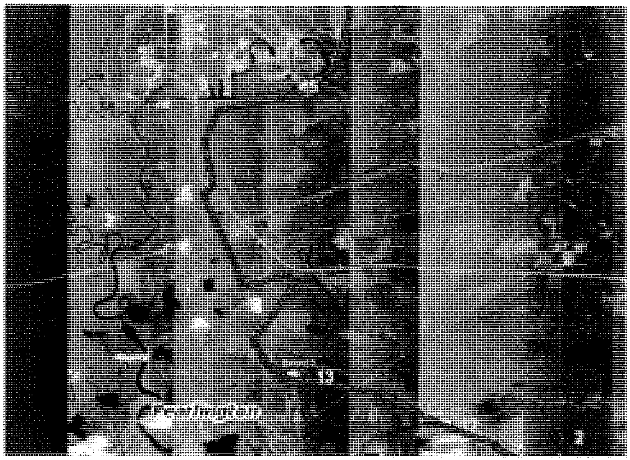

Figure 3.4.1.4-5.
Pump/Culvert/Sub-basin Site Locations

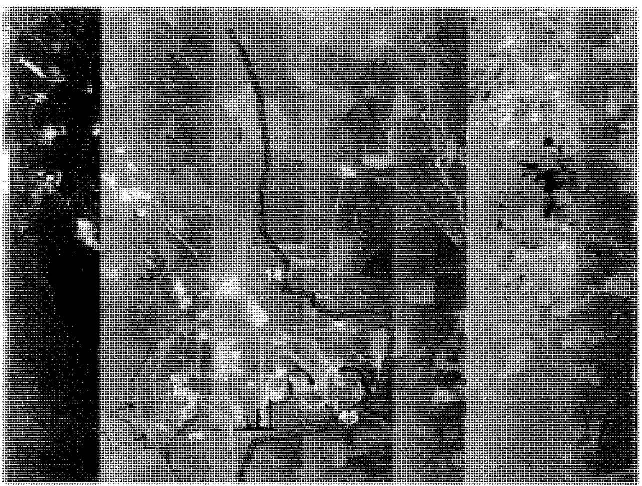

Figure 3.4.1.4-6.
Pump/Culvert/Sub-basin Site Locations

The inland barrier earthen levee section will have one vertical to three horizontal side slopes with a fifteen foot crest width. All work areas to receive fill shall be cleared and grubbed of all trees and surface organics and all existing foundations, streets, utilities, etc. will be removed and the subsequent cavities backfilled and compacted. The levee will be constructed of sand clay materials obtained from off site commercial sources, and trucked to the work area. The final surface will be armored by the placement of 24 inch thick gabion mattress filled with small stone for erosion protection during an event that overtops the levee. The armoring will be anchored on the front face by trenching and extend across the downstream slope and a 25 foot area beyond the toe. The front side of the levee and all non critical surface areas will be subsequently covered by grassing. In order to maintain the natural runoff patterns culverts would be inserted through the protection line at appropriate locations. For Options A, B, and C, drainage features would be required at 16 locations ranging from 20-inch diameter reinforced concrete pipe to reinforced concrete box culverts having 11 water passages, each measuring 12' wide by 4' high. Each water passage would be fitted with both a flap gate at the outlet end and a sluice gate placed near the center of the culvert with a vertical operator stem extending through an access shaft to the top of levee elevation.

Road crossings will incorporate small gate structures or ramping over the embankment where the surface elevation is near that of the crest elevation. The elevation relationship of the crest and the adjacent railroad will be a governing factor. At each point where a roadway crosses the protection line the decision must be made whether to maintain this artery and adapt the protection line to accommodate it, or to terminate the artery at the protection line and divert traffic to cross the protection line at another location. For this study it was assumed that all roadways and railways crossing the levee alignment would be retained except where it was very evident that traffic could be combined without undue congestion. Once the decision has been made to retain a particular roadway, it must then be determined how best to configure the artery to conduct traffic across the protection line. The simplest means of passing roadway traffic is to ramp the roadway over the protection line. This alternative is not always viable because of severe right-of-way restraints caused by extreme levee height, urban congestion, etc. In such instances other methods can be used including partial ramping in combination with low profile roller gates. In more restricted areas full height gates which would leave the roadway virtually unaltered might be preferable, even though this alternative would usually be more costly than ramping. In some extreme circumstances where high levees are required to pass through very congested areas, installation of tunnels with closure gates may be required.

Because of the extreme gradient restrictions necessarily placed on railway construction, it is practically never acceptable to elevate a railway up and over a levee. Therefore, the available alternatives would include gated pass through structures. Because of the vertical clearance requirements of railroad traffic all railroad pass through structures for this study were configured having vertical walls on either side of the railway with double swing gates extending to the full height of the levee. With the installation of a ring levee at Option A, elevation 20.0, 14 roadway/railroad intersections would have to be accommodated. For this study it was estimated that 4 roller gate structures and 6 swing gate structures would be required. In addition, 4 railroad gate structures would be required. At Option B, elevation 30.0, 31 roadway/railroad intersections would have to be accommodated, and it was estimated that 9 roller gate structures and 18 swing gate structures would be required. In addition, 4 railroad gate structures would be required. At Option C, elevation 40.0, 40 roadway/railroad intersections would have to be accommodated, and it was estimated that all 36 of the highway crossings would require swing gates. In addition, 4 railroad gate structures would be required.

The features that require periodic operations will be the exercising of the pumps and emergency generators at the various pump stations, the testing of the gate structures at the various road crossings, grass cutting of the levee slopes and toe areas and the filling of rilled areas within the embankment due to surface erosion. Scheduled maintenance should include periodic greasing of all gears and coupled joints, maintaining any battery backup systems, and replacement of standby fuel supplies.

3.4.1.5 Real Estate Requirements

Real Estate requirements for Line of Defense 4, Hancock County Levee include lands, easements, rights-of-way and relocations, and disposal/borrow areas (LERRD), and the right to construct an earthen levee, drainage ditches and 3 pump station facilities.

Based on the footprint of the Option A, 20.0 foot elevation, it was determined that approximately 426 parcels and 160 structures would be impacted. The acreage to be acquired for the levee is unknown. It is known that the 3 pump stations will require approximately 0.23 of an acre each for a total of 0.69 of an acre. Lands required for construction of the levee will be acquired in fee simple interest. Based on the number of structures being impacted, the assumption is that there will be 160 relocations.

Based on the footprint of the Option B, 30.0 foot elevation, it was determined that 484 parcels and 186 structures would be impacted. The acreage to be acquired for the levee is unknown. It is known that the 3 pump stations will require approximately 0.23 of an acre each for a total of 0.69 of an acre. Lands required for construction of the levee will be acquired in fee simple interest. Based on the number of structures being impacted, the assumption is that there will be 186 relocations.

Based on the footprint of the Option C, 40.0 foot elevation, it was determined that 537 parcels and 209 structures would be impacted. The acreage to be acquired for the levee is unknown. It is known that the 3 pump stations will require approximately 0.23 of an acre each for a total of 0.69 of an acre. Lands required for construction of the levee will be acquired in fee simple interest. Based on the number of structures being impacted, the assumption is that there will be 209 relocations.

Any modifications to the roadways and utilities will most probably need to be accomplished thorough a relocation contract. This will be further investigated and confirmed during PED.

Footprints for drainage ditches are not available at time of this report. However, from the figures it appears that acquisition of additional lands for drainage ditches outside the footprint of the levee will be minimal. Until final plans and specifications are completed, land requirements for drainage ditches are assumed to be covered by contingency. This additional requirement will be determined during PED.

In some areas the levee alignment would cross a moderately sized water course where it is apparent that boats currently traverse the area. To allow continued free boat access to areas behind the levee these water courses will be fitted with a scaled down adaptation of the larger rising sector gate structure used for the bay barriers at Biloxi and Bay St. Louis. A small boat access structure is shown at the mouth of multiple basins in the project footprint. Rising sector gates will be provided at these gates allowing shallow draft traffic most of the time. The gates will be closed prior to hurricane storm surge. No additional real estate interest is identified for boat access points as they fall within the footprint of the project and impacted parcels are included in the total that is projected. For those lands required for construction that lay below the mean high water mark, navigation servitude will apply.

An assumption is made that excavated materials from clearing, snagging, and construction of ditches, etc. will be disposed of in county owned or commercial landfills. However, In the event that the excavated material is not suitable for a landfill a disposal site will have to be acquired. Typically if disposal sites are required, this would be considered as part of the LERRD requirement. Real Estate would provide an analysis during PED to compare the cost of acquiring an upland disposal site with the cost of using a commercial landfill and make a determination which method is most cost effective.

The recommended plan proposes to use material from an inventory of upland borrow sites to construct the levee. A specific site has not been identified or confirmed for use at time of this report. Typically if borrow sites are required, this would be considered a part of the LERRD requirement. Real Estate would provide an analysis during PED to compare the cost of acquiring an upland borrow site with the cost of using a commercial borrow site and make a determination which method is most cost effective. The requirement for temporary work areas is unknown. Sponsor owned lands will be used if available. Otherwise, this may be an additional real estate requirement, and will be further defined during PED.

3.4.1.6 Utility/Facility Relocation

The plan calls for roads to be ramped over the proposed levee and possible relocation of utilities. An assumption is made that this work will be accomplished through a relocation contract. This will be further investigated and confirmed during PED. See Chapter 2 Section 2.10 for more detailed discussion.

3.4.1.7 Existing Projects/Studies

Relevant projects and studies are found in the main report at Section 1.6, History of the Investigation and Section 1.7, Prior and On-Going Studies, Reports and Programs.

3.4.1.8 Environmental Impacts

See the Main Report, Chapter 6. Environmental Effects of Plans and the Environmental Appendix, for a full discussion on environmental effects.

3.4.1.9 Project Sponsor Responsibilities and Capabilities

The State of Mississippi will be the non-Federal Project Sponsor (NFS). The NFS has the responsibility to acquire all real estate interests required for the Project. The NFS shall accomplish all alterations and relocations of facilities, structures and improvements determined by the government to be necessary for construction of the Project.

Title to any acquired real estate will be retained by the Project Sponsor and will not be conveyed to the United States Government. Prior to advertisement of any construction contract, the NFS shall furnish to the government an Authorization for Entry for Construction (Exhibit “A” to the Real Estate Appendix) to all lands, easements and rights-of-way, as necessary. The NFS will also furnish to the government evidence supporting their legal authority to grant rights-of-way to such lands. The NFS shall comply with applicable provisions of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970, Public Law 91-646, approved 2 January 1971, and amended by Title IV of the Surface Transportation Uniform Relocation Assistance Act of 1987, Public Law 100-17, effective 2 April 1989, in acquiring real estate interests for the Project, and inform all affected persons of applicable benefits, policies, and procedures in connection with said Act(s). A form for the Assessment of the Non-Federal Sponsor’s Capability to Acquire Real Estate is at Exhibit “B” to the Real Estate Appendix. The assessment will be made during PED phase.

The non-Federal sponsor is entitled to receive credit against its share of project costs for the value of lands it provides and the value of the relocations that are required for the project. Generally, for the purpose of determining the amount of credit to be afforded, the value of the LER is the fair market value of the real property interest, plus certain incidental costs of acquiring those interests, that the

non-federal sponsor provided for the project as required by the Government. The NFS cannot receive credit for the value of any LER, including incidental costs, which were previously provided as an item of cooperation for another Federal project, including projects that preceded enactment of WRDA 1986.

3.4.1.10 Government Owned Property

There are 18-25 Government owned parcels within the footprint of the project that will be impacted depending on the option recommended for construction. In viewing the footprint, it is noted that the levee will run through the middle of many of these parcels. However, others may have only minimal impact. These lands are in the vicinity of the John C. Stennis Space Center, or within lands shown as NASA Restricted Area on a state map. Land and structure values are not listed in the public records. Ownership is listed in public records as USA or United States of America. Specific impacts to Government owned lands will be determined during PED.

3.4.1.11 Historical Significance

See the Main Report, Section 3.2.9 Cultural and Archaeological Resources, for a general discussion on cultural and archaeological resources.

3.4.1.12 Mineral Rights

There are no known mineral activities within the scope of the proposed project.

3.4.1.13 Hazardous, Toxic, and Radioactive Waste (HTRW)

Due to the extent of the project, no preliminary assessment was performed to identify the possibility of hazardous waste on the sites. These studies will be conducted during the next phase of work. See Sections 3.2.8 and 6.16 of the Main Report for a discussion on HTRW.

3.4.1.14 Public Law 91-646, Relocation Assistance Benefits

The Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970 establishes a uniform policy for fair and equitable treatment of persons displaced as a result of federal and federally assisted programs in order that such persons shall not suffer disproportionate injuries as a result of programs designed for the benefits of the public as a whole. A qualified displaced person may be entitled to certain relocation assistance benefits which include reimbursement of moving costs and a replacement housing benefit. Moving expense can be reimbursed either based on actual costs or a fixed moving cost schedule. The replacement housing payment is separated into 3 basic types - purchase supplement, rental assistance and down payment. All replacement housing must be decent, safe, and sanitary (DSS) before a replacement housing payment can be made.

It is estimated that there are approximately 160 relocations in Option A, approximately 186 relocations in Option B, and approximately 209 relocations in Option C. No relocation plan has been completed nor has a relocation survey been done. All estimates are based on information from county public records. The number of business relocations as compared to residential relocations is unknown. In order to accomplish the relocation activity in a timely manner, the plan set forth in Chapter 2. Section 2.5 can be used.

3.4.1.15 Attitude of Property Owners

Real Estate has not interviewed property owners or tenants during the study phase for the MsCIP. However, numerous public meetings have been held at different locations throughout the study area to inform stakeholders and property owners about the study and the protective measures under consideration for the Mississippi coastal area. A number of local newspapers have published articles that discuss the MsCIP study and the perceived positive effects as well as the negative impacts that may occur as a result of the project. Some of these articles can be found on web sites. While many of the locals may welcome the benefits of the proposed project, there are some who oppose the project.

3.4.1.16 Acquisition Schedule

An acquisition schedule will be developed when plans and specifications become available and more definite information is available pertaining to the specific areas and number of parcels for acquisition. The acquisition schedule will be developed during PED and will be a joint effort of the NFS, the project manager and Real Estate. The schedule will set forth a time line for title, survey, appraisal, negotiation, preparation of documents and closing activity. After acquisition activity is completed certification of lands acquired/owned by the sponsor will be necessary prior to advertisement for construction. The Certification of Real Estate can be accomplished within 30 - 60 days after acquisition. See Chapter 2. Section 2.5. for discussion on an acquisition implementation/management plan.

3.4.1.17 Estates for Proposed Project

All lands required for the levee will be acquired in Fee Simple. Should a borrow site be required, the Borrow Easement will be used. The Temporary Work Area Easement will be used for staging or temporary work areas, and the Drainage Ditch Easement will be used for construction of any drainage ditches outside the footprint of the levee as required. The estates recommended are standard estates.

FEE.

The fee simple title to (the land described in Schedule A) I/(Tracts Nos. ____, ____ and ___), subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

BORROW EASEMENT.

A (temporary) (perpetual and assignable) right and easement to clear, borrow, excavate and remove sand, soil, dirt, and other materials from (the land described in Schedule A) (Tracts Nos. _____, _____ and _____); subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines; reserving, however, to the landowners, their heirs and assigns, all such rights and privileges in said land as may be used without interfering with or abridging the rights and easement hereby acquired.

TEMPORARY WORK AREA EASEMENT.

A temporary easement and right-of-way in, on, over and across (the land described in Schedule A) (Tracts Nos. _____, _____ and _____), for a period not to exceed ________________, beginning with date possession of the land is granted to the Project Sponsor, for use by the Project Sponsor, its representatives, agents, and contractors as a work area, including the right to deposit backfill, move, store and remove equipment and supplies, and erect and remove temporary structures on the land and to perform any other work necessary and incident to the construction of the __________________ Project, together with the right to trim, cut, fell and remove there from all trees, underbrush, obstructions, and any other vegetation, structures, or obstacles within the limits of the right-of-way; reserving, however, to the landowners, their heirs and assigns, all such rights and privileges as may be used without interfering with or abridging the rights and easement hereby acquired; subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

DRAINAGE DITCH EASEMENT.

A perpetual and assignable easement and right-of-way in, over and across (the land described in Schedule A) (Tracts Nos. ____, ____ and _____) to construct, maintain, repair, operate, patrol and replace a drainage ditch, reserving, however, to the owners, their heirs and assigns, all such rights and privileges in the land as may be used without interfering with or abridging the rights and easement hereby acquired; subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

3.4.1.18 Real Estate Estimate

A summary of the cost for each option is at Table 3.4.1.18-1. The real estate estimates at Tables 3.4.1.18-2 through 3.4.1.18-3 include the land cost for acquisition of land, relocation benefits to include a replacement housing payment and fixed rate move expenses, and Federal and non-Federal administrative costs. Administrative costs are those costs incurred for verifying ownership of lands, certification of those lands required for project purposes, legal opinions, analysis or other requirements that may be necessary, during PED. No cost is included for a borrow site or temporary work area. The requirement, if any, for a borrow site or temporary work area will be identified during PED. If further real estate requirements are identified during PED or if there is a significant increase in cost, a supplement to the Real Estate Appendix will be prepared. A 25% contingency is applied to the current estimate.

Table 3.4.1.18-1.
Real Estate Cost Summary

Option	Impacted Parcels	Relocations	Total Cost
Option A - 20.0	426	160	66,177,000
Option B - 30.0	484	186	74,262,000
Option C - 40.0	537	209	81,107,000

Table 3.4.1.18-2.
LOD4 Hancock County Inland Barrier - Option A 20.0 Estimate

a. Lands and Improvements/Permits					
423 Ownerships for Levee, 160 Improvements					37,633,020
3 Pump Stations					43,699
426 Ownerships				Subtotal	37,676,719
b. Mineral Rights					0
c. Damages					0
d. P.L. 91-646 Relocation costs - 160 relocations					4,480,000
e. Administrative Cost					10,785,000
		Relocation	Acquisition	Total	
	Federal	240,000	1,065,000	1,305,000	
	Non-Federal	960,000	8,520,000	9,480,000	
		1,200,000	9,585,000	10,785,000	
Sub-Total					52,941,719
Contingencies (25%)					13,235,430
	Totals				**66,177,149**
	Rounded				**66,177,000**

Table 3.4.1.18-3.
LOD4 Hancock County Inland Barrier - Option B 30.0 Estimate

a. Lands and Improvements/Permits					
481 Ownerships for Levee, 186 Improvements					41,884,250
3 Pump Stations					43,699
484 Ownerships				Subtotal	41,927,949
b. Mineral Rights					0
c. Damages					0
d. P.L. 91-646 Relocation costs - 186 relocations					5,196,800
e. Administrative Cost					12,285,000
		Relocation	Acquisition	Total	
	Federal	279,000	1,210,000	1,489,000	
	Non-Federal	1,116,000	9,680,000	10,796,000	
		1,395,000	10,890,000	12,285,000	
Sub-Total					59,409,749
Contingencies (25%)					14,852,437
	Totals				**74,262,186**
	Rounded				**74,262,000**

Table 3.4.1.18-4.
LOD4 Hancock County Inland Barrier - Option C 40.0 Estimate

a. Lands and Improvements/Permits					
534 Ownerships for Levee, 209 Improvements					45,345,335
3 Pump Stations					43,699
537 Ownerships				Subtotal	45,389,034
b. Mineral Rights					0
c. Damages					0
d. P.L. 91-646 Relocation costs - 209 relocations					5,846,400
e. Administrative Cost					13,650,000
		Relocation	Acquisition	Total	
	Federal	313,500	1,342,500	1,656,000	
	Non-Federal	1,254,000	10,740,000	11,994,000	
		1,567,500	12,082,500	13,650,000	
Sub-Total					64,885,434
Contingencies (25%)					16,221,359
		Totals			**81,106,793**
		Rounded			**81,107,000**

3.4.1.19 Summary of Potential Real Estate Issues

The requirement for temporary work areas, disposal or borrow areas has not been identified. Should these areas be required, these would be considered as part of the LERRD requirements. Typically if disposal or borrow sites are required, Real estate would provide an analysis during PED to compare the cost of acquiring an these sites with the cost of using a commercial sites and make a determination which method is most cost effective. See Section 2.8 Borrow Areas on page 5.

Should drainage ditches, temporary work areas, disposal or borrow areas become a necessary real estate acquisition requirement, valuation of lands will be performed. Land costs associated with these areas, and administrative costs will be added to the Real Estate Cost Estimate. If further real estate requirements are identified during PED or if there is a significant increase in cost, a supplement to the Real Estate Appendix will be prepared.

Any requirements for relocation contracts pertaining to facilities/utilities will be identified and completed during PED.

Any requirement for mitigation lands will be identified during PED.

Should condemnation of any required real estate interest be necessary, it is the responsibility of the NFS. This issue is addressed during the Assessment of the Non-Federal Sponsor's Real Estate Acquisition Capability. However, if the real estate interest is one that the NFS does not have authority to condemn, the Federal Government can perform the condemnation on behalf of the NFS.

A relocation plan will need to be completed during PED to address potential relocation activity under P.L 91-646. There are a number of factors pertaining to relocations that can impact the project both in cost and in schedule. Payments for Housing of Last Resort, which would exceed the standard housing replacement payments, are very likely due to the size of the project and the lack of available decent, safe and sanitary housing in the area. Another factor that could increase cost and impact schedule is the cost of business relocations. Depending on the type of business and the operation, this could involve moving equipment and machinery to new locations. It is necessary to interview each impacted individual and business during Pre-Construction, Engineering and Design Phase to determine the requirements for relocation and to estimate a cost for the relocation.

Costs for easements for drainage ditches are not included in this report as the requirement was identified late in the study, and a footprint for the drainage ditches is not provided At this time it is believed that the cost will be minor and that it will have minimal impacts to the overall project costs. A determination of additional land requirements for drainage ditches will be made during PED.

3.4.1.20 Chart of Accounts

The cost estimate for all Federal and non-Federal real estate activities necessary for implementation of the project after completion of the feasibility study for land acquisition, construction, LERRD, and other items are coded as delineated in the Cost Work Breakdown Structure (CWBS). This real estate cost estimate is then incorporated into the Total Current Working Estimate utilizing the Microcomputer Aided Cost Engineering System (MCACES). The Chart of Accounts at Tables 3.4.1.20-1 through 3.4.1.20-3 shows the CWBS for real estate activities.

Table 3.4.1.20-1.
Chart of Accounts - LOD4 Hancock County Inland Barrier - Option A 20.0

01A	Project Planning	Federal	Non-Federal	Totals
	Other			
	Project Cooperation Agreement			
01AX	Contingencies (25%)			
	Subtotal			
01B	Lands and Damage/Permits			
01B40	Acquisition/Review of NFS	1,065,000		1,065,000
01B20	Acquisition by NFS		8,520,000	8,520,000
01BX	Contingencies (25%)	266,250	2,130,000	2,396,250
	Subtotal	1,331,250	10,650,000	11,981,250
01F	PL 91-646 Assistance			
01F20	By NFS		960,000	960,000
01FX	Contingencies (25%)		240,000	240,000
	Subtotal		1,200,000	1,200,000
01R	Real Estate Land Payments			
01R1B	Land Payments by NFS		37,676,719	37,676,719
01R2B	PL91-646 Relocation Payment by NFS		4,480,000	4,480,000
01R2D	Review of NFS	240,000		240,000
01RX	Contingencies (25%)	60,000	10,539,180	10,599,180
	Subtotal	300,000	52,695,899	52,995,899
	Totals	**1,631,250**	**64,545,899**	**66,177,149**
	Rounded			**66,177,000**

Table 3.4.1.20-2.
Chart of Accounts - LOD4 Hancock County Inland Barrier - Option B 30.0

01A	Project Planning	Federal	Non-Federal	Totals
	Other			
	Project Cooperation Agreement			
01AX	Contingencies (25%)			
	Subtotal			
01B	Lands and Damage/Permits			
01B40	Acquisition/Review of NFS	1,210,000		1,210,000
01B20	Acquisition by NFS		9,680,000	9,680,000
01BX	Contingencies (25%)	302,500	2,420,000	2,722,500
	Subtotal	1,512,500	12,100,000	13,612,500
01F	PL 91-646 Assistance			
01F20	By NFS		1,116,000	1,116,000
01FX	Contingencies (25%)		279,000	279,000
	Subtotal		1,395,000	1,395,000
01R	Real Estate Land Payments			
01R1B	Land Payments by NFS		41,927,949	41,927,949
01R2B	PL91-646 Relocation Payment by NFS		5,196,800	5,196,800
01R2D	Review of NFS	279,000		279,000
01RX	Contingencies (25%)	69,750	11,781,187	11,850,937
	Subtotal	348,750	58,905,936	59,254,686
	Totals	**1,861,250**	**72,400,936**	**74,262,186**
	Rounded			**74,262,000**

Table 3.4.1.20-3.
Chart of Accounts - LOD4 Hancock County Inland Barrier - Option C 40.0

01A	Project Planning	Federal	Non-Federal	Totals
	Other			
	Project Cooperation Agreement			
01AX	Contingencies (25%)			
	Subtotal			
01B	Lands and Damage/Permits			
01B40	Acquisition/Review of NFS	1,342,500		1,342,500
01B20	Acquisition by NFS		10,740,000	10,740,000
01BX	Contingencies (25%)	335,625	2,685,000	3,020,625
	Subtotal	1,678,125	13,425,000	15,103,125
01F	PL 91-646 Assistance			
01F20	By NFS		1,254,000	1,254,000
01FX	Contingencies (25%)		313,500	313,500
	Subtotal		1,567,500	1,567,500
01R	Real Estate Land Payments			
01R1B	Land Payments by NFS		45,389,034	45,389,034
01R2B	PL91-646 Relocation Payment by NFS		5,846,400	5,846,400
01R2D	Review of NFS	313,500		313,500
01RX	Contingencies (25%)	78,375	12,808,859	12,887,234
	Subtotal	391,875	64,044,293	64,436,168
	Totals	**2,070,000**	**79,036,793**	**81,106,793**
	Rounded			**81,107,000**

3.4.2 St. Louis Bay Surge Barrier

In order to protect the properties surrounding Saint Louis Bay and along the lower portions of the various rivers and streams flowing into the bay, a barrier would be required at some point to block storm waters during major storm events. A search of other similar facilities constructed world wide revealed that the structure model best satisfying both the engineering and socio-ecological necessities of this site was that used for the Thames River Barrier in London, UK. The structure tentatively investigated for incorporation into this work was patterned after the Thames River Barrier with certain minor modifications to adapt to the site and environment specific conditions.

A photograph of the Thames River Gates is at Figure 3.4.2-1. The St. Louis Bay watershed covers approximately 654 square miles and is comprised of six sub-basins that stretch across the Mississippi counties of Harrison, Hancock, Stone and Pearl River.

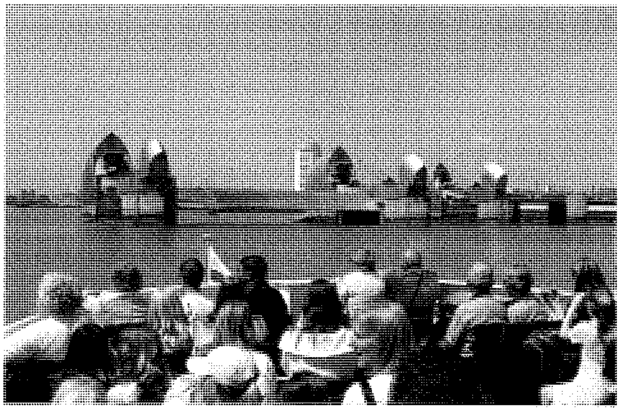

Figure 3.4.2-1.
Thames River Gates, London, UK

In the event of an imminent hurricane, the gates St Louis Bay would be closed, and flow from the rivers feeding these bays, as well as local runoff would pond behind the gates. The tentative location of the barrier chosen for this study is shown below in Figure 3.4.2-2. The alternatives for this proposed measure are identified as Option A, Option B and Option C.

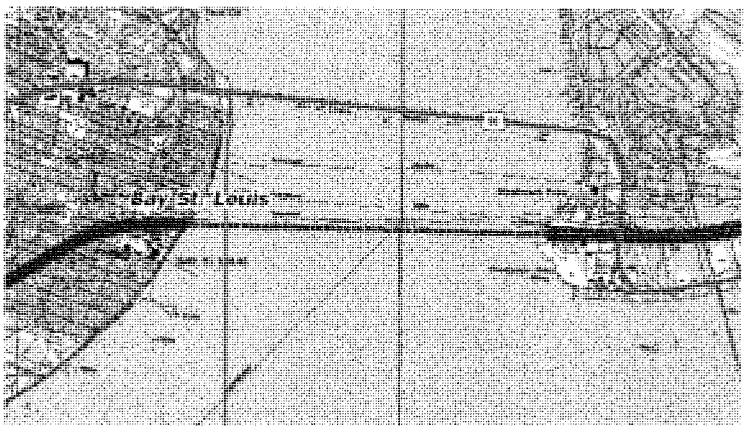

Figure 3.4.2-2.
St Louis Bay Surge Barrier Location

3.4.2.1 Option A - Elevation 20.0 ft NAVD88

Option A is the design and construction of a rising sector gate in the St. Louis Bay creating a barrier to elevation 20.0.

3.4.2.2 Option B - Elevation 30.0 ft NAVD88

Option B is the design and construction of a rising sector gate in the St. Louis Bay creating a barrier to elevation 30.0.

3.4.2.3 Option C - Elevation 40.0 ft NAVD88

Option C is the design and construction of a rising sector gate in the St. Louis Bay creating a barrier to elevation 40.0.

3.4.2.4 Project Description

The alignment for the barrier structure would run parallel with and south of the Railroad Bridge crossing Saint Louis Bay. This would approximate the shortest route across the inlet leading form the Mississippi Sound into the bay. As the layout of the barrier was developed it became apparent that, because of the excavation required, a significant amount of separation would be required between the railroad bridge and the ultimate location of the structures included in the barrier. For this study the centerline of the barrier was positioned approximately 260 feet from the center of the railroad bridge. This was left unaltered for all protection levels. The entire barrier would be approximately 10,320 feet in length from water's edge to water's edge, and would consist of rock fill levees extending from the overland levee at each bank for some distance into the bay and enveloping the mass concrete non-overflow wall sections leading to each end of the gated structure.

The points at which the barrier would come ashore in Harrison County on the east and Hancock County on the west, are in urban areas with extensive residential and commercial development. Several structures would need to be relocated and it is uncertain the extent to which existing utilities might have to be relocated to clear the way for this facility.

Structurally, the Barrier as configured for this study would consist of a series of 38 large stainless steel clad, structural steel framed gates called rising sector gates. Each of these would be supported on reinforced concrete piers resting on large continuous concrete sills with pile foundations. The tentative layout used to estimate the scope of the structure was configured having gates 132 feet long mounted on 28-foot wide piers. The number of gates was determined by the extent of water having depth sufficient to support their operation. To facilitate as nearly as possible the normal ebb and flow of tide waters through the barrier, the concrete connector wall and rock fill portions of the barrier either side of the gated structure would be fitted with a series of closely spaced low level gated culverts. The gate and pier heights were varied to accommodate the "level of protection" under consideration. The three elevations selected for this study were 20, 30, and 40 NAVD88. In each instance the gate heights were set to match the protection level elevations with pier heights set approximately 3 feet higher to provide minor wave clearance for protection of operating equipment. Atop each pier an operating machinery block would be mounted to house the operating equipment. Operating and utility access would be provided through two continuous tunnels passing through the sill section and the rock fill, to operating facilities located on each bank.

In order to assure proper functioning of the facilities once they are placed in service a program of Operations and Maintenance would be developed by the U.S. Army Corps of Engineers, in conjunction and cooperation with the affected state and local entities. This O & M Plan would address specific responsibilities as to daily operation of the facilities, the periodic testing and maintenance of the operating machinery, maintenance of specified stocks of replacement parts, security of the facilities, and maintenance of any buildings and grounds associated with the operation and maintenance of the facilities. As presently envisioned, this O & M responsibility would remain under control of the U.S. Army Corps of Engineers and would be administered under its Operations mission.

3.4.2.5 Real Estate Requirements

Real Estate requirements for Line of Defense 4, St. Louis Bay Surge Barrier include lands, easements, rights-of-way and relocations, and disposal/borrow areas (LERRD), and the right to construct, rock levees and an elevated gate barrier in St. Louis Bay with operating facilities located on each landward bank of the barrier. The rock levees on either side of the gates will tie into the LOD4 inland barrier. There will be 2 operating facilities, one located in Hancock County and the other in Harrison County. Each site will be comprised of approximately 5 acres and these will be acquired in fee. The real estate cost estimate will be the same for each option as they all have the same requirements.

For those lands required for construction that lay below the mean high water mark, navigation servitude will apply. Navigation servitude is the dominant right of the Government under the Commerce Clause of the U.S. Constitution (U.S. CONST. Art.I,§8,cl.3) to use, control and regulate the navigable waters of the United States and the submerged lands hereunder for various commerce-related purposes including navigation and flood control. In tidal areas, the servitude extends to all lands below the, mean high water mark. In non-tidal areas, the servitude extends to all lands within the bed and banks of a navigable stream that lie below the ordinary high water mark. The determination of the availability of the navigation servitude should be made on a case by case basis and consists of a two -step process. First the government must determine whether the project serves a purpose that has a nexus to navigation. Purposes recognized by the courts to have the nexus include navigation, flood control and hydroelectric power. If determined that such a nexus exists, then the second step is to determine whether the land at issue is located below the mean or ordinary high water mark of a navigable watercourse. As a general rule, the Government does not acquire interests in real property that it already possesses or over which its use or control is or can be legally exercised. Therefore, if the navigation servitude is found to be available as a result of application of the process described in subparagraph b of this paragraph, then the Government will generally exercise its rights hereunder and, to the extent of such rights, will not acquire a real property interest in the land to which the navigation servitude applies. Generally, it is the policy of the U.S. Army Corps of Engineers (USACE) to utilize the navigation servitude in all situations where available, for cost shared and full Federal projects. The determination of availability will be made during PED.

3.4.2.6 Utility/Facility Relocation

It is probable that there will be some utility/facility relocations for this plan. Specific requirements are unknown at this time but will be defined during PED. See Chapter 2 Section 2.10 for more detailed discussion.

3.4.2.7 Existing Projects/Studies

Relevant projects and studies are found in the main report at Section 1.6, History of the Investigation and Section 1.7, Prior and On-Going Studies, Reports and Programs.

3.4.2.8 Environmental Impacts

See the Main Report, Chapter 6. Environmental Effects of Plans and the Environmental Appendix, for a full discussion on environmental effects.

3.4.2.9 Project Sponsor Responsibilities and Capabilities

The State of Mississippi will be the non-Federal Project Sponsor (NFS). The NFS has the responsibility to acquire all real estate interests required for the Project. The NFS shall accomplish all alterations and relocations of facilities, structures and improvements determined by the government to be necessary for construction of the Project.

Title to any acquired real estate will be retained by the Project Sponsor and will not be conveyed to the United States Government. Prior to advertisement of any construction contract, the NFS shall furnish to the government an Authorization for Entry for Construction (Exhibit "A" to the Real Estate Appendix) to all lands, easements and rights-of-way, as necessary. The NFS will also furnish to the government evidence supporting their legal authority to grant rights-of-way to such lands. The NFS shall comply with applicable provisions of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970, Public Law 91-646, approved 2 January 1971, and amended by Title IV of the Surface Transportation Uniform Relocation Assistance Act of 1987, Public Law 100-17, effective 2 April 1989, in acquiring real estate interests for the Project, and inform all affected persons of applicable benefits, policies, and procedures in connection with said Act(s). A form for the Assessment of the Non-Federal Sponsor's Capability to Acquire Real Estate is at Exhibit "B" to the Real Estate Appendix. The assessment will be made during PED phase.

The non-Federal sponsor is entitled to receive credit against its share of project costs for the value of lands it provides and the value of the relocations that are required for the project. Generally, for the purpose of determining the amount of credit to be afforded, the value of the LER is the fair market value of the real property interest, plus certain incidental costs of acquiring those interests, that the non-federal sponsor provided for the project as required by the Government. The NFS cannot receive credit for the value of any LER, including incidental costs, which were previously provided as an item of cooperation for another Federal project, including projects that preceded enactment of WRDA 1986.

3.4.2.10 Government Owned Property

There are no known Government owned lands within the proposed project.

3.4.2.11 Historical Significance

See the Main Report, Section 3.2.9 Cultural and Archaeological Resources, for a general discussion on cultural and archaeological resources.

3.4.2.12 Mineral Rights

There are no known mineral activities within the scope of the proposed project.

3.4.2.13 Hazardous, Toxic, and Radioactive Waste (HTRW)

Due to the extent of the project, no preliminary assessment was performed to identify the possibility of hazardous waste on the sites. These studies will be conducted during the next phase of work. See Sections 3.2.8 and 6.16 of the Main Report for a discussion on HTRW.

3.4.2.14 *Public Law 91-646, Relocation Assistance Benefits*

No relocations are expected with this alternative.

3.4.2.15 *Attitude of Property Owners*

Real Estate has not interviewed property owners or tenants during the study phase for the MsCIP. However, numerous public meetings have been held at different locations throughout the study area to inform stakeholders and property owners about the study and the protective measures under consideration for the Mississippi coastal area. A number of local newspapers have published articles that discuss the MsCIP study and the perceived positive effects as well as the negative impacts that may occur as a result of the project. Some of these articles can be found on web sites. While many of the locals may welcome the benefits of the proposed project, there are some who oppose the project.

3.4.2.16 *Acquisition Schedule*

An acquisition schedule will be developed when plans and specifications become available and more definite information is available pertaining to the specific areas and number of parcels for acquisition. The acquisition schedule will be developed during PED and will be a joint effort of the NFS, the project manager and Real Estate. The schedule will set forth a time line for title, survey, appraisal, negotiation, preparation of documents and closing activity. After acquisition activity is completed certification of lands acquired/owned by the sponsor will be necessary prior to advertisement for construction. The Certification of Real Estate can be accomplished within 30 - 60 days after acquisition. See Chapter 2. Section 2.5. for discussion on an acquisition implementation/management plan.

3.4.2.17 *Estates for Proposed Project*

All lands required for the operating facilities will either be acquired in Fee Simple or are available under navigation servitude.

FEE.

The fee simple title to (the land described in Schedule A) l/(Tracts Nos. ____, ____ and ___), subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

3.4.2.18 *Real Estate Estimate*

The real estate estimate at Table 3.4.2.18-1 includes the land cost for acquisition of land, permits, and Federal and non-Federal administrative costs. Administrative costs are those costs incurred for verifying ownership of lands, certification of those lands required for project purposes, legal opinions, analysis or other requirements that may be necessary, during PED. No cost is included for a temporary work area. The requirement, if any, for a temporary work area will be identified during PED. If further real estate requirements are identified during PED or if there is a significant increase in cost, a supplement to the Real Estate Appendix will be prepared. A 25% contingency is applied to the current estimate.

Table 3.4.2.18-1.
LOD4 St. Louis Bay Surge Barrier - Option A, B or C Estimate

a. Lands and Improvements/Permits		
4 Ownerships, 0 Improvements	Hancock	316,663
4 Ownerships, 0 Improvements	Harrison	391,310
	Subtotal	707,973
b. Mineral Rights		0
c. Damages		0
d. P.L. 91-646 Relocation costs - 0 relocations		0
e. Administrative Cost		180,000

	Relocation	Acquisition	Total
Federal	0	20,000	20,000
Non-federal	0	160,000	160,000
	0	180,000	180,000

Sub-Total	887,973
Contingencies (25%)	221,993
Totals	**1,109,966**
Rounded	**1,110,000**

3.4.2.19 Summary of Potential Real Estate Issues

It is expected that navigation servitude will be exercised to construct the surge barrier in St. Louis Bay. This determination will be made during PED

It is probable that there will be some utility/facility relocations for this plan. Specific requirements are unknown at this time but will be defined during PED.

The requirement for temporary work areas has not been identified. Should these areas be required, these would be considered as part of the LERRD requirements.

Should temporary work areas become a necessary real estate acquisition requirement, valuation of lands will be performed. Land costs associated with temporary work areas and administrative costs will be added to the Real Estate Cost Estimate. If further real estate requirements are identified during PED or if there is a significant increase in cost, a supplement to the Real Estate Appendix will be prepared.

Any requirement for mitigation lands will be identified during PED.

Should condemnation of any required real estate interest be necessary, it is the responsibility of the NFS. This issue is addressed during the Assessment of the Non-Federal Sponsor's Real Estate Acquisition Capability. However, if the real estate interest is one that the NFS does not have authority to condemn, the Federal Government can perform the condemnation on behalf of the NFS.

3.4.2.20 Chart of Accounts

The cost estimate for all Federal and non-Federal real estate activities necessary for implementation of the project after completion of the feasibility study for land acquisition, construction, LERRD, and other items are coded as delineated in the Cost Work Breakdown Structure (CWBS). This real estate cost estimate is then incorporated into the Total Current Working Estimate utilizing the Microcomputer Aided Cost Engineering System (MCACES). The Chart of Accounts at Table 3.4.2.20-1 shows the CWBS for real estate activities.

Table 3.4.2.20-1.
Chart of Accounts - LOD4 St. Louis Bay Surge Barrier - Option A, B or C

01A	Project Planning	Federal	Non-Federal	Totals
	Other			
	Project Cooperation Agreement			
01AX	Contingencies (25%)			
	Subtotal			
01B	Lands and Damages/Permits			
01B40	Acquisition/Review of NFS	20,000		20,000
01B20	Acquisition by NFS		160,000	160,000
01BX	Contingencies (25%)	5,000	40,000	45,000
	Subtotal	25,000	200,000	225,000
01F	PL 91-646 Assistance			
01F20	By NFS		0	0
01FX	Contingencies (25%)		0	0
	Subtotal		0	0
01R	Real Estate Land Payments			
01R1B	Land Payments by NFS		707,973	707,973
01R2B	PL91-646 Relocation Payment by NFS		0	0
01R2D	Review of NFS	0		0
01RX	Contingencies (25%)	0	176,993	176,993
	Subtotal	0	884,966	884,966
	Totals	**25,000**	**1,084,966**	**1,109,966**
	Rounded			**1,110,000**

3.4.3 Harrison County Inland Barrier

Harrison County is located along the coast of Mississippi Sound with Hancock County to the west and Jackson County to the east. In Harrison County, ground elevations over most of the residential and business areas vary between elevation 8-12 ft NAVD88 on the coast and rising within 1000 ft to elevation 30-36 along a ridge parallel to the coast line, then decreasing to the north.

Residential and business areas along the coast in Harrison County are susceptible to damage from storm surges associated with hurricanes. Earthen levees were evaluated for protection of these areas. The levees were evaluated at elevations 20 ft NAVD88 and 30 ft NAVD88 and 40 ft NAVD88. The top width was assumed 15 ft with side-slopes of 1 vertical to 3 horizontal. The location of the proposed inland barrier in Harrison County is shown in Figure 3.4.3-1 extending from Biloxi Bay to Pass Christian approximately 1000 - 3000 feet north of, and parallel to, the shoreline. This alignment is evaluated in Options A through E. For Options F through J, an alternate alignment is evaluated. This alternate alignment extends from Biloxi Bay to Menge Avenue, thence northward along Menge Avenue to high ground.

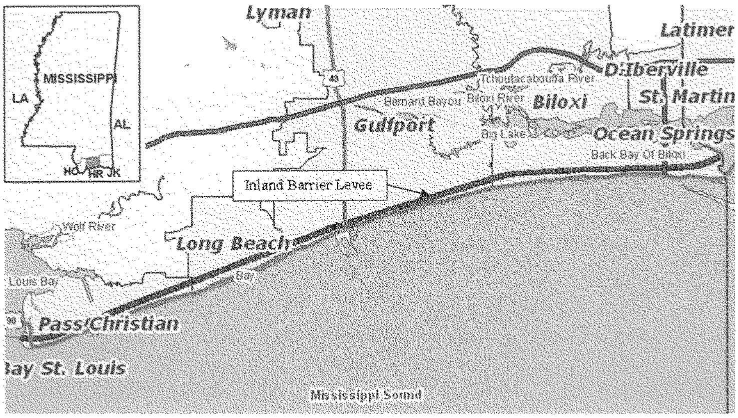

Figure 3.4.3-1.
Vicinity Map Harrison County, MS

3.4.3.1 Option A - Elevation 20.0 ft NAVD88

This option consists of constructing a levee to elevation 20 ft NAVD88 along the coast of Harrison County along with the internal sub-basins and levee culvert/pump locations. These sites will be ditched along the levee to drain to St. Louis Bay and Biloxi Bay.

3.4.3.2 Option B - Elevation 30.0 ft NAVD88

The alignment of the levee is the same as Option A, above but with an elevation of 30.0 feet. The only difference between the description of this option and preceding description of Option A is the height of the levee, pumping facilities, number of roadway and railroad intersections, and the length of the levee culverts.

3.4.3.3 Option C - Elevation 40.0 ft NAVD88

The alignment of the levee is the same as Option A, above but with an elevation of 40.0 feet. The only difference between the description of this option and preceding description of Option A is the height of the levee, pumping facilities, number of roadway and railroad intersections, and the length of the levee culverts.

3.4.3.4 Option D - Levee for Roadway, Elevation 20.0 ft NAVD88

The alignment of the levee is the same as Option A, above. The difference between this option and Option A is that the width of the top of the levee in Harrison County is 75 ft for Option D and 15 ft for Option A. This added width will allow Highway 90 to be relocated along the top of the levee.

3.4.3.5 Option E - Levee for Roadway, Elevation 30.0 ft NAVD88

The alignment of the levee is the same as option A, above. The difference between this option and Option A is that the width of the top of the levee in Harrison County is 75 ft for Option A. In addition, the height of the levee is at 30 ft NAVD88 for Option E and 20 ft NAVD88 for Option A. This added width will allow Highway 90 to be relocated along the top of the levee.

3.4.3.6 Option F - Menge Avenue Alternate Route, Elevation 20.0 ft NAVD88

The alignment of the levee is the same as Option A on the east side of Harrison County but extends to the north along Menge Avenue instead of continuing westward.

3.4.3.7 Option G - Menge Avenue Alternate Route, Elevation 30.0 ft NAVD88

The alignment of the levee is the same as Option F. The primary difference between this option and Option F is the height of the levee. Option F levee height is elevation 20 ft NAVD88 and Option G levee height is elevation 30 ft NAVD88.

3.4.3.8 Option H - Menge Avenue Alternate Route, Elevation 40.0 ft NAVD88

The alignment of the levee is the same as Option F. The primary difference between this option and Option F is the height of the levee. Option F levee height is elevation 20ft NAVD88 and Option H levee height is elevation 40 ft NAVD88.

3.4.3.9 Option I - Levee for Roadway with Menge Avenue Alternate, Route Elevation 20.0 ft NAVD88

The alignment of the levee is the same as Option F. The primary difference between this option and Option F is the top width of the east-west leg of the levee (Biloxi Bay to Menge Avenue). The east-west leg of Option F barrier top width is 15 ft and the east-west leg of Option I barrier top width is 75 ft. This will allow Highway 90 to be relocated along the top of the levee.

3.4.3.10 Option J - Levee for Roadway with Menge Avenue Alternate, Route Elevation 30.0 ft NAVD88

The alignment of the levee is the same as Option F. The primary difference between this option and Option F is the top width of the east-west leg of the levee (Biloxi Bay to Menge Avenue). The east-west leg of Option F barrier top width is 15ft and the east-west leg of Option J barrier top width is 75 ft. This will allow Highway 90 to be relocated along the top of the levee. In addition, the height of this Option J is at elevation 30 ft NAVD88.

3.4.3.11 Project Description

The location of the proposed project is shown above in Figure 3.4.3-1. As described, the levee will be an earthen levee constructed either at elevation 20.0 feet, 30.0 or 40.0 feet along with the internal sub-basins and levee culvert/pump locations. Drainage on the interior of the ring levee would be collected at the levee and channeled to culverts placed in the levee. 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. In addition, pumps would be constructed near the outflow points to remove water from the interior during storm events occurring when the culverts are closed because of high water in the sound. Drainage ditches along the toe of the levee will be required to assure that smaller basins can be drained to a culvert/pump site. Figures 3.4.3.11-1 through 3.4.3.11-3 show the proposed locations of the pump/culvert sites for Options A through E. Figures 3.4.3.11-4 through 3.4.3.11-6 show the Menge Avenue alternate route. 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. Further studies will detail the requirement for the appropriate ponding areas, pump sizes, or buyouts in the affected areas. In order to prevent hurricane surges from circumventing the levee, surge barrier gates would be constructed across both Biloxi Bay and St. Louis Bay. In the event of an imminent hurricane, the gates across the Back Bay of Biloxi and St. Louis Bay would be closed, and flow from the rivers feeding these bays, as well as local runoff would pond behind the gates.

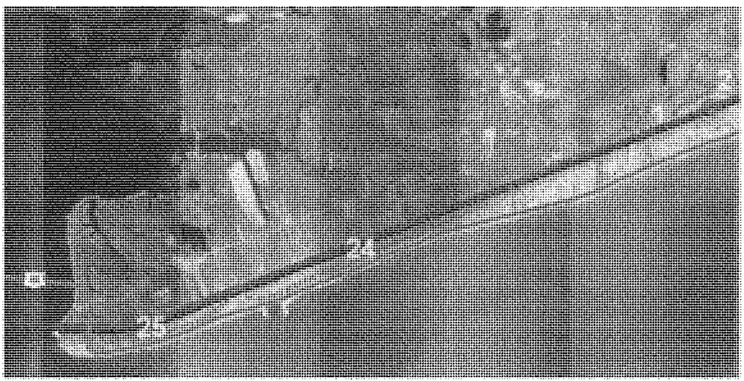

Figure 3.4.3.11-1.
Pump/Culvert/Sub-basin Site Locations, Options A-E

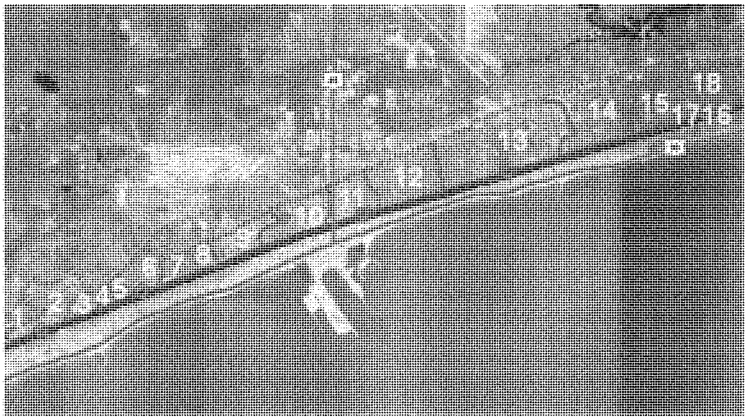

Figure 3.4.3.11-2.
Pump/Culvert/Sub-basin Site Locations, Options A-E

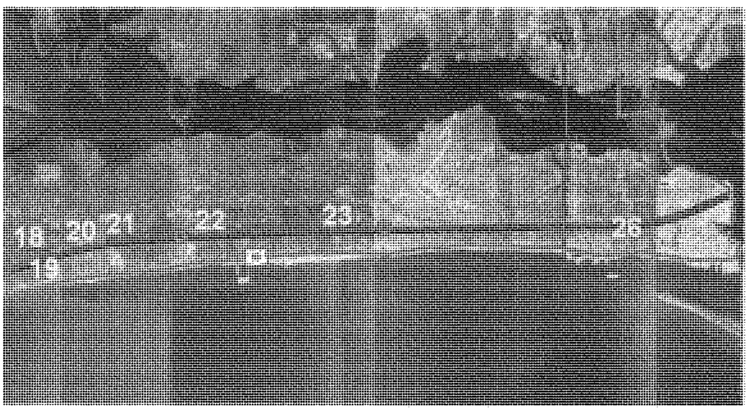

Figure 3.4.3.11-3.
Pump/Culvert/Sub-basin Site Locations, Options A-E

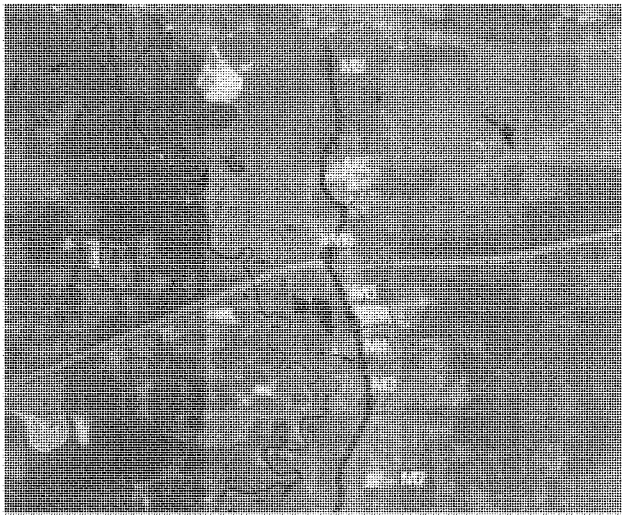

Figure 3.4.3.11-4.
Menge Avenue Alternate Route, Pump/Culvert, Sub-basin Site Locations, Options F-J

Figure 3.4.3.11-5.
Menge Avenue Alternate Route, Pump/Culvert, Sub-basin Site Locations, Options F-J

Figure 3.4.3.11-6.
Menge Avenue Alternate Route, Pump/Culvert, Sub-basin Site Locations, Options F-J

The inland barrier earthen levee section will have one vertical to three horizontal side slopes with a fifteen foot crest width. All work areas to receive fill shall be cleared and grubbed of all trees and surface organics and all existing foundations, streets, utilities, etc. will be removed and the subsequent cavities backfilled and compacted. The levee will be constructed of sand clay materials obtained from off site commercial sources, and trucked to the work area. The final surface will be armored by the placement of 24 inch thick gabion mattress filled with small stone for erosion protection during an event that overtops the levee. The armoring will be anchored on the front face by trenching and extend across the downstream slope and a 25 foot area beyond the toe. The front side of the levee and all non critical surface areas will be subsequently covered by grassing. In order to maintain the natural runoff patterns culverts would be inserted through the protection line at appropriate locations. Pump facilities would be required at 7 - 14 locations varying with the option.

Road crossings will incorporate small gate structures or ramping over the embankment where the surface elevation is near that of the crest elevation. The elevation relationship of the crest and the adjacent railroad will be a governing factor. At each point where a roadway crosses the protection line the decision must be made whether to maintain this artery and adapt the protection line to accommodate it, or to terminate the artery at the protection line and divert traffic to cross the protection line at another location. For this study it was assumed that all roadways and railways crossing the levee alignment would be retained except where it was very evident that traffic could be combined without undue congestion. Once the decision has been made to retain a particular roadway, it must then be determined how best to configure the artery to conduct traffic across the protection line. The simplest means of passing roadway traffic is to ramp the roadway over the protection line. This alternative is not always viable because of severe right-of-way restraints caused by extreme levee height, urban congestion, etc. In such instances other methods can be used including partial ramping in combination with low profile roller gates. In more restricted areas full height gates which would leave the roadway virtually unaltered might be preferable, even though this alternative would usually be more costly than ramping. In some extreme circumstances where high levees are required to pass through very congested areas, installation of tunnels with closure gates may be required.

Because of the extreme gradient restrictions necessarily placed on railway construction, it is practically never acceptable to elevate a railway up and over a levee. Therefore, the available alternatives would include gated pass through structures. Because of the vertical clearance requirements of railroad traffic all railroad pass through structures for this study were configured having vertical walls on either side of the railway with double swing gates extending to the full height of the levee.

Table 3.4.3.11-1 summarizes the number of roadway/railway intersections impacted by the various options. The number of roller gate, swing gate and railroad gate structures are listed for each option.

Table 3.4.3.11-1.
Levee and Roadway/Railway Intersections

Option	Roadway/Railway Intersections	Roller Gates	Swing Gates	Railroad Gates
Option A	45	18	27	
Option B	30	158	78	2
Option C	161	1	158	2
Option D	42	18	48	
Option E	140	82	112	2
Option F	21	17	4	
Option G	125	86	37	2
Option H	157	3	152	2
Option I	20	16	4	
Option J	123	86	35	2

The features that require periodic operations will be the exercising of the pumps and emergency generators at the various pump stations, the testing of the gate structures at the various road crossings, grass cutting of the levee slopes and toe areas and the filling of rilled areas within the embankment due to surface erosion. Scheduled maintenance should include periodic greasing of all gears and coupled joints, maintaining any battery backup systems, and replacement of standby fuel supplies.

3.4.3.12 Real Estate Requirements

Real Estate requirements for Line of Defense 4, Harrison County Levee include lands, easements, rights-of-way and relocations, and disposal/borrow areas (LERRD), and the right to construct an earthen levee, drainage ditches, and culvert/pump station facilities.

Based on the footprint of the Option A, 20.0 foot elevation, it was determined that approximately 1512 parcels and 756 structures would be impacted. The acreage to be acquired for the levee is unknown. It is known that the 7 pump stations will require approximately 0.23 of an acre each for a total of 1.61 acres. Lands required for construction of the levee will be acquired in fee simple interest, and lands for the drainage ditches that will be constructed outside the levee footprint will be acquired either in easement or fee as necessary. Based on the number of structures being impacted, the assumption is that there will be 756 relocations.

Based on the footprint of the Option B, 30.0 foot elevation, it was determined that 1688 parcels and 835 structures would be impacted. The acreage to be acquired for the levee is unknown. It is known that the 7 pump stations will require approximately 0.23 of an acre each for a total of 1.61 acres. Lands required for construction of the levee will be acquired in fee simple interest, and lands for the drainage ditches that will be constructed outside the levee footprint will be acquired either in easement or fee as necessary. Based on the number of structures being impacted, the assumption is that there will be 835 relocations.

Based on the footprint of the Option C, 40.0 foot elevation, it was determined that 1927 parcels and 938 structures would be impacted. The acreage to be acquired for the levee is unknown. It is known that the 7 pump stations will require approximately 0.23 of an acre each for a total of 1.161 acres. Lands required for construction of the levee will be acquired in fee simple interest, and lands for the drainage ditches that will be constructed outside the levee footprint will be acquired either in easement or fee as necessary. Based on the number of structures being impacted, the assumption is that there will be 938 relocations.

Based on the footprint of the Option D, 20.0 foot elevation, it was determined that 568 parcels and 174 structures would be impacted. The acreage to be acquired for the levee is unknown. It is known that the 7 pump stations will require approximately 0.23 of an acre each for a total of 1.61 acres. Lands required for construction of the levee will be acquired in fee simple interest, and lands for the drainage ditches that will be constructed outside the levee footprint will be acquired either in easement or fee as necessary. Based on the number of structures being impacted, the assumption is that there will be 174 relocations.

Based on the footprint of the Option E, 30.0 foot elevation, it was determined that 1916 parcels and 1172 structures would be impacted. The acreage to be acquired for the levee is unknown. It is known that the 7 pump stations will require approximately 0.23 of an acre each for a total of 1.61 acres. Lands required for construction of the levee will be acquired in fee simple interest, and lands for the drainage ditches that will be constructed outside the levee footprint will be acquired either in easement or fee as necessary. Based on the number of structures being impacted, the assumption is that there will be 1172 relocations.

Based on the footprint of the Option F, 20.0 foot elevation, it was determined that 76 parcels and 38 structures would be impacted. The acreage to be acquired for the levee is unknown. It is known that the 9 pump stations will require approximately 0.23 of an acre each for a total of 2.07 acres. Lands required for construction of the levee will be acquired in fee simple interest. Footprints of the drainage ditches for this option appear to be within the footprint of the lands being acquired for the levee. Based on the number of structures being impacted, the assumption is that there will be 38 relocations.

Based on the footprint of the Option G 30.0 foot elevation, it was determined that 189 parcels and 104 structures would be impacted. The acreage to be acquired for the levee is unknown. It is known that the 9 pump stations will require approximately 0.23 of an acre each for a total of 2.07 acres. Lands required for construction of the levee will be acquired in fee simple interest. Footprints of the drainage ditches for this option appear to be within the footprint of the lands being acquired for the levee. Based on the number of structures being impacted, the assumption is that there will be 38 relocations.

Based on the footprint of the Option H 40.0 foot elevation, it was determined that 209 parcels and 101 structures would be impacted. The acreage to be acquired for the levee is unknown. It is known that the 14 pump stations will require approximately 0.23 of an acre each for a total of 3.22 acres. Lands required for construction of the levee will be acquired in fee simple interest. Footprints of the drainage ditches for this option appear to be within the footprint of the lands being acquired for the levee. Based on the number of structures being impacted, the assumption is that there will be 101 relocations.

Based on the footprint of the Option I 20.0 foot elevation, it was determined that 225 parcels and 122 structures would be impacted. The acreage to be acquired for the levee is unknown. It is known that the 9 pump stations will require approximately 0.23 of an acre each for a total of 2.07 acres. Lands required for construction of the levee will be acquired in fee simple interest. Footprints of the drainage ditches for this option appear to be within the footprint of the lands being acquired for the levee. Based on the number of structures being impacted, the assumption is that there will be 122 relocations.

Based on the footprint of the Option J 30.0 foot elevation, it was determined that 171 parcels and 92 structures would be impacted. The acreage to be acquired for the levee is unknown. It is known that the 9 pump stations will require approximately 0.23 of an acre each for a total of 2.07 acres. Lands required for construction of the levee will be acquired in fee simple interest. Footprints of the drainage ditches for this option appear to be within the footprint of the lands being acquired for the levee. Based on the number of structures being impacted, the assumption is that there will be 92 relocations.

An assumption is made that excavated materials from clearing, snagging, and construction of ditches, etc. will be disposed of in county owned or commercial landfills. However, In the event that the excavated material is not suitable for a landfill a disposal site will have to be acquired. Typically if disposal sites are required, this would be considered as part of the LERRD requirement. Real Estate would provide an analysis during PED to compare the cost of acquiring an upland disposal site with the cost of using a commercial landfill and make a determination which method is most cost effective.

The recommended plan proposes to use material from an inventory of upland borrow sites to construct the levee. A specific site has not been identified or confirmed for use at time of this report. Typically if borrow sites are required, this would be considered a part of the LERRD requirement. Real Estate would provide an analysis during PED to compare the cost of acquiring an upland borrow site with the cost of using a commercial borrow site and make a determination which method is most cost effective. The requirement for temporary work areas is unknown. Sponsor owned lands will be used if available. Otherwise, this may be an additional real estate requirement, and will be further defined during PED.

Table 3.4.3.12-1 below summarizes the real estate requirements for the various alternatives.

Table 3.4.3.12-1.
Real Estate Requirements - LOD4 Harrison County

Option	Impacted Parcels	Impacted Structures	# Pump Stations/AC	Relocations
Option A	1,512	756	7 1.16 AC	756
Option B	1,688	835	7 1.16 AC	835
Option C	1,927	938	7 1.16 AC	938
Option D	568	174	7 1.16 AC	174
Option E	1,916	1,172	7 1.16 AC	1,172
Option F	76	38	9 2.07 AC	38
Option G	189	104	9 2.07 AC	104
Option H	209	101	14 3.22 AC	101
Option I	225	122	14 3.22 AC	122
Option J	171	92	9 2.07 AC	92

Any modifications to the roadways and utilities will most probably need to be accomplished through a relocation contract. This will be further investigated and confirmed during PED.

The recommended plan proposes to use material from an inventory of upland borrow sites to construct the levee. A specific site has not been identified or confirmed for use at time of this report. Typically if borrow sites are required, this would be considered a part of the LERRD requirement. Real Estate would provide an analysis during PED to compare the cost of acquiring an upland borrow site with the cost of using a commercial borrow site and make a determination which method is most cost effective. The requirement for temporary work areas is unknown. Sponsor owned lands will be used if available. Otherwise, this may be an additional real estate requirement, and will be further defined during PED.

3.4.3.13 Utility/Facility Relocation

The plan calls for roads to be ramped over the proposed levee and possible relocation of utilities and Highway 90. An assumption is made that this work will be accomplished through a relocation contract. This will be further investigated and confirmed during PED. See Chapter 2 Section 2.10 for more detailed discussion.

3.4.3.14 Existing Projects/Studies

Relevant projects and studies are found in the main report at Section 1.6, History of the Investigation and Section 1.7, Prior and On-Going Studies, Reports and Programs.

3.4.3.15 Environmental Impacts

See the Main Report, Chapter 6. Environmental Effects of Plans and the Environmental Appendix, for a full discussion on environmental effects.

3.4.3.16 Project Sponsor Responsibilities and Capabilities

The State of Mississippi will be the non-Federal Project Sponsor (NFS). The NFS has the responsibility to acquire all real estate interests required for the Project. The NFS shall accomplish all alterations and relocations of facilities, structures and improvements determined by the government to be necessary for construction of the Project.

Title to any acquired real estate will be retained by the Project Sponsor and will not be conveyed to the United States Government. Prior to advertisement of any construction contract, the NFS shall furnish to the government an Authorization for Entry for Construction (Exhibit "A" to the Real Estate Appendix) to all lands, easements and rights-of-way, as necessary. The NFS will also furnish to the government evidence supporting their legal authority to grant rights-of-way to such lands. The NFS shall comply with applicable provisions of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970, Public Law 91-646, approved 2 January 1971, and amended by Title IV of the Surface Transportation Uniform Relocation Assistance Act of 1987, Public Law 100-17, effective 2 April 1989, in acquiring real estate interests for the Project, and inform all affected persons of applicable benefits, policies, and procedures in connection with said Act(s). A form for the Assessment of the Non-Federal Sponsor's Capability to Acquire Real Estate is at Exhibit "B" to the Real Estate Appendix. The assessment will be made during PED phase.

The non-Federal sponsor is entitled to receive credit against its share of project costs for the value of lands it provides and the value of the relocations that are required for the project. Generally, for the purpose of determining the amount of credit to be afforded, the value of the LER is the fair market value of the real property interest, plus certain incidental costs of acquiring those interests, that the non-federal sponsor provided for the project as required by the Government. The NFS cannot receive credit for the value of any LER, including incidental costs, which were previously provided as an item of cooperation for another Federal project, including projects that preceded enactment of WRDA 1986.

3.4.3.17 Government Owned Property

There are 1-5 Government owned parcels within the footprint of the project that will be impacted depending on the option recommended for construction. In viewing the footprint, it is noted that the parcels will be impacted where they abut Highway 90. The parcels may be impacted by approximately 20-30%. Land and structure values are not listed in the public records. Ownership is listed in public records as US Govt, US Veterans Hospital and United States of America. Specific impacts to Government owned lands will be determined during PED.

3.4.3.18 Historical Significance

See the Main Report, Section 3.2.9 Cultural and Archaeological Resources, for a general discussion on cultural and archaeological resources.

3.4.3.19 Mineral Rights

There are no known mineral activities within the scope of the proposed project.

3.4.3.20 Hazardous, Toxic, and Radioactive Waste (HTRW)

Due to the extent of the project, no preliminary assessment was performed to identify the possibility of hazardous waste on the sites. These studies will be conducted during the next phase of work. See Sections 3.2.8 and 6.16 of the Main Report for a discussion on HTRW.

3.4.3.21 Public Law 91-646, Relocation Assistance Benefits

The Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970 establishes a uniform policy for fair and equitable treatment of persons displaced as a result of federal and federally assisted programs in order that such persons shall not suffer disproportionate injuries as a result of programs designed for the benefits of the public as a whole. A qualified displaced person may be entitled to certain relocation assistance benefits which include reimbursement of moving costs and a replacement housing benefit. Moving expense can be reimbursed either based on actual costs or a fixed moving cost schedule. The replacement housing payment is separated into 3 basic types - purchase supplement, rental assistance and down payment. All replacement housing must be decent, safe, and sanitary (DSS) before a replacement housing payment can be made.

Table 3.4.3.21-1 shows the number of expected relocations for each Option. No relocation plan has been completed nor has a relocation survey been done. All estimates are based on information from county public records. The number of business relocations as compared to residential relocations is unknown. In order to accomplish the relocation activity in a timely manner, the plan set forth in Chapter 2. Section 2.5 can be used.

Table 3.4.3.21-1.
PL 91-646 - Relocation Assistance

Option	Number of Relocations
Option A	756
Option B	835
Option C	938
Option D	174
Option E	1,172
Option F	38
Option G	104
Option H	101
Option I	122
Option J	92

3.4.3.22 Attitude of Property Owners

Real Estate has not interviewed property owners or tenants during the study phase for the MsCIP. However, numerous public meetings have been held at different locations throughout the study area to inform stakeholders and property owners about the study and the protective measures under consideration for the Mississippi coastal area. A number of local newspapers have published articles that discuss the MsCIP study and the perceived positive effects as well as the negative impacts that may occur as a result of the project. Some of these articles can be found on web sites. While many of the locals may welcome the benefits of the proposed project, there are some who oppose the project.

3.4.3.23 Acquisition Schedule

An acquisition schedule will be developed when plans and specifications become available and more definite information is available pertaining to the specific areas and number of parcels for acquisition. The acquisition schedule will be developed during PED and will be a joint effort of the NFS, the project manager and Real Estate. The schedule will set forth a time line for title, survey, appraisal, negotiation, preparation of documents and closing activity. After acquisition activity is completed certification of lands acquired/owned by the sponsor will be necessary prior to advertisement for construction. The Certification of Real Estate can be accomplished within 30 - 60 days after acquisition. See Chapter 2. Section 2.5. for discussion on an acquisition implementation/management plan.

3.4.3.24 Estates for Proposed Project

All lands required for the levee will be acquired in Fee Simple. Should a borrow site be required, the Borrow Easement will be used. The Temporary Work Area Easement will be used for staging or temporary work areas, and for drainage ditches constructed outside the footprint of the levee, fee or the Drainage Ditch Easement will be used as appropriate. The estates recommended are standard estates.

FEE.

The fee simple title to (the land described in Schedule A) I/(Tracts Nos. ____, ____ and ___), subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

BORROW EASEMENT.

A (temporary) (perpetual and assignable) right and easement to clear, borrow, excavate and remove sand, soil, dirt, and other materials from (the land described in Schedule A) (Tracts Nos. _____, _____ and _____); subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines; reserving, however, to the landowners, their heirs and assigns, all such rights and privileges in said land as may be used without interfering with or abridging the rights and easement hereby acquired.

TEMPORARY WORK AREA EASEMENT.

A temporary easement and right-of-way in, on, over and across (the land described in Schedule A) (Tracts Nos. _____, _____ and _____), for a period not to exceed ___________________, beginning with date possession of the land is granted to the Project Sponsor, for use by the Project Sponsor, its representatives, agents, and contractors as a work area, including the right to deposit backfill, move, store and remove equipment and supplies, and erect and remove temporary structures on the land and to perform any other work necessary and incident to the construction of the ___________________ Project, together with the right to trim, cut, fell and remove there from all trees, underbrush, obstructions, and any other vegetation, structures, or obstacles within the limits of the right-of-way; reserving, however, to the landowners, their heirs and assigns, all such rights and privileges as may be used without interfering with or abridging the rights and easement hereby acquired; subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

DRAINAGE DITCH EASEMENT.

A perpetual and assignable easement and right-of-way in, over and across (the land described in Schedule A) (Tracts Nos. ____, ____ and _____) to construct, maintain, repair, operate, patrol and replace a drainage ditch, reserving, however, to the owners, their heirs and assigns, all such rights and privileges in the land as may be used without interfering with or abridging the rights and easement hereby acquired; subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

3.4.3.25 Real Estate Estimate

A summary of the cost for each option is at Table 3.4.3.25-1. The real estate cost estimates at Tables 3.4.3.25-2 through 3.4.3.25-11 include the land cost for acquisition of land, relocation benefits to include a replacement housing payment and fixed rate move expenses, and Federal and non-Federal administrative costs. Administrative costs are those costs incurred for verifying ownership of lands, certification of those lands required for project purposes, legal opinions, analysis or other requirements that may be necessary, during PED. No cost is included for a borrow site or temporary work area. The requirement, if any, for a borrow site or temporary work area will be identified during PED. If further real estate requirements are identified during PED or if there is a significant increase in cost, a supplement to the Real Estate Appendix will be prepared. A 25% contingency is applied to the current estimate.

Table 3.4.3.25-1.
Real Estate Cost Summary

Option	Impacted Parcels	Relocations	Total Cost
Option A - 20.0	1,512	756	253,268,000
Option B - 30.0	1,688	835	271,797,000
Option C - 40.0	1,927	938	300,446,000
Option D - 20.0	568	174	58,266,000
Option E - 30.0	1,916	1172	298,748,000
Option F - 20.0	76	38	8,917,000
Option G - 30.0	189	104	20,801,000
Option H - 40.0	209	101	28,271,000
Option I - 20.0	225	122	23,938,000
Option J - 30.0	171	92	25,351,000

Table 3.4.3.25-2.
LOD4 Harrison County Inland Barrier - Option A 20.0 Estimate

a. Lands and Improvements/Permits					
1,350 Ownerships for Levee, 722 Improvements					131,791,462
155 Ownerships for Ditches, 34 Improvements					9,827,564
7 Pump Stations					126,002
1,512 Ownerships				Subtotal	141,745,028
b. Mineral Rights					0
c. Damages					0
d. P.L. 91-646 Relocation costs - 756 relocations					21,179,200
e. Administrative Cost					39,690,000
		Relocation	Acquisition	Total	
	Federal	1,134,000	3,780,000	4,914,000	
	Non-Federal	4,536,000	30,240,000	34,776,000	
		5,670,000	34,020,000	39,690,000	
Sub-Total					202,614,228
Contingencies (25%)					50,653,557
	Totals				**253,267,785**
	Rounded				**253,268,000**

Table 3.4.3.25-3.
LOD4 Harrison County Inland Barrier - Option B 30.0 Estimate

a. Lands and Improvements/Permits					
1,526 Ownerships for Levee, 801 Improvements					139,799,904
155 Ownerships for Ditches, 34 Improvements					9,827,564
7 Pump Stations					126,002
1,688 Ownerships				Subtotal	149,753,470
b. Mineral Rights					0
c. Damages					0
d. P.L. 91-646 Relocation costs - 835 relocations					23,441,600
e. Administrative Cost					44,242,500
		Relocation	Acquisition	Total	
	Federal	1,252,500	4,220,000	5,472,500	
	Non-Federal	5,010,000	33,760,000	38,770,000	
		6,262,500	37,980,000	44,242,500	
Sub-Total					217,437,570
Contingencies (25%)					54,359,393
	Totals				**271,796,963**
	Rounded				**271,797,000**

Table 3.4.3.25-4.
LOD4 Harrison County Inland Barrier - Option C 40.0 Estimate

a. Lands and Improvements/Permits				
1,765 Ownerships for Levee, 904 Improvements				153,724,698
155 Ownerships for Ditches, 34 Improvements				9,827,564
7 Pump Stations				126,002
1,927 Ownerships			subtotal	163,678,264
b. Mineral Rights				0
c. Damages				0
d. P.L. 91-646 Relocation costs - 938 relocations				26,286,400
e. Administrative Cost				50,392,500
	Relocation	Acquisition	Total	
Federal	1,407,000	4,817,500	6,224,500	
Non- Federal	5,628,000	38,540,000	44,168,000	
	7,035,000	43,357,500	50,392,500	
Sub-Total				240,357,164
Contingencies (25%)				60,089,291
Totals				**300,446,455**
Rounded				**300,446,000**

Table 3.4.3.25-5.
Option D - Levee for Roadway - Elevation 20.0 Estimate

a. Lands and Improvements/Permits				
406 Ownerships for Levee, 140 Improvements				18,486,170
155 Ownerships for Ditches, 34 Improvements				9,827,564
7 Pump Stations				126,002
568 Ownerships			Subtotal	28,439,736
b. Mineral Rights				0
c. Damages				0
d. P.L. 91-646 Relocation costs - 174 relocations				4,088,000
e. Administrative Cost				14,085,000
	Relocation	Acquisition	Total	
Federal	261,000	1,420,000	1,681,000	
Non-Federal	1,044,000	11,360,000	12,404,000	
	1,305,000	12,780,000	14,085,000	
Sub-Total				46,612,736
Contingencies (25%)				11,653,184
Totals				**58,265,920**
Rounded				**58,266,000**

Table 3.4.3.25-6.
Option E - Levee for Roadway - Elevation 30.0 Estimate

a. Lands and Improvements/Permits					
1,754 Ownerships for Levee, 1,138 Improvements					150,701,678
155 Ownerships for Ditches, 34 Improvements					9,827,564
7 Pump Stations					126,002
1,916 Ownerships				Subtotal	160,655,244
b. Mineral Rights					0
c. Damages					0
d. P.L. 91-646 Relocation costs - 1,172 relocations					26,443,200
e. Administrative Cost					51,900,000
		Relocation	Acquisition	Total	
	Federal	1,758,000	4,790,000	6,548,000	
	Non-Federal	7,032,000	38,320,000	45,352,000	
		8,790,000	43,110,000	51,900,000	
Sub-Total					238,998,444
Contingencies (25%)					59,749,611
	Totals				**298,748,055**
	Rounded				**298,748,000**

Table 3.4.3.25-7.
Option F - Menge Avenue Alternate Route - Elevation 20.0 Estimate

a. Lands and Improvements/Permits					
67 Ownerships for Levee, 38 Improvements					4,125,356
9 Pump Stations					162,002
76 Ownerships				Subtotal	4,287,358
b. Mineral Rights					0
c. Damages					0
d. P.L. 91-646 Relocation costs - 38 relocations					851,200
e. Administrative Cost					1,995,000
		Relocation	Acquisition	Total	
	Federal	57,000	190,000	247,000	
	Non-Federal	228,000	1,520,000	1,748,000	
		285,000	1,710,000	1,995,000	
Sub-Total					7,133,558
Contingencies (25%)					1,783,390
	Totals				**8,916,948**
	Rounded				**8,917,000**

Table 3.4.3.25-8.
Option G - Menge Avenue Alternate Route - Elevation 30.0 Estimate

a. Lands and Improvements/Permits					
180 Ownerships for Levee, 104 Improvements					9,116,968
9 Pump Stations					162,002
189 Ownerships				Subtotal	9,278,970
b. Mineral Rights					0
c. Damages					0
d. P.L. 91-646 Relocation costs - 104 relocations					2,329,600
e. Administrative Cost					5,032,500
		Relocation	Acquisition	Total	
	Federal	156,000	472,500	628,500	
	Non-Federal	624,000	3,780,000	4,404,000	
		780,000	4,252,500	5,032,500	
Sub-Total					16,641,070
Contingencies (25%)					4,160,268
	Totals				**20,801,338**
	Rounded				**20,801,000**

Table 3.4.3.25-9.
Option H - Menge Avenue Alternate Route - Elevation 40.0 Estimate

a. Lands and Improvements/Permits					
195 Ownerships for Levee, 101 Improvements					14,642,288
14 Pump Stations					252,004
209 Ownerships				Subtotal	14,894,292
b. Mineral Rights					0
c. Damages					0
d. P.L. 91-646 Relocation costs - 101 relocations					2,262,400
e. Administrative Cost					5,460,000
		Relocation	Acquisition	Total	
	Federal	151,500	522,500	674,000	
	Non-Federal	606,000	4,180,000	4,786,000	
		757,500	4,702,500	5,460,000	
Sub-Total					22,616,692
Contingencies (25%)					5,654,173
	Totals				**28,270,865**
	Rounded				**28,271,000**

Table 3.4.3.25-10.
Option I - Levee for Roadway with Menge Avenue Alternate - Route Elevation 20.0 Estimate

a. Lands and Improvements/Permits				
216 Ownerships for Levee, 122 Improvements				10,277,860
<u>9 Pump Stations</u>				162,002
225 Ownerships			Subtotal	10,439,862
b. Mineral Rights				0
c. Damages				0
d. P.L. 91-646 Relocation costs - 122 relocations				2,732,800
e. Administrative Cost				5,977,500
	Relocation	Acquisition	Total	
Federal	183,000	562,500	745,500	
Non-Federal	732,000	4,500,000	5,232,000	
	915,000	5,062,500	5,977,500	
Sub-Total				19,150,162
Contingencies (25%)				4,787,541
Totals				**23,937,703**
Rounded				**23,938,000**

Table 3.4.3.25-11.
Option J - Levee for Roadway with Menge Avenue Alternate - Route Elevation 30.0 Estimate

a. Lands and Improvements/Permits				
162 Ownerships for Levee, 92 Improvements				13,520,366
<u>9 Pump Stations</u>				162,002
171 Ownerships			Subtotal	13,682,368
b. Mineral Rights				0
c. Damages				0
d. P.L. 91-646 Relocation costs - 92 relocations				2,060,800
e. Administrative Cost				4,537,500
	Relocation	Acquisition	Total	
Federal	138,000	427,500	565,500	
Non-Federal	552,000	3,420,000	3,972,000	
	690,000	3,847,500	4,537,500	
Sub-Total				20,280,668
Contingencies (25%)				5,070,167
Totals				**25,350,835**
Rounded				**25,351,000**

3.4.3.26 Summary of Potential Real Estate Issues

The requirement for temporary work areas, disposal or borrow areas has not been identified. Should these areas be required, these would be considered as part of the LERRD requirements. Typically if disposal or borrow sites are required, Real estate would provide an analysis during PED to compare the cost of acquiring an these sites with the cost of using a commercial sites and make a determination which method is most cost effective. See Section 2.8 Borrow Areas on page 5.

Should drainage ditches, temporary work areas, disposal or borrow areas become a necessary real estate acquisition requirement, valuation of lands will be performed. Land costs associated with these areas, and administrative costs will be added to the Real Estate Cost Estimate. If further real estate requirements are identified during PED or if there is a significant increase in cost, a supplement to the Real Estate Appendix will be prepared.

Any requirements for relocation contracts pertaining to facilities/utilities will be identified and completed during PED.

Any requirement for mitigation lands will be identified during PED.

Should condemnation of any required real estate interest be necessary, it is the responsibility of the NFS. This issue is addressed during the Assessment of the Non-Federal Sponsor's Real Estate Acquisition Capability. However, if the real estate interest is one that the NFS does not have authority to condemn, the Federal Government can perform the condemnation on behalf of the NFS.

A relocation plan will need to be completed during PED to address potential relocation activity under P.L. 91-646. There are a number of factors pertaining to relocations that can impact the project both in cost and in schedule. Payments for Housing of Last Resort, which would exceed the standard housing replacement payments, are very likely due to the size of the project and the lack of available decent, safe and sanitary housing in the area. Another factor that could increase cost and impact schedule is the cost of business relocations. Depending on the type of business and the operation, this could involve moving equipment and machinery to new locations. It is necessary to interview each impacted individual and business during Pre-Construction, Engineering and Design Phase to determine the requirements for relocation and to estimate a cost for the relocation.

3.4.3.27 Chart of Accounts

The cost estimate for all Federal and non-Federal real estate activities necessary for implementation of the project after completion of the feasibility study for land acquisition, construction, LERRD, and other items are coded as delineated in the Cost Work Breakdown Structure (CWBS). This real estate cost estimate is then incorporated into the Total Current Working Estimate utilizing the Microcomputer Aided Cost Engineering System (MCACES). The Chart of Accounts at Tables 3.4.3.27-1 through 3.4.3.27-10 shows the CWBS for real estate activities.

Table 3.4.3.27-1.
Chart of Accounts - LOD4 Harrison County Inland Barrier - Option A 20.0

01A	Project Planning	Federal	Non-Federal	Totals
	Other			
	Project Cooperation Agreement			
01AX	Contingencies (25%)			
	Subtotal			
01B	Lands and Damages/Permits			
01B40	Acquisition/Review of NFS	3,780,000		3,780,000
01B20	Acquisition by NFS		30,240,000	30,240,000
01BX	Contingencies (25%)	945,000	7,560,000	8,505,000
	Subtotal	4,725,000	37,800,000	42,525,000
01F	PL 91-646 Assistance			
01F20	By NFS		4,536,000	4,536,000
01FX	Contingencies (25%)		1,134,000	1,134,000
	Subtotal		5,670,000	5,670,000
01R	Real Estate Land Payments			
01R1B	Land Payments by NFS		141,745,028	141,745,028
01R2B	PL91-646 Relocation Payment by NFS		21,179,200	21,179,200
01R2D	Review of NFS	1,134,000		1,134,000
01RX	Contingencies (25%)	283,500	40,731,057	41,014,557
	Subtotal	1,417,500	203,655,285	205,072,785
	Totals	**6,142,500**	**247,125,285**	**253,267,785**
	Rounded			**253,268,000**

Table 3.4.3.27-2.
Chart of Accounts - LOD4 Harrison County Inland Barrier - Option B 30.0

01A	Project Planning	Federal	Non-Federal	Totals
	Other			
	Project Cooperation Agreement			
01AX	Contingencies (25%)			
	Subtotal			
01B	Lands and Damages/Permits			
01B40	Acquisition/Review of NFS	4,220,000		4,220,000
01B20	Acquisition by NFS		33,760,000	33,760,000
01BX	Contingencies (25%)	1,055,000	8,440,000	9,495,000
	Subtotal	5,275,000	42,200,000	47,475,000
01F	PL 91-646 Assistance			
01F20	By NFS		5,010,000	5,010,000
01FX	Contingencies (25%)		1,252,500	1,252,500
	Subtotal		6,262,500	6,262,500
01R	Real Estate Land Payments			
01R1B	Land Payments by NFS		149,753,470	149,753,470
01R2B	PL91-646 Relocation Payment by NFS		23,441,600	23,441,600
01R2D	Review of NFS	1,252,500		1,252,500
01RX	Contingencies (25%)	313,125	43,298,768	43,611,893
	Subtotal	1,565,625	216,493,838	218,059,463
	Totals	**6,840,625**	**264,956,338**	**271,796,963**
	Rounded			**271,797,000**

Table 3.4.3.27-3.
Chart of Accounts - LOD4 Harrison County Inland Barrier - Option C 40.0

01A	Project Planning	Federal	Non-Federal	Totals
	Other			
	Project Cooperation Agreement			
01AX	Contingencies (25%)			
	Subtotal			
01B	Lands and Damages/Permits			
01B40	Acquisition/Review of NFS	4,817,500		4,817,500
01B20	Acquisition by NFS		38,540,000	38,540,000
01BX	Contingencies (25%)	1,204,375	9,635,000	10,839,375
	Subtotal	6,021,875	48,175,000	54,196,875
01F	PL 91-646 Assistance			
01F20	By NFS		5,628,000	5,628,000
01FX	Contingencies (25%)		1,407,000	1,407,000
	Subtotal		7,035,000	7,035,000
01R	Real Estate Land Payments			
01R1B	Land Payments by NFS		163,678,264	163,678,264
01R2B	PL91-646 Relocation Payment by NFS		26,286,400	26,286,400
01R2D	Review of NFS	1,407,000		1,407,000
01RX	Contingencies (25%)	351,750	47,491,166	47,842,916
	Subtotal	1,758,750	237,455,830	239,214,580
	Totals	**7,780,625**	**292,665,830**	**300,446,455**
	Rounded			**300,446,000**

Table 3.4.3.27-4.
Chart of Accounts - LOD 4 Harrison County Inland Barrier Option D 20.0 - Levee for Roadway

01A	Project Planning	Federal	Non-Federal	Totals
	Other			
	Project Cooperation Agreement			
01AX	Contingencies (25%)			
	Subtotal			
01B	Lands and Damages/Permits			
01B40	Acquisition/Review of NFS	1,420,000		1,420,000
01B20	Acquisition by NFS		11,360,000	11,360,000
01BX	Contingencies (25%)	355,000	2,840,000	3,195,000
	Subtotal	1,775,000	14,200,000	15,975,000
01F	PL 91-646 Assistance			
01F20	By NFS		1,044,000	1,044,000
01FX	Contingencies (25%)		261,000	261,000
	Subtotal		1,305,000	1,305,000
01R	Real Estate Land Payments			
01R1B	Land Payments by NFS		28,439,736	28,439,736
01R2B	PL91-646 Relocation Payment by NFS		4,088,000	4,088,000
01R2D	Review of NFS	261,000		261,000
01RX	Contingencies (25%)	65,250	8,131,934	8,197,184
	Subtotal	326,250	40,659,670	40,985,920
	Totals	**2,101,250**	**56,164,670**	**58,265,920**
	Rounded			**58,266,000**

Table 3.4.3.27-5.
Chart of Accounts - LOD 4 Harrison County Inland Barrier Option E 30.0 - Levee for Roadway

01A	Project Planning	Federal	Non-Federal	Totals
	Other			
	Project Cooperation Agreement			
01AX	Contingencies (25%)			
	Subtotal			
01B	Lands and Damages/Permits			
01B40	Acquisition/Review of NFS	4,790,000		4,790,000
01B20	Acquisition by NFS		38,320,000	38,320,000
01BX	Contingencies (25%)	1,197,500	9,580,000	10,777,500
	Subtotal	5,987,500	47,900,000	53,887,500
01F	PL 91-646 Assistance			
01F20	By NFS		7,032,000	7,032,000
01FX	Contingencies (25%)		1,758,000	1,758,000
	Subtotal		8,790,000	8,790,000
01R	Real Estate Land Payments			
01R1B	Land Payments by NFS		160,655,244	160,655,244
01R2B	PL91-646 Relocation Payment by NFS		26,443,200	26,443,200
01R2D	Review of NFS	1,758,000		1,758,000
01RX	Contingencies (25%)	439,500	46,774,611	47,214,111
	Subtotal	2,197,500	233,873,055	236,070,555
	Totals	**8,185,000**	**290,563,055**	**298,748,055**
	Rounded			**298,748,000**

Table 3.4.3.27-6.
Chart of Accounts - LOD4 Harrison County Inland Barrier Option F 20.0 - Menge Avenue Alternate Route

01A	Project Planning	Federal	Non-Federal	Totals
	Other			
	Project Cooperation Agreement			
01AX	Contingencies (25%)			
	Subtotal			
01B	Lands and Damages/Permits			
01B40	Acquisition/Review of NFS	190,000		190,000
01B20	Acquisition by NFS		1,520,000	1,520,000
01BX	Contingencies (25%)	47,500	380,000	427,500
	Subtotal	237,500	1,900,000	2,137,500
01F	PL 91-646 Assistance			
01F20	By NFS		228,000	228,000
01FX	Contingencies (25%)		57,000	57,000
	Subtotal		285,000	285,000
01R	Real Estate Land Payments			
01R1B	Land Payments by NFS		4,287,358	4,287,358
01R2B	PL91-646 Relocation Payment by NFS		851,200	851,200
01R2D	Review of NFS	57,000		57,000
01RX	Contingencies (25%)	14,250	1,284,640	1,298,890
	Subtotal	71,250	6,423,198	6,494,448
	Totals	**308,750**	**8,608,198**	**8,916,948**
	Rounded			**8,917,000**

Table 3.4.3.27-7.
Chart of Accounts - LOD4 Harrison County Inland Barrier Option G 30.0 - Menge Avenue Alternate Route

01A	Project Planning	Federal	Non-Federal	Totals
	Other			
	Project Cooperation Agreement			
01AX	Contingencies (25%)			
	Subtotal			
01B	Lands and Damages/Permits			
01B40	Acquisition/Review of NFS	472,500		472,500
01B20	Acquisition by NFS		3,780,000	3,780,000
01BX	Contingencies (25%)	118,125	945,000	1,063,125
	Subtotal	590,625	4,725,000	5,315,625
01F	PL 91-646 Assistance			
01F20	By NFS		624,000	624,000
01FX	Contingencies (25%)		156,000	156,000
	Subtotal		780,000	780,000
01R	Real Estate Land Payments			
01R1B	Land Payments by NFS		9,278,970	9,278,970
01R2B	PL91-646 Relocation Payment by NFS		2,329,600	2,329,600
01R2D	Review of NFS	156,000		156,000
01RX	Contingencies (25%)	39,000	2,902,143	2,941,143
	Subtotal	195,000	14,510,713	14,705,713
	Totals	**785,625**	**20,015,713**	**20,801,338**
	Rounded			**20,801,000**

Table 3.4.3.27-8.
Chart of Accounts - LOD4 Harrison County Inland Barrier Option H 40.0 - Menge Avenue Alternate Route

01A	Project Planning	Federal	Non-Federal	Totals
	Other			
	Project Cooperation Agreement			
01AX	Contingencies (25%)			
	Subtotal			
01B	Lands and Damages/Permits			
01B40	Acquisition/Review of NFS	522,500		522,500
01B20	Acquisition by NFS		4,180,000	4,180,000
01BX	Contingencies (25%)	130,625	1,045,000	1,175,625
	Subtotal	653,125	5,225,000	5,878,125
01F	PL 91-646 Assistance			
01F20	By NFS		606,000	606,000
01FX	Contingencies (25%)		151,500	151,500
	Subtotal		757,500	757,500
01R	Real Estate Land Payments			
01R1B	Land Payments by NFS		14,894,292	14,894,292
01R2B	PL91-646 Relocation Payment by NFS		2,262,400	2,262,400
01R2D	Review of NFS	151,500		151,500
01RX	Contingencies (25%)	37,875	4,289,173	4,327,048
	Subtotal	189,375	21,445,865	21,635,240
	Totals	**842,500**	**27,428,365**	**28,270,865**
	Rounded			**28,271,000**

Table 3.4.3.27-9.
Chart of Accounts - LOD4 Harrison County Inland Barrier Option I 20.0 - Levee for Roadway with Menge Avenue Alternate Route

01A	Project Planning	Federal	Non-Federal	Totals
	Other			
	Project Cooperation Agreement			
01AX	Contingencies (25%)			
	Subtotal			
01B	Lands and Damages/Permits			
01B40	Acquisition/Review of NFS	562,500		562,500
01B20	Acquisition by NFS		4,500,000	4,500,000
01BX	Contingencies (25%)	140,625	1,125,000	1,265,625
	Subtotal	703,125	5,625,000	6,328,125
01F	PL 91-646 Assistance			
01F20	By NFS		732,000	732,000
01FX	Contingencies (25%)		183,000	183,000
	Subtotal		915,000	915,000
01R	Real Estate Land Payments			
01R1B	Land Payments by NFS		10,439,862	10,439,862
01R2B	PL91-646 Relocation Payment by NFS		2,732,800	2,732,800
01R2D	Review of NFS	183,000		183,000
01RX	Contingencies (25%)	45,750	3,293,166	3,338,916
	Subtotal	228,750	16,465,828	16,694,578
	Totals	**931,875**	**23,005,828**	**23,937,703**
	Rounded			**23,938,000**

Table 3.4.3.27-10.
Chart of Accounts - LOD4 Harrison County Inland Barrier Option J 30.0 - Levee for Roadway with Menge Avenue Alternate Route

01A	Project Planning	Federal	Non-Federal	Totals
	Other			
	Project Cooperation Agreement			
01AX	Contingencies (25%)			
	Subtotal			
01B	Lands and Damages/Permits			
01B40	Acquisition/Review of NFS	427,500		427,500
01B20	Acquisition by NFS		3,420,000	3,420,000
01BX	Contingencies (25%)	106,875	855,000	961,875
	Subtotal	534,375	4,275,000	4,809,375
01F	PL 91-646 Assistance			
01F20	By NFS		552,000	552,000
01FX	Contingencies (25%)		138,000	138,000
	Subtotal		690,000	690,000
01R	Real Estate Land Payments			
01R1B	Land Payments by NFS		13,682,368	13,682,368
01R2B	PL91-646 Relocation Payment by NFS		2,060,800	2,060,800
01R2D	Review of NFS	138,000		138,000
01RX	Contingencies (25%)	34,500	3,935,792	3,970,292
	Subtotal	172,500	19,678,960	19,851,460
	Totals	**706,875**	**24,643,960**	**25,350,835**
	Rounded			**25,351,000**

3.4.4 Back Bay of Biloxi Surge Barrier

In order to protect the properties surrounding Biloxi Bay and along the lower portions of the various rivers and streams flowing into the bay, a barrier would be required at some point to block storm waters during major storm events. A search of other similar facilities constructed world wide revealed that the structure model best satisfying both the engineering and socio-ecological necessities of this site was that used for the Thames River Barrier in London, UK. The structure tentatively investigated for incorporation into this work was patterned after the Thames River Barrier with certain minor modifications to adapt to the site and environment specific conditions. A photograph of the Thames River Gates is at Figure 3.4.4-1. The Biloxi Bay watershed covers approximately 640 square miles and is comprised of six sub-basins that stretch across Harrison, Hancock, Stone and Jackson County, MS.

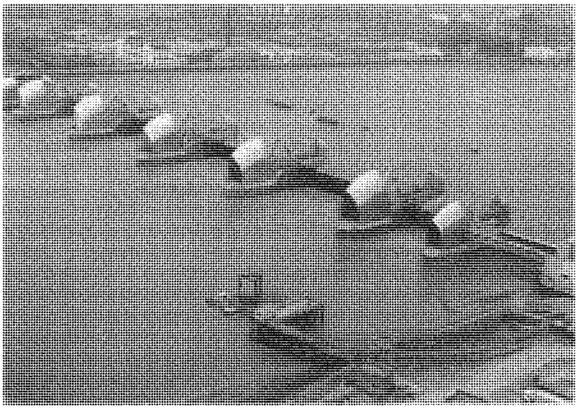

Figure 3.4.4-1.
Thames River Gates, London, UK

In the event of an imminent hurricane, the gates across the Back Bay of Biloxi would be closed, and flow from the rivers feeding these bays, as well as local runoff would pond behind the gates. The tentative location of the barrier chosen for this study is shown below in Figure 3.4.4-2. The alternatives for this proposed measure are identified as Option A, Option B and Option C.

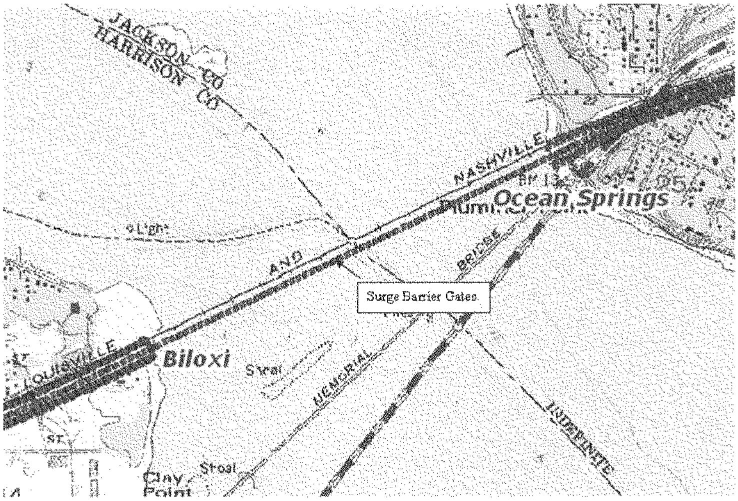

Figure 3.4.4-2.
Back Bay of Biloxi Surge Barrier Location

3.4.4.1 Option A - Elevation 20.0 ft NAVD88

Option A is the design and construction of a rising sector gate in the Back Bay of Biloxi creating a barrier to elevation 20.0.

3.4.4.2 Option B - Elevation 30.0 ft NAVD88

Option B is the design and construction of a rising sector gate in the Back Bay of Biloxi creating a barrier to elevation 30.0.

3.4.4.3 Option C - Elevation 40.0 ft NAVD88

Option C is the design and construction of a rising sector gate in the Back Bay of Biloxi creating a barrier to elevation 40.0.

3.4.4.4 Project Description

The alignment suggested herein for the barrier structure would run parallel with and south of the Railroad Bridge crossing Biloxi Bay. This would approximate the shortest route across the inlet leading from the Mississippi Sound into the bay. As the preliminary layout of the barrier was developed it became apparent that, because of the excavation required, a significant amount of separation would be required between the railroad bridge and the ultimate location of the structures included in the barrier. For this study the centerline of the barrier was positioned approximately 260 feet from the center of the railroad bridge. This was left unaltered for all protection levels. The entire barrier would be approximately 6,100 feet in length from water's edge to water's edge, and would consist of rock fill levees extending from the overland levee at each bank for some distance into the bay and enveloping the mass concrete non-overflow wall sections leading to each end of the gated structure.

The points at which the barrier would come ashore in Jackson County on the east and Harrison County on the west, are in urban areas with extensive residential and commercial development. Several structures would need to be relocated and it is uncertain the extent to which existing utilities might have to be relocated to clear the way for this facility.

Structurally, the Barrier as configured for this study would consist of a series of 25 large stainless steel clad, structural steel framed gates called rising sector gates. Each of these would be supported on reinforced concrete piers resting on large continuous concrete sills with pile foundations. The tentative layout used to estimate the scope of the structure was configured having gates 132 feet long mounted on 28-foot wide piers. The number of gates was determined by the extent of water having depth sufficient to support their operation. To facilitate as nearly as possible the normal ebb and flow of tide waters through the barrier, the concrete connector wall and rock fill portions of the barrier either side of the gated structure would be fitted with a series of closely spaced low level gated culverts. The gate and pier heights were varied to accommodate the "level of protection" under consideration. The three elevations selected for this study were 20, 30, and 40 NAVD88. In each instance the gate heights were set to match the protection level elevations with pier heights set approximately 3 feet higher to provide minor wave clearance for protection of operating equipment. Atop each pier an operating machinery block would be mounted to house the operating equipment. Operating and utility access would be provided through two continuous tunnels passing through the sill section and the rock fill, to operating facilities located on each bank.

In order to assure proper functioning of the facilities once they are placed in service a program of Operations and Maintenance would be developed by the U.S. Army Corps of Engineers, in conjunction and cooperation with the affected state and local entities. This O & M Plan would address specific responsibilities as to daily operation of the facilities, the periodic testing and maintenance of the operating machinery, maintenance of specified stocks of replacement parts, security of the facilities, and maintenance of any buildings and grounds associated with the operation and maintenance of the facilities. As presently envisioned, this O & M responsibility would remain under control of the U.S. Army Corps of Engineers and would be administered under its Operations mission.

3.4.4.5 Real Estate Requirements

Real Estate requirements for Line of Defense 4, Back Bay of Biloxi Surge Barrier include lands, easements, rights-of-way and relocations, and disposal/borrow areas (LERRD), and the right to construct, rock levees and an elevated gate barrier in the Back Bay of Biloxi with operating facilities located on each landward bank of the barrier. The rock levees on either side of the gates will tie into the LOD4 inland barrier. There will be 2 operating facilities, one located in Jackson County and the other in Harrison County. Each site will be comprised of approximately 5 acres and these will be acquired in fee. The real estate cost estimate will be the same for each option as they all have the same requirements.

For those lands required for construction that lay below the mean high water mark, navigation servitude will apply. Navigation servitude is the dominant right of the Government under the Commerce Clause of the U.S. Constitution (U.S. CONST. Art.I,§8,cl.3) to use, control and regulate the navigable waters of the United States and the submerged lands hereunder for various commerce-related purposes including navigation and flood control. In tidal areas, the servitude extends to all lands below the, mean high water mark. In non-tidal areas, the servitude extends to all lands within the bed and banks of a navigable stream that lie below the ordinary high water mark. The determination of the availability of the navigation servitude should be made on a case by case basis and consists of a two -step process. First the government must determine whether the project serves a purpose that has a nexus to navigation. Purposes recognized by the courts to have the nexus include navigation, flood control and hydroelectric power. If determined that such a nexus exists, then the second step is to determine whether the land at issue is located below the mean or ordinary high water mark of a navigable watercourse. As a general rule, the Government does not acquire interests in real property that it already possesses or over which its use or control is or can be legally exercised. Therefore, if the navigation servitude is found to be available as a result of application of the process described in subparagraph b of this paragraph, then the Government will generally exercise its rights hereunder and, to the extent of such rights, will not acquire a real property interest in the land to which the navigation servitude applies. Generally, it is the policy of the U.S. Army Corps of Engineers (USACE) to utilize the navigation servitude in all situations where available, for cost shared and full Federal projects. The determination of availability will be made during PED.

3.4.4.6 Utility/Facility Relocation

It is probable that there will be some utility/facility relocations for this plan. Specific requirements are unknown at this time but will be defined during PED. See Chapter 2 Section 2.10 for more detailed discussion.

3.4.4.7 Existing Projects/Studies

Relevant projects and studies are found in the main report at Section 1.6, History of the Investigation and Section 1.7, Prior and On-Going Studies, Reports and Programs.

3.4.4.8 Environmental Impacts

See the Main Report, Chapter 6. Environmental Effects of Plans and the Environmental Appendix, for a full discussion on environmental effects.

3.4.4.9 Project Sponsor Responsibilities and Capabilities

The State of Mississippi will be the non-Federal Project Sponsor (NFS). The NFS has the responsibility to acquire all real estate interests required for the Project. The NFS shall accomplish all alterations and relocations of facilities, structures and improvements determined by the government to be necessary for construction of the Project.

Title to any acquired real estate will be retained by the Project Sponsor and will not be conveyed to the United States Government. Prior to advertisement of any construction contract, the NFS shall furnish to the government an Authorization for Entry for Construction (Exhibit "A" to the Real Estate Appendix) to all lands, easements and rights-of-way, as necessary. The NFS will also furnish to the government evidence supporting their legal authority to grant rights-of-way to such lands. The NFS shall comply with applicable provisions of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970, Public Law 91-646, approved 2 January 1971, and amended by Title IV of the Surface Transportation Uniform Relocation Assistance Act of 1987, Public Law 100-17, effective 2 April 1989, in acquiring real estate interests for the Project, and inform all affected persons of applicable benefits, policies, and procedures in connection with said Act(s). A form for the Assessment of the Non-Federal Sponsor's Capability to Acquire Real Estate is at Exhibit "B" to the Real Estate Appendix. The assessment will be made during PED phase.

The non-Federal sponsor is entitled to receive credit against its share of project costs for the value of lands it provides and the value of the relocations that are required for the project. Generally, for the purpose of determining the amount of credit to be afforded, the value of the LER is the fair market value of the real property interest, plus certain incidental costs of acquiring those interests, that the non-federal sponsor provided for the project as required by the Government. The NFS cannot receive credit for the value of any LER, including incidental costs, which were previously provided as an item of cooperation for another Federal project, including projects that preceded enactment of WRDA 1986.

3.4.4.10 Government Owned Property

There are no known Government owned lands within the proposed project.

3.4.4.11 Historical Significance

See the Main Report, Section 3.2.9 Cultural and Archaeological Resources, for a general discussion on cultural and archaeological resources.

3.4.4.12 Mineral Rights

There are no known mineral activities within the scope of the proposed project.

3.4.4.13 Hazardous, Toxic, and Radioactive Waste (HTRW)

Due to the extent of the project, no preliminary assessment was performed to identify the possibility of hazardous waste on the sites. These studies will be conducted during the next phase of work. See Sections 3.2.8 and 6.16 of the Main Report for a discussion on HTRW.

3.4.4.14 Public Law 91-646, Relocation Assistance Benefits

No relocations are expected with this alternative.

3.4.4.15 Attitude of Property Owners

Real Estate has not interviewed property owners or tenants during the study phase for the MsCIP. However, numerous public meetings have been held at different locations throughout the study area to inform stakeholders and property owners about the study and the protective measures under consideration for the Mississippi coastal area. A number of local newspapers have published articles that discuss the MsCIP study and the perceived positive effects as well as the negative impacts that may occur as a result of the project. Some of these articles can be found on web sites. While many of the locals may welcome the benefits of the proposed project, there are some who oppose the project.

3.4.4.16 Acquisition Schedule

An acquisition schedule will be developed when plans and specifications become available and more definite information is available pertaining to the specific areas and number of parcels for acquisition. The acquisition schedule will be developed during PED and will be a joint effort of the NFS, the project manager and Real Estate. The schedule will set forth a time line for title, survey, appraisal, negotiation, preparation of documents and closing activity. After acquisition activity is completed certification of lands acquired/owned by the sponsor will be necessary prior to advertisement for construction. The Certification of Real Estate can be accomplished within 30 - 60 days after acquisition. See Chapter 2. Section 2.5. for discussion on an acquisition implementation/management plan.

3.4.4.17 Estates for Proposed Project

All lands required for the operating facilities will be acquired in Fee Simple.

FEE.

The fee simple title to (the land described in Schedule A) l/(Tracts Nos. ____, ____ and ___), subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

3.4.4.18 Real Estate Estimate

The real estate cost estimate at Table 3.4.4.18-1 includes the land cost for acquisition of land, permits, and Federal and non-Federal administrative costs. Administrative costs are those costs incurred for verifying ownership of lands, certification of those lands required for project purposes, legal opinions, analysis or other requirements that may be necessary, during PED. No cost is included for a temporary work area. The requirement, if any, for a temporary work area will be identified during PED. If further real estate requirements are identified during PED or if there is a significant increase in cost, a supplement to the Real Estate Appendix will be prepared. A 25% contingency is applied to the current estimate.

Table 3.4.4.18-1.
LOD4 Back Bay of Biloxi Surge Barrier - Option A, B or C Estimate

a. Lands and Improvements/Permits				
4 Ownerships, 0 Improvements			Hancock	842,573
4 Ownerships, 0 Improvements			Harrison	391,310
			Subtotal	1,233,883
b. Mineral Rights				0
c. Damages				0
d. P.L. 91-646 Relocation costs - 0 relocations				0
e. Administrative Cost				180,000
	Relocation	Acquisition	Total	
Federal	0	20,000	20,000	
Non-Federal	0	160,000	160,000	
	0	180,000	180,000	
Sub-Total				1,413,883
Contingencies (25%)				353,471
Totals				**1,767,354**
Rounded				**1,767,000**

3.4.4.19 Summary of Potential Real Estate Issues

It is expected that navigation servitude will be exercised to construct the surge barrier in the Back Bay of Biloxi. This determination will be made during PED.

It is probable that there will be some utility/facility relocations for this plan. Specific requirements are unknown at this time but will be defined during PED.

The requirement for temporary work areas has not been identified. Should these areas be required, these would be considered as part of the LERRD requirements.

Should temporary work areas become a necessary real estate acquisition requirement, valuation of lands will be performed. Land costs associated with temporary work areas and administrative costs will be added to the Real Estate Cost Estimate. If further real estate requirements are identified during PED or if there is a significant increase in cost, a supplement to the Real Estate Appendix will be prepared.

Any requirement for mitigation lands will be identified during PED.

Should condemnation of any required real estate interest be necessary, it is the responsibility of the NFS. This issue is addressed during the Assessment of the Non-Federal Sponsor's Real Estate Acquisition Capability. However, if the real estate interest is one that the NFS does not have authority to condemn, the Federal Government can perform the condemnation on behalf of the NFS.

3.4.4.20 Chart of Accounts

The cost estimate for all Federal and non-Federal real estate activities necessary for implementation of the project after completion of the feasibility study for land acquisition, construction, LERRD, and other items are coded as delineated in the Cost Work Breakdown Structure (CWBS). This real estate cost estimate is then incorporated into the Total Current Working Estimate utilizing the Microcomputer Aided Cost Engineering System (MCACES). The Chart of Accounts at Table 3.4.4.20-1 shows the CWBS for real estate activities.

Table 3.4.4.20-1.
Chart of Accounts - LOD4 Back Bay of Biloxi Surge Barrier - Option A, B or C

01A	Project Planning	Federal	Non-Federal	Totals
	Other			
	Project Cooperation Agreement			
01AX	Contingencies (25%)			
	Subtotal			
01B	Lands and Damages/Permits			
01B40	Acquisition/Review of NFS	20,000		20,000
01B20	Acquisition by NFS		160,000	160,000
01BX	Contingencies (25%)	5,000	40,000	45,000
	Subtotal	25,000	200,000	225,000
01F	PL 91-646 Assistance			
01F20	By NFS		0	0
01FX	Contingencies (25%)		0	0
	Subtotal		0	0

01A	Project Planning	Federal	Non-Federal	Totals
01R	Real Estate Land Payments			
01R1B	Land Payments by NFS		1,233,883	1,233,883
01R2B	PL91-646 Relocation Payment by NFS		0	0
01R2D	Review of NFS	0		0
01RX	Contingencies (25%)	0	308,471	308,471
	Subtotal	0	1,542,354	1,542,354
	Totals	**25,000**	**1,742,354**	**1,767,354**
	Rounded			**1,767,000**

3.4.5 Jackson County Inland Barrier

Residential and business areas along the coast in Jackson County are susceptible to damage from storm surges associated with hurricanes. Earthen levees were evaluated for protection of these areas. The levees were evaluated at elevations 20 ft NAVD88 and 30 ft NAVD88 and 40 ft NAVD88. The top width was assumed 15 ft with side-slopes of 1 vertical to 3 horizontal. These alternatives are identified as Option A, Option B and Option C. The location of the proposed project in Jackson County is shown in Figures 3.4.5-1. The levee will be constructed parallel to the CSX Railroad, Highway 57 and Highway 90.

Jackson County is located on the east side of the Mississippi at the Mississippi Sound coast. The main residential and business area is at Ocean Springs, which is mostly south of the proposed levee. Ground elevations over the areas behind the proposed levee vary between elevations 10-20 ft NAVD88 at low areas to as high as 50 ft NAVD88. The area is drained by Old Fort Bayou.

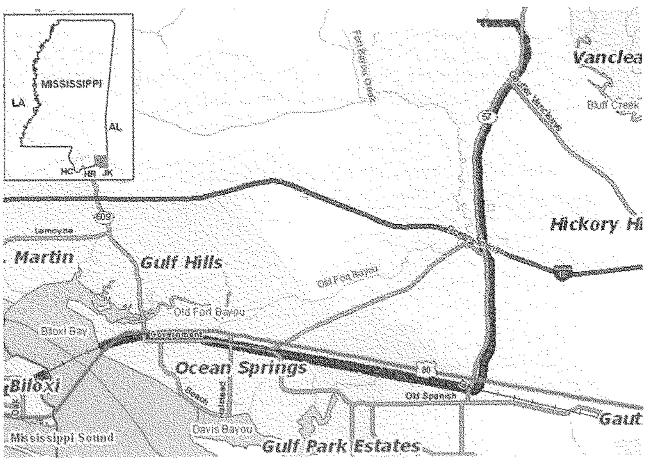

Figure 3.4.5-1.
Vicinity Map Jackson County, MS

3.4.5.1 Option A - Elevation 20.0 ft NAVD88

This option consists of constructing a levee to elevation 20 ft NAVD88 parallel to Highway 90 along with the internal sub-basins and levee culvert/pump locations. The levee will be located mostly along high ground so ponding at the levee would be minimal. Ponding will occur on the outside of the levee which would require ditching to other drainage basins.

3.4.5.2 Option B - Elevation 30.0 ft NAVD88

The alignment of the levee is the same as Option A, above but with an elevation of 30.0 feet. The only difference between the description of this option and preceding description of Option A is the height of the levee, pumping facilities, number of roadway and railroad intersections, and the length of the levee culverts.

3.4.5.3 Option C - Elevation 40.0 ft NAVD88

The alignment of the levee is the same as Option A, above but with an elevation of 40.0 feet. The only difference between the description of this option and preceding description of Option A is the height of the levee, pumping facilities, number of roadway and railroad intersections, and the length of the levee culverts.

3.4.5.4 Project Description

The location of the proposed levee project is shown in Figures 3.4.5.4-1 through 3.4.5.4-3. As described, the levee will be an earthen berm constructed either at elevation 20.0 feet, 30.0 or 40.0 feet along with the internal sub-basins and levee culvert/pump locations. Drainage on the interior of the ring levee would be collected at the levee and channeled to culverts placed in the levee. 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. In addition, pumps would be constructed near the outflow points to remove water from the interior during storm events occurring when the culverts are closed because of high water in the sound. Drainage ditches along the toe of the levee will be required to assure that smaller basins can be drained to a culvert/pump site. Figure 3.4.5.4-4 shows the proposed locations of the pump/culvert sites. 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. Further studies will detail the requirement for the appropriate ponding areas, pump sizes, or buyouts in the affected areas. In order to prevent hurricane surges from circumventing the levee, surge barrier gates would be constructed across both Biloxi Bay and St. Louis Bay. In the event of an imminent hurricane, barrier gates across the Back Bay of Biloxi would be closed, and flow from the Biloxi and Tchoutacabouffa Rivers, as well as local runoff would pond behind the gates.

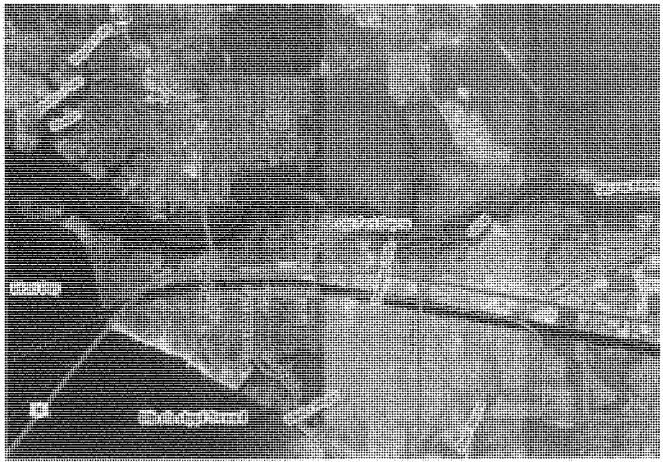

Figure 3.4.5.4-1.
Jackson County Inland Barrier

Figure 3.4.5.4-2.
Jackson County Inland Barrier

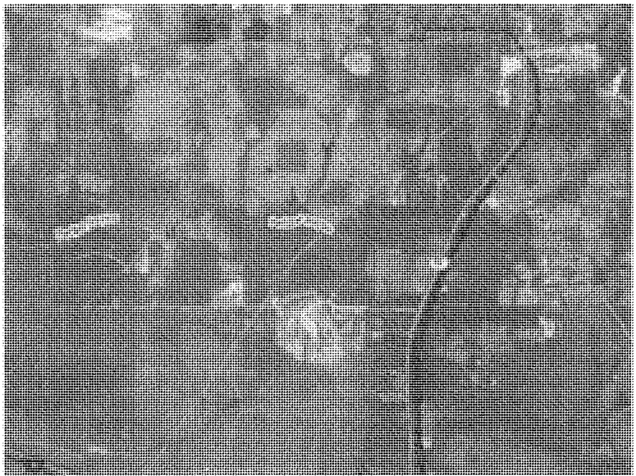

Figure 3.4.5.4-3.
Jackson County Inland Barrier

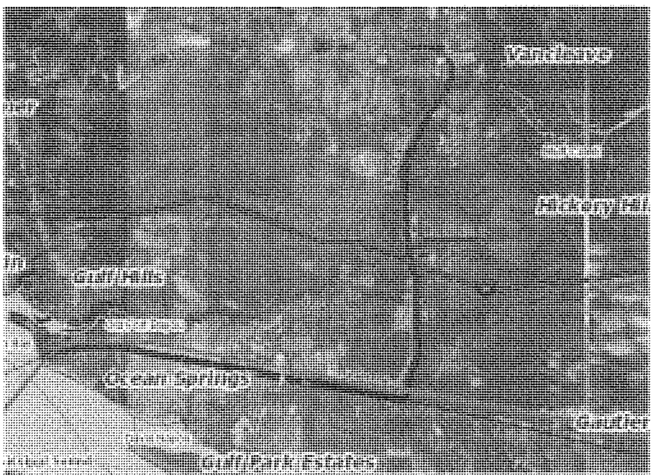

Figure 3.4.5.4-4.
Pump/Culvert/Sub-basin Site Locations

The inland barrier earthen levee section will have one vertical to three horizontal side slopes with a fifteen foot crest width. All work areas to receive fill shall be cleared and grubbed of all trees and surface organics and all existing foundations, streets, utilities, etc. will be removed and the subsequent cavities backfilled and compacted. The levee will be constructed of sand clay materials obtained from off site commercial sources, and trucked to the work area. The final surface will be armored by the placement of 24 inch thick gabion mattress filled with small stone for erosion protection during an event that overtops the levee. The armoring will be anchored on the front face by trenching and extend across the downstream slope and a 25 foot area beyond the toe. The front side of the levee and all non critical surface areas will be subsequently covered by grassing. In order to maintain the natural runoff patterns culverts would be inserted through the protection line at appropriate locations. For Options A, B, and C, drainage features would be required at 2 locations with the culvert requirement ranging from seven 7' wide by 3' high, to eleven 10' wide by 4; high water passages. Each water passage would be fitted with both a flap gate at the outlet end and a sluice gate placed near the center of the culvert with a vertical operator stem extending through an access shaft to the top of levee elevation.

Road crossings will incorporate small gate structures or ramping over the embankment where the surface elevation is near that of the crest elevation. The elevation relationship of the crest and the adjacent railroad will be a governing factor. At each point where a roadway crosses the protection line the decision must be made whether to maintain this artery and adapt the protection line to accommodate it, or to terminate the artery at the protection line and divert traffic to cross the protection line at another location. For this study it was assumed that all roadways and railways crossing the levee alignment would be retained except where it was very evident that traffic could be combined without undue congestion. Once the decision has been made to retain a particular roadway, it must then be determined how best to configure the artery to conduct traffic across the protection line. The simplest means of passing roadway traffic is to ramp the roadway over the protection line. This alternative is not always viable because of severe right-of-way restraints caused by extreme levee height, urban congestion, etc. In such instances other methods can be used including partial ramping in combination with low profile roller gates. In more restricted areas full height gates which would leave the roadway virtually unaltered might be preferable, even though this alternative would usually be more costly than ramping. In some extreme circumstances where high levees are required to pass through very congested areas, installation of tunnels with closure gates may be required.

Because of the extreme gradient restrictions necessarily placed on railway construction, it is practically never acceptable to elevate a railway up and over a levee. Therefore, the available alternatives would include gated pass through structures. Because of the vertical clearance requirements of railroad traffic all railroad pass through structures for this study were configured having vertical walls on either side of the railway with double swing gates extending to the full height of the levee. Roadway and railway intersections are not applicable to Option A, 20.0 and Option B, 30.0. At Option C, elevation 40.0, 3 roadway intersections would have to be accommodated. It was determined that roller gate structures would suffice for all thee of these locations.

There are two sites in Jackson County that would require special flood protection with the flood protection level set at elevation 40, the court facilities located immediately south of the protection line in downtown Biloxi and similar governmental facilities in downtown Moss Point. The Biloxi facilities would require a three sided Tee Wall structure approximately 1410 feet long originating and terminating in the levee at its northwest and northeast ends. It would be fitted with four face sealing roller gates to close off the required street and driveway access points in time of flood. The Moss Point Tee Wall would be similarly configured and would extend approximately 1552 feet. It would require two roadway closure gates.

The features that require periodic operations will be the exercising of the pumps and emergency generators at the various pump stations, the testing of the gate structures at the various road crossings, grass cutting of the levee slopes and toe areas and the filling of rilled areas within the embankment due to surface erosion. Scheduled maintenance should include periodic greasing of all gears and coupled joints, maintaining any battery backup systems, and replacement of standby fuel supplies.

3.4.5.5 Real Estate Requirements

Real Estate requirements for Line of Defense 4, Jackson County Levee include lands, easements, rights-of-way and relocations, and disposal/borrow areas (LERRD), and the right to construct an earthen levee, drainage ditches and 2 pump station facilities.

Based on the footprint of the Option A, 20.0 foot elevation, it was determined that approximately 323 parcels and 171 structures would be impacted. The acreage to be acquired for the levee is unknown. It is known that the 2 pump stations will require approximately 0.23 of an acre each for a total of 0.46 of an acre. Lands required for construction of the levee will be acquired in fee simple interest. Based on the number of structures being impacted, the assumption is that there will be 171 relocations.

Based on the footprint of the Option B, 30.0 foot elevation, it was determined that 361 parcels and 191 structures would be impacted. The acreage to be acquired for the levee is unknown. It is known that the 2 pump stations will require approximately 0.23 of an acre each for a total of 0.46 of an acre. Lands required for construction of the levee will be acquired in fee simple interest. Based on the number of structures being impacted, the assumption is that there will be 191 relocations.

Based on the footprint of the Option C, 40.0 foot elevation, it was determined that 404 parcels and 217 structures would be impacted. The acreage to be acquired for the levee is unknown. It is known that the 2 pump stations will require approximately 0.23 of an acre each for a total of 0.46 of an acre. Lands required for construction of the levee will be acquired in fee simple interest. Based on the number of structures being impacted, the assumption is that there will be 217 relocations.

Any modifications to the roadways and utilities will most probably need to be accomplished through a relocation contract. This will be further investigated and confirmed during PED.

Footprints for drainage ditches are not available at time of this report. However, from the figures it appears that acquisition of additional lands for drainage ditches outside the footprint of the levee will be minimal. Until final plans and specifications are completed, land requirements for drainage ditches are assumed to be covered by contingency. This additional requirement will be determined during PED.

During the formulation of the nonstructural (NS) measures and alternative plans, the NS PDT became aware of local efforts by the leadership of Moss Point, MS to relocate several public buildings out of the hurricane surge zone to a higher elevation within the municipal area. A series of meetings with the Mayor of Moss Point and other city officials followed to work toward development of a plan to relocate these facilities that are critical to the safety and continued operations of the local government. As a result of the meetings the NS PDT developed a Pilot Relocations Project for Moss Point, MS. The public buildings included in the pilot project are the city hall, police station, fire station and community recreation center. As these structures are owned and operated by the City of Moss Point and are considered essential to the operation of the city, they would therefore be eligible for facility relocation. The description of the relocations measure, eligible facilities and costs are included in the Nonstructural Appendix at Section 4.3.9.6 Pilot Moss Point Public Buildings Relocations Project. Any substitute facilities relocations will be performed under a Real Estate Relocation Contract. The cost for these relocations is captured in the Nonstructural Appendix but final crediting would be considered as part of the LERRD credit.

An assumption is made that excavated materials from clearing, snagging, and construction of ditches, etc. will be disposed of in county owned or commercial landfills. However, In the event that the excavated material is not suitable for a landfill a disposal site will have to be acquired. Typically if disposal sites are required, this would be considered as part of the LERRD requirement. Real Estate would provide an analysis during PED to compare the cost of acquiring an upland disposal site with the cost of using a commercial landfill and make a determination which method is most cost effective.

The recommended plan proposes to use material from an inventory of upland borrow sites to construct the levee. A specific site has not been identified or confirmed for use at time of this report. Typically if borrow sites are required, this would be considered a part of the LERRD requirement. Real Estate would provide an analysis during PED to compare the cost of acquiring an upland borrow site with the cost of using a commercial borrow site and make a determination which method is most cost effective. The requirement for temporary work areas is unknown. Sponsor owned lands will be used if available. Otherwise, this may be an additional real estate requirement, and will be further defined during PED.

3.4.5.6 Utility/Facility Relocation

The plan calls for roads to be ramped over the proposed levee and possible relocation of utilities. An assumption is made that this work will be accomplished through a relocation contract. This will be further investigated and confirmed during PED. As discussed above any municipal buildings designated as essential to the operation of the city could be relocated as substitute facilities relocations See Chapter 2 Section 2.10 for more detailed discussion, and the Nonstructural Appendix at Section 4.3.9.6.

3.4.5.7 Existing Projects/Studies

Relevant projects and studies are found in the main report at Section 1.6, History of the Investigation and Section 1.7, Prior and On-Going Studies, Reports and Programs.

3.4.5.8 Environmental Impacts

See the Main Report, Chapter 6. Environmental Effects of Plans and the Environmental Appendix for a full discussion on environmental effects.

3.4.5.9 Project Sponsor Responsibilities and Capabilities

The State of Mississippi will be the non-Federal Project Sponsor (NFS). The NFS has the responsibility to acquire all real estate interests required for the Project. The NFS shall accomplish all alterations and relocations of facilities, structures and improvements determined by the government to be necessary for construction of the Project.

Title to any acquired real estate will be retained by the Project Sponsor and will not be conveyed to the United States Government. Prior to advertisement of any construction contract, the NFS shall furnish to the government an Authorization for Entry for Construction (Exhibit "A" to the Real Estate Appendix) to all lands, easements and rights-of-way, as necessary. The NFS will also furnish to the government evidence supporting their legal authority to grant rights-of-way to such lands. The NFS shall comply with applicable provisions of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970, Public Law 91-646, approved 2 January 1971, and amended by Title IV of the Surface Transportation Uniform Relocation Assistance Act of 1987, Public Law 100-17, effective 2 April 1989, in acquiring real estate interests for the Project, and inform all affected persons of applicable benefits, policies, and procedures in connection with said Act(s). A form for the

Assessment of the Non-Federal Sponsor's Capability to Acquire Real Estate is at Exhibit "B" to the Real Estate Appendix. The assessment will be made during PED phase.

The non-Federal sponsor is entitled to receive credit against its share of project costs for the value of lands it provides and the value of the relocations that are required for the project. Generally, for the purpose of determining the amount of credit to be afforded, the value of the LER is the fair market value of the real property interest, plus certain incidental costs of acquiring those interests, that the non-federal sponsor provided for the project as required by the Government. The NFS cannot receive credit for the value of any LER, including incidental costs, which were previously provided as an item of cooperation for another Federal project, including projects that preceded enactment of WRDA 1986.

3.4.5.10 Government Owned Property

There are 7-8 Government owned parcels within the footprint of the project that will be impacted depending on the option recommended for construction. In viewing the footprint, it is noted that the parcels will be impacted where they abut Highway 90 and Highway 57. The parcels may be impacted by approximately 10-30%. Land values are listed in the public records, but no improvement values are listed. Ownership is listed in public records as United States of America and USA Dept of the Navy. Specific impacts to Government owned lands will be determined during PED.

3.4.5.11 Historical Significance

See the Main Report, Section 3.2.9 Cultural and Archaeological Resources, for a general discussion on cultural and archaeological resources.

3.4.5.12 Mineral Rights

There are no known mineral activities within the scope of the proposed project.

3.4.5.13 Hazardous, Toxic, and Radioactive Waste (HTRW)

Due to the extent of the project, no preliminary assessment was performed to identify the possibility of hazardous waste on the sites. These studies will be conducted during the next phase of work. See Sections 3.2.8 and 6.16 of the Main Report for a discussion on HTRW.

3.4.5.14 Public Law 91-646, Relocation Assistance Benefits

The Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970 establishes a uniform policy for fair and equitable treatment of persons displaced as a result of federal and federally assisted programs in order that such persons shall not suffer disproportionate injuries as a result of programs designed for the benefits of the public as a whole. A qualified displaced person may be entitled to certain relocation assistance benefits which include reimbursement of moving costs and a replacement housing benefit. Moving expense can be reimbursed either based on actual costs or a fixed moving cost schedule. The replacement housing payment is separated into 3 basic types - purchase supplement, rental assistance and down payment. All replacement housing must be decent, safe, and sanitary (DSS) before a replacement housing payment can be made.

It is estimated that there are approximately 171 relocations in Option A, approximately 191 relocations in Option B, and approximately 217 relocations in Option C. No relocation plan has been completed nor has a relocation survey been done. All estimates are based on information from county public records. The number of business relocations as compared to residential relocations is unknown. In order to accomplish the relocation activity in a timely manner, the plan set forth in Chapter 2. Section 2.5 can be used.

3.4.5.15 Attitude of Property Owners

Real Estate has not interviewed property owners or tenants during the study phase for the MsCIP. However, numerous public meetings have been held at different locations throughout the study area to inform stakeholders and property owners about the study and the protective measures under consideration for the Mississippi coastal area. A number of local newspapers have published articles that discuss the MsCIP study and the perceived positive effects as well as the negative impacts that may occur as a result of the project. Some of these articles can be found on web sites. While many of the locals may welcome the benefits of the proposed project, there are some who oppose the project.

3.4.5.16 Acquisition Schedule

An acquisition schedule will be developed when plans and specifications become available and more definite information is available pertaining to the specific areas and number of parcels for acquisition. The acquisition schedule will be developed during PED and will be a joint effort of the NFS, the project manager and Real Estate. The schedule will set forth a time line for title, survey, appraisal, negotiation, preparation of documents and closing activity. After acquisition activity is completed certification of lands acquired/owned by the sponsor will be necessary prior to advertisement for construction. The Certification of Real Estate can be accomplished within 30 - 60 days after acquisition. See Chapter 2. Section 2.5. for discussion on an acquisition implementation/management plan.

3.4.5.17 Estates for Proposed Project

All lands required for the levee will be acquired in Fee Simple. Should a borrow site be required, the Borrow Easement will be used. The Temporary Work Area Easement will be used for staging or temporary work areas, and the Drainage Ditch Easement will be used for construction of any drainage ditches outside the footprint of the levee as required. The estates recommended are standard estates.

FEE.

The fee simple title to (the land described in Schedule A) I/(Tracts Nos. ____, ____ and ___), subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

BORROW EASEMENT.

A (temporary) (perpetual and assignable) right and easement to clear, borrow, excavate and remove sand, soil, dirt, and other materials from (the land described in Schedule A) (Tracts Nos. _____, _____ and _____); subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines; reserving, however, to the landowners, their heirs and assigns, all such rights and privileges in said land as may be used without interfering with or abridging the rights and easement hereby acquired.

TEMPORARY WORK AREA EASEMENT.

A temporary easement and right-of-way in, on, over and across (the land described in Schedule A) (Tracts Nos. _____, _____ and _____), for a period not to exceed __________________, beginning with date possession of the land is granted to the Project Sponsor, for use by the Project Sponsor, its representatives, agents, and contractors as a work area, including the right to deposit backfill, move, store and remove equipment and supplies, and erect and remove temporary structures on the land and to perform any other work necessary and incident to the construction of the __________________ Project, together with the right to trim, cut, fell and remove there from all trees, underbrush, obstructions, and any other vegetation, structures, or obstacles within the limits of the right-of-way; reserving, however, to the landowners, their heirs and assigns, all such rights and privileges as may be used without interfering with or abridging the rights and easement hereby acquired; subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

DRAINAGE DITCH EASEMENT.

A perpetual and assignable easement and right-of-way in, over and across (the land described in Schedule A) (Tracts Nos. ____, ____ and _____) to construct, maintain, repair, operate, patrol and replace a drainage ditch, reserving, however, to the owners, their heirs and assigns, all such rights and privileges in the land as may be used without interfering with or abridging the rights and easement hereby acquired; subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

3.4.5.18 Real Estate Estimate

A summary of the cost for each option is at Table 3.4.5.18-1. The real estate estimates at Tables 3.4.5.18-2 through 3.4.5.18-4 include the land cost for acquisition of land, relocation benefits to include a replacement housing payment and fixed rate move expenses, and Federal and non-Federal administrative costs. Administrative costs are those costs incurred for verifying ownership of lands, certification of those lands required for project purposes, legal opinions, analysis or other requirements that may be necessary, during PED. No cost is included for a borrow site or temporary work area. The requirement, if any, for a borrow site or temporary work area will be identified during PED. If further real estate requirements are identified during PED or if there is a significant increase in cost, a supplement to the Real Estate Appendix will be prepared. A 25% contingency is applied to the current estimate.

Table 3.4.5.18-1.
Real Estate Cost Summary

Option	Impacted Parcels	Relocations	Total Cost
Option A - 20.0	323	171	58,506,000
Option B - 30.0	361	191	66,571,000
Option C - 40.0	404	217	76,231,000

Table 3.4.5.18-2.
LOD4 Jackson County Inland Barrier - Option A 20.0 Estimate

a. Lands and Improvements/Permits					
321 Ownerships for Levee, 171 Improvements					33,383,509
2 Pump Stations					77,517
323 Ownerships				Subtotal	33,461,026
b. Mineral Rights					0
c. Damages					0
d. P.L. 91-646 Relocation costs – 171 relocations					4,793,600
e. Administrative Cost					8,550,000
		Relocation	Acquisition	Total	
	Federal	256,500	807,500	1,064,000	
	Non-Federal	1,026,000	6,460,000	7,486,000	
		1,282,500	7,267,500	8,550,000	
Subtotal					46,804,626
Contingencies (25%)					11,701,157
		Totals			**58,505,783**
		Rounded			**58,506,000**

Table 3.4.5.18-3.
LOD4 Jackson County Inland Barrier - Option B 30.0 Estimate

a. Lands and Improvements/Permits					
359 Ownerships for Levee, 191 Improvements					38,270,710
2 Pump Stations					77,517
361 ownerships				Subtotal	38,348,227
b. Mineral Rights					0
c. Damages					0
d. P.L. 91-646 Relocation costs – 191 relocations					5,353,600
e. Administrative Cost					9,555,000
		Relocation	Acquisition	Total	
	Federal	286,500	902,500	1,189,000	
	Non-Federal	1,146,000	7,220,000	8,366,000	
		1,432,500	8,122,500	9,555,000	
Subtotal					53,256,827
Contingencies (25%)					13,314,207
		Totals			**66,571,034**
		Rounded			**66,571,000**

Table 3.4.5.18-4.
LOD4 Jackson County Inland Barrier - Option C 40.0 Estimate

a. Lands and Improvements/Permits					
402 Ownerships for Levee, 217 Improvements					44,096,883
2 Pump Stations					77,517
404 Ownerships				Subtotal	44,174,400
b. Mineral Rights					0
c. Damages					0
d. P.L. 91-646 Relocation costs – 217 relocations					6,092,800
e. Administrative Cost					10,717,500
		Relocation	Acquisition	Total	
	Federal	325,500	1,010,000	1,335,500	
	Non-Federal	1,302,000	8,080,000	9,382,000	
		1,627,500	9,090,000	10,717,500	
Subtotal					60,984,700
Contingencies (25%)					15,246,175
		Totals			**76,230,875**
		Rounded			**76,231,000**

3.4.5.19 Summary of Potential Real Estate Issues

The requirement for temporary work areas, disposal or borrow areas has not been identified. Should these areas be required, these would be considered as part of the LERRD requirements. Typically if disposal or borrow sites are required, Real estate would provide an analysis during PED to compare the cost of acquiring an these sites with the cost of using a commercial sites and make a determination which method is most cost effective. See Section 2.8 Borrow Areas on page 5.

Should drainage ditches, temporary work areas, disposal or borrow areas become a necessary real estate acquisition requirement, valuation of lands will be performed. Land costs associated with these areas, and administrative costs will be added to the Real Estate Cost Estimate. If further real estate requirements are identified during PED or if there is a significant increase in cost, a supplement to the Real Estate Appendix will be prepared.

Any requirements for relocation contracts pertaining to facilities/utilities will be identified and completed during PED.

Any requirement for mitigation lands will be identified during PED.

Should condemnation of any required real estate interest be necessary, it is the responsibility of the NFS. This issue is addressed during the Assessment of the Non-Federal Sponsor's Real Estate Acquisition Capability. However, if the real estate interest is one that the NFS does not have authority to condemn, the Federal Government can perform the condemnation on behalf of the NFS.

A relocation plan will need to be completed during PED to address potential relocation activity under P.L. 91-646. There are a number of factors pertaining to relocations that can impact the project both in cost and in schedule. Payments for Housing of Last Resort, which would exceed the standard housing replacement payments, are very likely due to the size of the project and the lack of available decent, safe and sanitary housing in the area. Another factor that could increase cost and impact schedule is the cost of business relocations. Depending on the type of business and the operation, this could involve moving equipment and machinery to new locations. It is necessary to interview each impacted individual and business during Pre-Construction, Engineering and Design Phase to determine the requirements for relocation and to estimate a cost for the relocation.

3.4.5.20 Chart of Accounts

The cost estimate for all Federal and non-Federal real estate activities necessary for implementation of the project after completion of the feasibility study for land acquisition, construction, LERRD, and other items are coded as delineated in the Cost Work Breakdown Structure (CWBS). This real estate cost estimate is then incorporated into the Total Current Working Estimate utilizing the Microcomputer Aided Cost Engineering System (MCACES). The Chart of Accounts at Tables 3.4.5.20-1 through 3.4.5.20-3 shows the CWBS for real estate activities.

Table 3.4.5.20-1.
Chart of Accounts LOD4 Jackson County Inland Barrier - Option A 20.0

01A	**Project Planning**	**Federal**	**Non-Federal**	**Totals**
	Other			
	Project Cooperation Agreement			
01AX	Contingencies (25%)			
	Subtotal			
01B	Lands and Damage/Permits			
01B40	Acquisition/Review of NFS	807,500		807,500
01B20	Acquisition by NFS		6,460,000	6,460,000
01BX	Contingencies (25%)	201,875	1,615,000	1,816,875
	Subtotal	1,009,375	8,075,000	9,084,375
01F	PL 91-646 Assistance			
01F20	By NFS		1,026,000	1,026,000
01FX	Contingencies (25%)		256,500	256,500
	Subtotal		1,282,500	1,282,500
01R	Real Estate Land Payments			
01R1B	Land Payments by NFS		33,461,026	33,461,026
01R2B	PL91-646 Relocation Payment by NFS		4,793,600	4,793,600
01R2D	Review of NFS	256,500		256,500
01RX	Contingencies (25%)	64,125	9,563,657	9,627,782
	Subtotal	320,625	47,818,283	48,138,908
	Totals	**1,330,000**	**57,175,783**	**58,505,783**
	Rounded			**58,506,000**

Table 3.4.5.20-2.
Chart of Accounts LOD4 Jackson County Inland Barrier - Option B 30.0

01A	Project Planning	Federal	Non-Federal	Totals
	Other			
	Project Cooperation Agreement			
01AX	Contingencies (25%)			
	Subtotal			
01B	Lands and Damage/Permits			
01B40	Acquisition/Review of NFS	902,500		902,500
01B20	Acquisition by NFS		7,220,000	7,220,000
01BX	Contingencies (25%)	225,625	1,805,000	2,030,625
	Subtotal	1,128,125	9,025,000	10,153,125
01F	PL 91-646 Assistance			
01F20	By NFS		1,146,000	1,146,000
01FX	Contingencies (25%)		286,500	286,500
	Subtotal		1,432,500	1,432,500
01R	Real Estate Land Payments			
01R1B	Land Payments by NFS		38,348,227	38,348,227
01R2B	PL91-646 Relocation Payment by NFS		5,353,600	5,353,600
01R2D	Review of NFS	286,500		286,500
01RX	Contingencies (25%)	71,625	10,925,457	10,997,082
	Subtotal	358,125	54,627,284	54,985,409
	Totals	**1,486,250**	**65,084,784**	**66,571,034**
	Rounded			**66,571,000**

Table 3.4.5.20-3.
Chart of Accounts LOD4 Jackson County Inland Barrier - Option C 40.0

01A	Project Planning	Federal	Non-Federal	Totals
	Other			
	Project Cooperation Agreement			
01AX	Contingencies (25%)			
	Subtotal			
01B	Lands and Damage/Permits			
01B40	Acquisition/Review of NFS	1,010,000		1,010,000
01B20	Acquisition by NFS		8,080,000	8,080,000
01BX	Contingencies (25%)	252,500	2,020,000	2,272,500
	Subtotal	1,262,500	10,100,000	11,362,500
01F	PL 91-646 Assistance			
01F20	By NFS		1,302,000	1,302,000
01FX	Contingencies (25%)		325,500	325,500
	Subtotal		1,627,500	1,627,500
01R	Real Estate Land Payments			
01R1B	Land Payments by NFS		44,174,400	44,174,400
01R2B	PL91-646 Relocation Payment by NFS		6,092,800	6,092,800
01R2D	Review of NFS	325,500		325,500
01RX	Contingencies (25%)	81,375	12,566,800	12,648,175
	Subtotal	406,875	62,834,000	63,240,875
	Totals	**1,669,375**	**74,561,500**	**76,230,875**
	Rounded			**76,231,000**

3.5 Line of Defense 5 - Retreat and/or Relocation of Critical Facilities

Hurricanes are a naturally occurring phenomena that wreak havoc on natural and man-made environments through three different but related mechanisms: torrential rainfall, high winds, and storm surge. While each of these can produce costly outcomes in their own right, storm surge is typically the most damaging and particularly deadly. It is also the most difficult and costly to provide enduring and confident protection against. However, if one cannot be reached by storm surge by virtue of being on ground at elevation higher than any storm surge might reach, one cannot be directly damaged by it. The limit of storm surge represents the first line of avoidance to hurricane related damages. It therefore makes sense to identify the potential inland limit of storm surge so that prudent choices might be made by any and all regarding their exposure to damage by storm surge.

The primary measures identified for the project area include permanent acquisitions, flood proofing by elevation and other means, relocations of public buildings, flood preparedness and evacuation planning, public education, changes in the current municipal and county NFIP and building codes, implementation of either a transfer of development rights or purchase of development rights program, potential changes in zoning ordinances, development impact fees, and redirection of new development. These measures have been combined into several plans that can be implemented by either agencies of the Federal government or collaboratively by those agencies and state, county and local governmental units. In several cases, only local jurisdictions can implement some of the measures identified.

Computer simulations have predicted how far inland storm surge will extend if the worse-case hurricane or maximum possible intensity (MPI) event hits the Mississippi coast.

This line of defense is shown in Figure 3.5-1. This line represents a line of safety where homes, facilities or transportation routes north of this line should not be directly damaged by storm surge. This would be an area where hospitals, schools, emergency response and management facilities, power stations, water supply facilities, or other critical infrastructure might be located. It would also represent an area whereby future development (commercial, industrial, or residential) might be redirected. The maximum water level along the Mississippi coastline was determined to be approximately 30 ft along the entire western half of the state and east of Pascagoula. The landward extent of the inundation indicates the storm surge reaches Interstate 10 for much of the western portion of the state. Lower peaks near Biloxi and Mobile Bay (24-27 ft) may be attributed to the protection afforded by the barrier islands. The line of defense accordingly approximates the 24 to 30 ft. (NAVD '88 datum) contours.

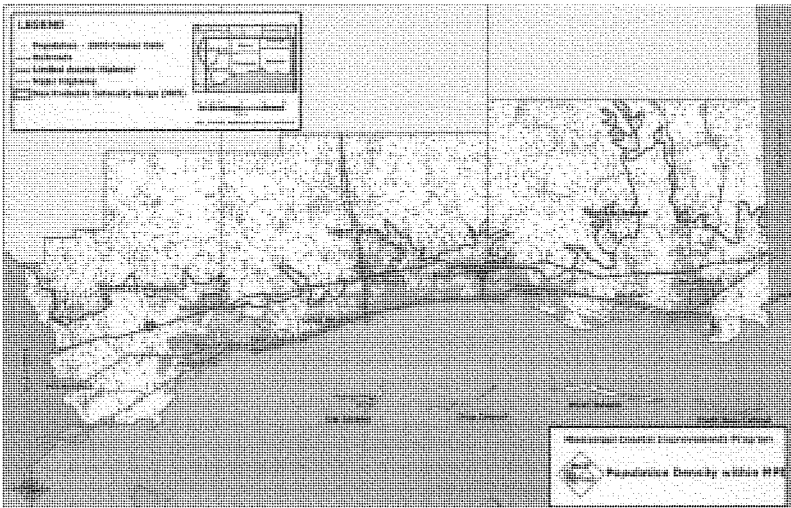

Figure 3.5-1.
Maximum Probable Intensity Storm Surge Limits

The area seaward of the line of defense is occupied by natural, rural, suburban, and urban environments and residential, commercial, and industrial development. Approximately 1/3 (visually estimated) of the coastal county areas fall within the estimated surge limits. With the exceptions of seawalls fronting Harrison County, Bay St. Louis, and the city of Pascagoula, there are no hurricane storm damage reduction structures in place. These structures provide little inundation protection over what the natural ground elevation would provide for and do not provide hurricane protection for surge events approaching or exceeding the 1 in 100 annual chance event.

There are no alternative alignments to this line of defense. The line of defense alignment could be changed or modified due to any of the following: (a) revised hydrodynamic modeling results; (b) the construction of storm damage reduction measures, such as levees and/or storm surge barriers; (c) sea level rise; (d) construction of other infrastructure (e.g. roadway embankments) that might materially obstruct or alter surge flow pathways.

A thorough discussion of non-structural alternative measures is provided in the Non-Structural Measures Plan Formulation Appendix.

No real estate plan has been prepared for this line of defense as specific sites for relocation of facilities have not been identified. A plan will be prepared during PED should this plan be approve for implementation.

CHAPTER 4. NONSTRUCTURAL

Flood damage reduction measures are divided into two distinct components: structural and nonstructural. Application of nonstructural measures or those measures directly associated with modifying the location, construction or operation of property, structures, and facilities located in hazard areas is one method of reducing storm/hurricane-related damages and saving lives that are at-risk. There are numerous nonstructural methods, but the Real Estate Appendix focuses on permanent evacuation of the hazard areas.

Permanent acquisition of coastal properties is an effective way to reduce flood damages and loss of life due to hurricane surge drowning. Existing properties with or without structures can be purchased under the provisions of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970 (P.L. 91-646). Permanent acquisition furthers the objectives of migrating the population northward and away from the coast. This nonstructural measure would be applied to a quilt-like, land use pattern of residential, commercial, and institutional uses as well as both occupied and vacant parcels. The purpose of purchasing vacant parcels is to prevent future building on those parcels. Post-acquisition use of the land could include wetland habitat restoration, recreation or open space uses that would not result in re-establishment of damageable property,

4.1 Hancock County Acquisition

4.1.1 Project Description

High Hazard Zones: The nonstructural project delivery team (PDT) identified several zones within the project area, where due to extreme forces generated by storms and hurricanes, other measures such as elevation of an existing or rebuilt structure would not be prudent and may endanger the future occupants. Within these zones, successful emergency evacuation during a storm event would be highly improbable and dangerous for the responders, elevated structures may be prone to foundation failures due to waves and surge, elevation by placed fill material is prohibited or infeasible, and non-elevated structures would likely suffer total or significant losses. Each of these zones was graphically identified using GIS mapping and FEMA database information. There are three identified zones where permanent acquisition and evacuation of the property is the preferred nonstructural treatment. Those zones are:

The FEMA-identified V/VE Zone displayed on the National Flood Insurance Rate Maps (FIRM) within the project area. This "Velocity" water zone features high-energy wave action that was responsible for much of the building damages during the Katrina event and makes elevating structures or otherwise flood-proofing structures in-place very dangerous.

The FEMA-identified "catastrophic damages zone" which was identified in a "post-Katrina" damage assessment of FEMA insured structures within the project area. This zone included a preponderance of insured structures that had received damages in excess of 50% of the structure's value. Field observations by the nonstructural PDT confirmed that most of those structures in the zone had been totally destroyed or severely damaged (major structural damages). This area includes the V/VE zone within its boundaries.

A flood damage zone was delineated extending 800 feet back from the beachfront within portions of Jackson County. The aforementioned "catastrophic damage zone" established by FEMA was based upon the Katrina event only and therefore did not account for the area of damages that could be expected along Jackson County should a Katrina-like storm strike at that location. The 800 feet zone approximated the spatial extent of observed total structure loss and severe structural damages observed within Hancock and Harrison counties located closer to the Katrina landfall. Modifications of this zone's extent from the waterline could be made to account for intervening topography that would limit the impacts of surge and waves.

The preferred nonstructural measure in these three high-hazard zones would be permanent acquisition of the property under the general provisions of the Uniform Act. Relocations assistance would be provided to residential landowners and/or tenants of the property to locate and secure suitable replacement housing. Remaining structures, pavements, foundations and utilities on the acquired parcel would be demolished and removed to approved landfills. The acquired property could be reused for ecosystem restoration (wetlands), recreation or other purposes that would be in keeping with the identified flood hazards, the National Flood Insurance Program (NFIP) and the provisions of the Project Cooperation Agreement (PCA). The acquired property would be transferred to a local project sponsor for future Operations, Maintenance, Repair, Replacement, and Rehabilitation (OMRR&R).

A High Hazard Area Risk Reduction Plan (HARP) is currently being considered as a component of the comprehensive plan to address hurricane and storm damage reduction for certain areas within the Advisory Base Flood Elevation (ABFE) zones along the coast defined as high hazard areas. This plan which is supported by the State of Mississippi contemplates acquisitions in identified areas within Hancock, Harrison and Jackson Counties that should be considered for acquisition anticipated to begin in FY 2010 to facilitate relocation of homeowners outside the ABFE prior to their rebuilding. The plan under consideration is not specifically reflected in the nonstructural portion of the Real Estate Appendix. However, the HARP is incorporated in the report at Exhibit "C" to the Real Estate Appendix. Should the plan be authorized, significant adjustments will have to be made to the real estate costs for the acquisition areas initially identified in the MsCIP report.

Non-Flood-proofing Zones: The nonstructural PDT also identified one additional zone within the project area where the preferred method of flood damage reduction would be permanent acquisition and evacuation of the property. This zone is located where water depths at the individual structure location occurring during the specified inundation event would exceed the maximum height of elevation prescribed by FEMA's 550 Guidelines for structure elevation. Those guidelines indicate that elevating structures more than 15 feet from the ground surface in hurricane areas would place the elevated structure in high-velocity hurricane force winds resulting in significant damages to the building. Any structure that would be required to be elevated more that 15 feet to place the first habitable or sales floor above the specified inundation level would be acquired. Using GIS software, a zone of inundation deeper than 13 feet (plus 2 feet of freeboard equals 15 feet) was identified within the project area where permanent acquisition would be the preferred method of nonstructural protection. The area for which permanent acquisition is recommended in Hancock County is shown in Figure 4.1.1-1. The acquisition area is shaded in dark green.

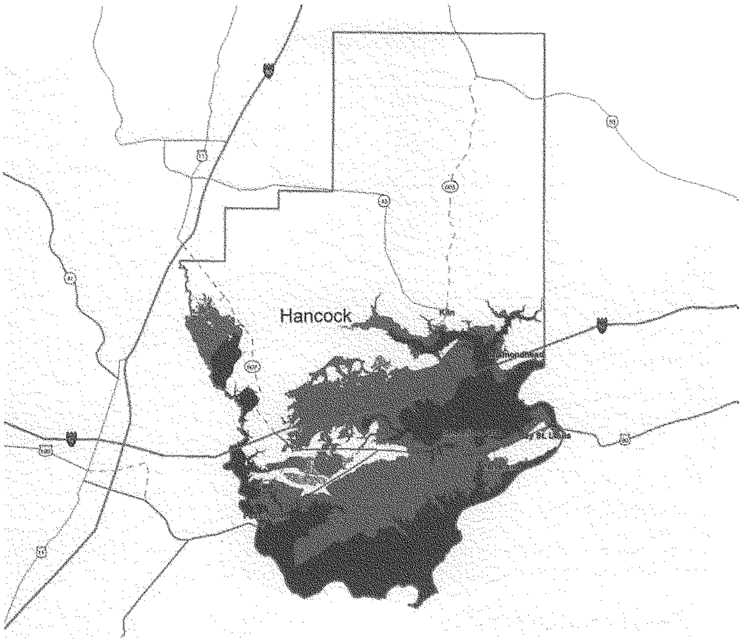

Figure 4.1.1-1.
Location of Acquisition Areas in Hancock County (dark green)

4.1.2 Real Estate Requirements

Real Estate requirements for the Nonstructural Acquisition in Hancock County include lands, easements, rights-of-way and relocations, and disposal/borrow areas (LERRD), and the right to acquire in fee simple approximately 17,845 impacted parcels and 10,192 structures. The project is divided into 9 reaches. The reaches are identified below in Table 4.1.2-1. Based on the number of structures being impacted, the assumption is that there will be 10,192 relocations to include residences and businesses. The plan calls to use an "approved landfill" for disposal of the demolished structures. An assumption is made that the excavated material will be disposed of in commercial or county landfills. In the event that the excavated material is not suitable for a landfill a disposal site will have to be acquired. Typically if disposal sites are required, this would be considered as part of the LERRD requirement. Real Estate would provide an analysis during PED to compare the cost of acquiring an upland disposal site with the cost of using a commercial landfill and make a determination which method is most cost effective.

Table 4.1.2-1.
Hancock County Acquisition Reaches

Reach	Impacted Parcels	Impacted Structures
1	997	268
2	9,911	7,133
3	2,202	1,326
4	922	373
5	2,714	447
6	567	540
7	450	79
36	32	2
38	50	24
Total	**17,845**	**10,192**

4.1.3 Utility/Facility Relocation

Specific information about relocation of utilities/facilities is unknown at this time. An assumption is made that if required, this work will be accomplished through a relocation contract. This will be further investigated and confirmed during PED. See Chapter 2 Section 2.10 for more detailed discussion.

4.1.4 Existing Projects/Studies

Relevant projects and studies are found in the main report at Section 1.6, History of the Investigation and Section 1.7, Prior and On-Going Studies, Reports and Programs.

4.1.5 Environmental Impacts

See the Main Report, Chapter 6. Environmental Effects of Plans and the Environmental Appendix, for a full discussion on environmental effects.

4.1.6 Project Sponsor Responsibilities and Capabilities

The State of Mississippi will be the non-Federal Project Sponsor (NFS). The NFS has the responsibility to acquire all real estate interests required for the Project. The NFS shall accomplish all alterations and relocations of facilities, structures and improvements determined by the government to be necessary for construction of the Project.

Title to any acquired real estate will be retained by the Project Sponsor and will not be conveyed to the United States Government. Prior to advertisement of any construction contract, the NFS shall furnish to the government an Authorization for Entry for Construction (Exhibit "A" to the Real Estate Appendix) to all lands, easements and rights-of-way, as necessary. The NFS will also furnish to the government evidence supporting their legal authority to grant rights-of-way to such lands. The NFS shall comply with applicable provisions of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970, Public Law 91-646, approved 2 January 1971, and amended by Title IV of the Surface Transportation Uniform Relocation Assistance Act of 1987, Public Law 100-17, effective 2 April 1989, in acquiring real estate interests for the Project, and inform all affected persons of applicable benefits, policies, and procedures in connection with said Act(s). A form for the Assessment of the Non-Federal Sponsor's Capability to Acquire Real Estate is at Exhibit "B" to the Real Estate Appendix. The assessment will be made during PED phase.

The non-Federal sponsor is entitled to receive credit against its share of project costs for the value of lands it provides and the value of the relocations that are required for the project. Generally, for the purpose of determining the amount of credit to be afforded, the value of the LER is the fair market value of the real property interest, plus certain incidental costs of acquiring those interests, that the non-federal sponsor provided for the project as required by the Government. The NFS cannot receive credit for the value of any LER, including incidental costs, which were previously provided as an item of cooperation for another Federal project, including projects that preceded enactment of WRDA 1986.

4.1.7 Government Owned Property

There are approximately 35 Government owned parcels within the footprint of the project proposed for acquisition in Hancock County. These lands are in the vicinity of the John C. Stennis Space Center, or within lands shown as NASA Restricted Area on a state map. Land and structure values are not listed in the public records. Ownership is listed in public records as USA. Specific impacts to Government owned lands and/or structures will be determined during PED.

4.1.8 Historical Significance

See the Main Report, Section 3.2.9 Cultural and Archaeological Resources, for a general discussion on cultural and archaeological resources.

4.1.9 Mineral Rights

There are no known mineral activities within the scope of the proposed project.

4.1.10 Hazardous, Toxic, and Radioactive Waste (HTRW)

Due to the extent of the project, no preliminary assessment was performed to identify the possibility of hazardous waste on the sites. These studies will be conducted during the next phase of work. See Sections 3.2.8 and 6.16 of the Main Report for a discussion on HTRW.

4.1.11 Public Law 91-646, Relocation Assistance Benefits

The Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970 establishes a uniform policy for fair and equitable treatment of persons displaced as a result of federal and federally assisted programs in order that such persons shall not suffer disproportionate injuries as a result of programs designed for the benefits of the public as a whole. A qualified displaced person may be entitled to certain relocation assistance benefits which include reimbursement of moving costs and a replacement housing benefit. Moving expense can be reimbursed either based on actual costs or a fixed moving cost schedule. The replacement housing payment is separated into 3 basic types - purchase supplement, rental assistance and down payment. All replacement housing must be decent, safe, and sanitary (DSS) before a replacement housing payment can be made.

It is estimated that there are approximately 10,192 relocations in Hancock County. No relocation plan has been completed nor has a relocation survey been done. All estimates are based on information from county public records. The number of business relocations as compared to residential relocations is unknown. The availability of decent safe and sanitary housing is a potential problem. Large scale construction of new residences will most likely be required. In order to accomplish the relocation activity in a timely manner, the plan set forth in Chapter 2. Section 2.5 can be used.

4.1.12 Attitude of Property Owners

Real Estate has not interviewed property owners or tenants during the study phase for the MsCIP. However, numerous public meetings have been held at different locations throughout the study area to inform stakeholders and property owners about the study and the protective measures under consideration for the Mississippi coastal area. A number of local newspapers have published articles that discuss the MsCIP study and the perceived positive effects as well as the negative impacts that may occur as a result of the project. Some of these articles can be found on web sites. While many of the locals may welcome the benefits of the proposed project, there are some who oppose the project.

4.1.13 Acquisition Schedule

An acquisition schedule will be developed when plans and specifications become available and more definite information is available pertaining to the specific areas and number of parcels for acquisition. The acquisition schedule will be developed during PED and will be a joint effort of the NFS, the project manager and Real Estate. The schedule will set forth a time line for title, survey, appraisal, negotiation, preparation of documents and closing activity. After acquisition activity is completed certification of lands acquired/owned by the sponsor will be necessary prior to advertisement for construction. The Certification of Real Estate can be accomplished within 30 - 60 days after acquisition. See Chapter 2. Section 2.5. for discussion on an acquisition implementation/management plan.

4.1.14 Estates for Proposed Project

All lands acquired in the buy-out area will be acquired in Fee Simple. The Temporary Work Area Easement will be used for a disposal site if required. The estates recommended are standard estates.

FEE.

The fee simple title to (the land described in Schedule A) l/(Tracts Nos. ____, ____ and ___), subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

TEMPORARY WORK AREA EASEMENT.

A temporary easement and right-of-way in, on, over and across (the land described in Schedule A) (Tracts Nos. _____, _____ and _____), for a period not to exceed __________________, beginning with date possession of the land is granted to the Project Sponsor, for use by the Project Sponsor, its representatives, agents, and contractors as a work area, including the right to deposit backfill, move, store and remove equipment and supplies, and erect and remove temporary structures on the land and to perform any other work necessary and incident to the construction of the __________________ Project, together with the right to trim, cut, fell and remove there from all trees, underbrush, obstructions, and any other vegetation, structures, or obstacles within the limits of the right-of-way; reserving, however, to the landowners, their heirs and assigns, all such rights and privileges as may be used without interfering with or abridging the rights and easement hereby acquired; subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

4.1.15 Real Estate Estimate

The real estate cost estimate at Table 4.1.15-1 includes the land cost for acquisition of land, relocation benefits to include a replacement housing payment and fixed rate move expenses, and Federal and non-Federal administrative costs. Administrative costs are those costs incurred for verifying ownership of lands, certification of those lands required for project purposes, legal opinions, analysis or other requirements that may be necessary, during PED. No cost is included for a disposal site. The requirement, if any, for a disposal site will be identified during PED. If further real estate requirements are identified during PED or if there is a significant increase in cost, a supplement to the Real Estate Appendix will be prepared. A 25% contingency is applied to the current estimate.

Table 4.1.15-1.
Hancock County Acquisitions Estimate

a. Lands and Improvements/Permits				
17,845 Ownerships & 10,192 Improvements				2,630,117,775
				0
			Subtotal	2,630,117,775
b. Mineral Rights				0
c. Damages				0
d. P.L. 91-646 Relocation costs – 10,192 relocations				285,376,000
e. Administrative Cost				477,952,500
	Relocation	Acquisition	Total	
Federal	15,288,000	44,612,500	59,900,500	
Non-Federal	61,152,000	356,900,000	418,052,000	
	76,440,000	401,512,500	477,952,500	
Subtotal				3,393,446,275
Contingencies (25%)				848,361,569
Totals				**4,241,807,844**
Rounded				**4,241,808,000**

4.1.16 Summary of Potential Real Estate Issues

In the event that the excavated material is not suitable for a landfill a disposal site will have to be acquired. Typically if disposal sites are required, this would be considered as part of the LERRD requirement. Real Estate would provide an analysis during PED to compare the cost of acquiring an upland disposal site with the cost of using a commercial landfill and make a determination which method is most cost effective.

Any requirements for relocation contracts pertaining to facilities/utilities will be identified and completed during PED.

If the nonstructural acquisition measure is approved, additional time would need to be allowed for staffing up to handle the increased workload for the large number of acquisitions.

Should condemnation of any required real estate interest be necessary, it is the responsibility of the NFS. This issue is addressed during the Assessment of the Non-Federal Sponsor's Real Estate Acquisition Capability. However, if the real estate interest is one that the NFS does not have authority to condemn, the Federal Government can perform the condemnation on behalf of the NFS.

A relocation plan will need to be completed during PED to address potential relocation activity under P.L. 91-646. There are a number of factors pertaining to relocations that can impact the project both in cost and in schedule. Payments for Housing of Last Resort, which would exceed the standard housing replacement payments, are very likely due to the size of the project and the lack of available decent, safe and sanitary housing in the area. Another factor that could increase cost and impact schedule is the cost of business relocations. Depending on the type of business and the operation, this could involve moving equipment and machinery to new locations. It is necessary to interview each impacted individual and business during Pre-Construction, Engineering and Design Phase to determine the requirements for relocation and to estimate a cost for the relocation.

The availability of decent safe and sanitary housing is a potential problem. Large scale construction of new residences will most likely be required.

4.1.17 Chart of Accounts

The cost estimate for all Federal and non-Federal real estate activities necessary for implementation of the project after completion of the feasibility study for land acquisition, construction, LERRD, and other items are coded as delineated in the Cost Work Breakdown Structure (CWBS). This real estate cost estimate is then incorporated into the Total Current Working Estimate utilizing the Microcomputer Aided Cost Engineering System (MCACES). The Chart of Accounts at Table 4.1.17-1 shows the CWBS for real estate activities.

Table 4.1.17-1.
Chart of Accounts - Hancock County Acquisitions

01A	Project Planning	Federal	Non-Federal	Totals
	Other			
	Project Cooperation Agreement			
01AX	Contingencies (25%)			
	Subtotal			
01B	Lands and Damage/Permits			
01B40	Acquisition/Review of NFS	44,612,500		44,612,500
01B20	Acquisition by NFS		356,900,000	356,900,000
01BX	Contingencies (25%)	11,153,125	89,225,000	100,378,125
	Subtotal	55,765,625	446,125,000	501,890,625
01F	PL 91-646 Assistance			
01F20	By NFS		61,152,000	61,152,000
01FX	Contingencies (25%)		15,288,000	15,288,000
	Subtotal		76,440,000	76,440,000
01R	Real Estate Land Payments			
01R1B	Land Payments by NFS		2,630,117,775	2,630,117,775
01R2B	PL91-646 Relocation Payment by NFS		285,376,000	285,376,000
01R2D	Review of NFS	15,288,000		15,288,000
01RX	Contingencies (25%)	3,822,000	728,873,444	732,695,444
	Subtotal	19,110,000	3,644,367,219	3,663,477,219
	Totals	**74,875,625**	**4,166,932,219**	**4,241,807,844**
	Rounded			**4,241,808,000**

4.2 Harrison County Acquisition

4.2.1 Project Description

High Hazard Zones: The nonstructural project delivery team (PDT) identified several zones within the project area, where due to extreme forces generated by storms and hurricanes, other measures such as elevation of an existing or rebuilt structure would not be prudent and may endanger the future occupants. Within these zones, successful emergency evacuation during a storm event would be highly improbable and dangerous for the responders, elevated structures may be prone to foundation failures due to waves and surge, elevation by placed fill material is prohibited or infeasible, and non-elevated structures would likely suffer total or significant losses. Each of these zones was graphically identified using GIS mapping and FEMA database information. There are three identified zones where permanent acquisition and evacuation of the property is the preferred nonstructural treatment. Those zones are:

The FEMA-identified V/VE Zone displayed on the National Flood Insurance Rate Maps (FIRM) within the project area. This "Velocity" water zone features high-energy wave action that was responsible for much of the building damages during the Katrina event and makes elevating structures or otherwise flood-proofing structures in-place very dangerous.

The FEMA-identified "catastrophic damages zone" which was identified in a "post-Katrina" damage assessment of FEMA insured structures within the project area. This zone included a preponderance of insured structures that had received damages in excess of 50% of the structure's value. Field observations by the nonstructural PDT confirmed that most of those structures in the zone had been totally destroyed or severely damaged (major structural damages). This area includes the V/VE zone within its boundaries.

A flood damage zone was delineated extending 800 feet back from the beachfront within portions of Jackson County. The aforementioned "catastrophic damage zone" established by FEMA was based upon the Katrina event only and therefore did not account for the area of damages that could be expected along Jackson County were a Katrina-like storm to strike at that location. The 800 feet zone approximated the spatial extent of observed total structure loss and severe structural damages observed within Hancock and Harrison counties located closer to the Katrina landfall. Modifications of this zone's extent from the waterline could be made to account for intervening topography that would limit the impacts of surge and waves.

The preferred nonstructural measure in these three high-hazard zones would be permanent acquisition of the property under the general provisions of the Uniform Act. Relocations assistance would be provided to residential landowners and/or tenants of the property to locate and secure suitable replacement housing. Remaining structures, pavements, foundations and utilities on the acquired parcel would be demolished and removed to approved landfills. The acquired property could be reused for ecosystem restoration (wetlands), recreation or other purposes that would be in keeping with the identified flood hazards, the NFIP and the provisions of the PCA. The acquired property would be transferred to a local project sponsor for future OMRR&R.

A High Hazard Area Risk Reduction Plan (HARP) is currently being considered as a component of the comprehensive plan to address hurricane and storm damage reduction for certain areas within the Advisory Base Flood Elevation (ABFE) zones along the coast defined as high hazard areas. This plan which is supported by the State of Mississippi contemplates acquisitions in identified areas within Hancock, Harrison and Jackson Counties that should be considered for acquisition anticipated to begin in FY 2010 to facilitate relocation of homeowners outside the ABFE prior to their rebuilding. The plan under consideration is not specifically reflected in the nonstructural portion of the Real Estate Appendix. However, the HARP is incorporated in the report at Exhibit "C" to the Real Estate Appendix. Should the plan be authorized, significant adjustments will have to be made to the real estate costs for the acquisition areas initially identified in the MsCIP report.

Non-Flood-proofing Zones: The nonstructural PDT also identified one additional zone within the project area where the preferred method of flood damage reduction would be permanent acquisition and evacuation of the property. This zone is located where water depths at the individual structure location occurring during the specified inundation event would exceed the maximum height of elevation prescribed by FEMA's 550 Guidelines for structure elevation. Those guidelines indicate that elevating structures more than 15 feet from the ground surface in hurricane areas would place the elevated structure in high-velocity hurricane force winds resulting in significant damages to the building. Any structure that would be required to be elevated more that 15 feet to place the first habitable or sales floor above the specified inundation level would be acquired. Using GIS software, a zone of inundation deeper than 13 feet (plus 2 feet of freeboard equals 15 feet) was identified within the project area where permanent acquisition would be the preferred method of nonstructural protection. The area for which permanent acquisition is recommended in Harrison County is shown in Figure 4.2.1-1. The acquisition area is shaded in dark green.

Figure 4.2.1-1.
Location of Acquisition Area in Harrison County (dark green)

4.2.2 Real Estate Requirements

Real Estate requirements for the Nonstructural Acquisition in Harrison County include lands, easements, rights-of-way and relocations, and disposal/borrow areas (LERRD), and the right to acquire in fee simple approximately 10,912 impacted parcels and 5,911 structures. The project is divided into 11 reaches. The reaches are identified below in Table 4.2.2-1. Based on the number of structures being impacted, the assumption is that there will be 5,911 relocations to include residences and businesses. The plan calls to use an "approved landfill" for disposal of the demolished structures. An assumption is made that the excavated material will be disposed of in commercial or county landfills. In the event that the excavated material is not suitable for a landfill a disposal site will have to be acquired. Typically if disposal sites are required, this would be considered as part of the LERRD requirement. Real Estate would provide an analysis during PED to compare the cost of acquiring an upland disposal site with the cost of using a commercial landfill and make a determination which method is most cost effective.

Table 4.2.2-1.
Harrison County Acquisition Reaches

Reach	Impacted Parcels	Impacted Structures
8	3,623	1,819
9	44	9
10	1,945	1,157
12	1,047	469
13	650	412
15	85	47
16	78	19
18	1,502	984
19	46	4
20	1,397	851
50	495	140
Total	**10,912**	**5,911**

4.2.3 Utility/Facility Relocation

Specific information about relocation of utilities/facilities is unknown at this time. An assumption is made that if required, this work will be accomplished through a relocation contract. This will be further investigated and confirmed during PED. See Chapter 2 Section 2.10 for more detailed discussion.

4.2.4 Existing Projects/Studies

Relevant projects and studies are found in the main report at Section 1.6, History of the Investigation and Section 1.7, Prior and On-Going Studies, Reports and Programs.

4.2.5 Environmental Impacts

See the Main Report, Chapter 6. Environmental Effects of Plans and the Environmental Appendix, for a full discussion on environmental effects.

4.2.6 Project Sponsor Responsibilities and Capabilities

The State of Mississippi will be the non-Federal Project Sponsor (NFS). The NFS has the responsibility to acquire all real estate interests required for the Project. The NFS shall accomplish all alterations and relocations of facilities, structures and improvements determined by the government to be necessary for construction of the Project.

Title to any acquired real estate will be retained by the Project Sponsor and will not be conveyed to the United States Government. Prior to advertisement of any construction contract, the NFS shall furnish to the government an Authorization for Entry for Construction (Exhibit "A" to the Real Estate Appendix) to all lands, easements and rights-of-way, as necessary. The NFS will also furnish to the government evidence supporting their legal authority to grant rights-of-way to such lands. The NFS shall comply with applicable provisions of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970, Public Law 91-646, approved 2 January 1971, and amended by Title IV of the Surface Transportation Uniform Relocation Assistance Act of 1987, Public Law 100-17, effective 2 April 1989, in acquiring real estate interests for the Project, and inform all affected persons of applicable benefits, policies, and procedures in connection with said Act(s). A form for the

Assessment of the Non-Federal Sponsor's Capability to Acquire Real Estate is at Exhibit "B" to the Real Estate Appendix. The assessment will be made during PED phase.

The non-Federal sponsor is entitled to receive credit against its share of project costs for the value of lands it provides and the value of the relocations that are required for the project. Generally, for the purpose of determining the amount of credit to be afforded, the value of the LER is the fair market value of the real property interest, plus certain incidental costs of acquiring those interests, that the non-federal sponsor provided for the project as required by the Government. The NFS cannot receive credit for the value of any LER, including incidental costs, which were previously provided as an item of cooperation for another Federal project, including projects that preceded enactment of WRDA 1986.

4.2.7 Government Owned Property

There are approximately 11 Government owned parcels within the footprint of the project proposed for acquisition in Harrison County. Some of these lands are associated with Keesler AFB and the US Coast Guard. Land and structure values are not listed in the public records. Ownership is listed in public records as US Govt, US Govt-Keesler AFB, US of America, US of America (USCG) and US Veterans Hospital. Specific impacts to Government owned lands and/or structures will be determined during PED.

4.2.8 Historical Significance

See the Main Report, Section 3.2.9 Cultural and Archaeological Resources, for a general discussion on cultural and archaeological resources.

4.2.9 Mineral Rights

There are no known mineral activities within the scope of the proposed project.

4.2.10 Hazardous, Toxic, and Radioactive Waste (HTRW)

Due to the extent of the project, no preliminary assessment was performed to identify the possibility of hazardous waste on the sites. These studies will be conducted during the next phase of work. See Sections 3.2.8 and 6.16 of the Main Report for a discussion on HTRW.

4.2.11 Public Law 91-646, Relocation Assistance Benefits

The Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970 establishes a uniform policy for fair and equitable treatment of persons displaced as a result of federal and federally assisted programs in order that such persons shall not suffer disproportionate injuries as a result of programs designed for the benefits of the public as a whole. A qualified displaced person may be entitled to certain relocation assistance benefits which include reimbursement of moving costs and a replacement housing benefit. Moving expense can be reimbursed either based on actual costs or a fixed moving cost schedule. The replacement housing payment is separated into 3 basic types - purchase supplement, rental assistance and down payment. All replacement housing must be decent, safe, and sanitary (DSS) before a replacement housing payment can be made.

It is estimated that there are approximately 5,911 relocations in Harrison County. No relocation plan has been completed nor has a relocation survey been done. All estimates are based on information from county public records. The number of business relocations as compared to residential relocations is unknown. The availability of decent safe and sanitary housing is a potential problem.

Large scale construction of new residences will most likely be required. In order to accomplish the relocation activity in a timely manner, the plan set forth in Chapter 2. Section 2.5 can be used.

4.2.12 Attitude of Property Owners

Real Estate has not interviewed property owners or tenants during the study phase for the MsCIP. However, numerous public meetings have been held at different locations throughout the study area to inform stakeholders and property owners about the study and the protective measures under consideration for the Mississippi coastal area. A number of local newspapers have published articles that discuss the MsCIP study and the perceived positive effects as well as the negative impacts that may occur as a result of the project. Some of these articles can be found on web sites. While many of the locals may welcome the benefits of the proposed project, there are some who oppose the project.

4.2.13 Acquisition Schedule

An acquisition schedule will be developed when plans and specifications become available and more definite information is available pertaining to the specific areas and number of parcels for acquisition. The acquisition schedule will be developed during PED and will be a joint effort of the NFS, the project manager and Real Estate. The schedule will set forth a time line for title, survey, appraisal, negotiation, preparation of documents and closing activity. After acquisition activity is completed certification of lands acquired/owned by the sponsor will be necessary prior to advertisement for construction. The Certification of Real Estate can be accomplished within 30 - 60 days after acquisition. See Chapter 2. Section 2.5. for discussion on an acquisition implementation/management plan.

4.2.14 Estates for Proposed Project

All lands acquired in the buy-out area will be acquired in Fee Simple. The Temporary Work Area Easement will be used for a disposal site if required. The estates recommended are standard estates.

FEE.

The fee simple title to (the land described in Schedule A) l/(Tracts Nos. ____, ____ and ___), subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

TEMPORARY WORK AREA EASEMENT.

A temporary easement and right-of-way in, on, over and across (the land described in Schedule A) (Tracts Nos. _____, _____ and _____), for a period not to exceed __________________, beginning with date possession of the land is granted to the Project Sponsor, for use by the Project Sponsor, its representatives, agents, and contractors as a work area, including the right to deposit backfill, move, store and remove equipment and supplies, and erect and remove temporary structures on the land and to perform any other work necessary and incident to the construction of the __________________ Project, together with the right to trim, cut, fell and remove there from all trees, underbrush, obstructions, and any other vegetation, structures, or obstacles within the limits of the right-of-way; reserving, however, to the landowners, their heirs and assigns, all such rights and privileges as may be used without interfering with or abridging the rights and easement hereby acquired; subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

4.2.15 Real Estate Estimate

The real estate cost estimate at Table 4.2.15-1 includes the land cost for acquisition of land, relocation benefits to include a replacement housing payment and fixed rate move expenses, and Federal and non-Federal administrative costs. Administrative costs are those costs incurred for verifying ownership of lands, certification of those lands required for project purposes, legal opinions, analysis or other requirements that may be necessary, during PED. No cost is included for a disposal site. The requirement, if any, for a disposal site will be identified during PED. If further real estate requirements are identified during PED or if there is a significant increase in cost, a supplement to the Real Estate Appendix will be prepared. A 25% contingency is applied to the current estimate.

Table 4.2.15-1.
Harrison County Acquisitions Estimate

a. Lands and Improvements/Permits					
10,912 Ownerships & 5,911 Improvements					1,722,841,076
					0
				Subtotal	1,722,841,076
b. Mineral Rights					0
c. Damages					0
d. P.L. 91-646 Relocation costs – 5,911 relocations					165,508,000
e. Administrative Cost					289,852,500
		Relocation	Acquisition	Total	
	Federal	8,866,500	27,280,000	36,146,500	
	Non-Federal	35,466,000	218,240,000	253,706,000	
		44,332,500	245,520,000	289,852,500	
Subtotal					2,178,201,576
Contingencies (25%)					544,550,394
		Totals			**2,722,751,970**
		Rounded			**2,722,752,000**

4.2.16 Summary of Potential Real Estate Issues

In the event that the excavated material is not suitable for a landfill a disposal site will have to be acquired. Typically if disposal sites are required, this would be considered as part of the LERRD requirement. Real Estate would provide an analysis during PED to compare the cost of acquiring an upland disposal site with the cost of using a commercial landfill and make a determination which method is most cost effective.

Any requirements for relocation contracts pertaining to facilities/utilities will be identified and completed during PED.

If the nonstructural acquisition measure is approved, additional time would need to be allowed for staffing up to handle the increased workload for the large number of acquisitions.

Should condemnation of any required real estate interest be necessary, it is the responsibility of the NFS. This issue is addressed during the Assessment of the Non-Federal Sponsor's Real Estate Acquisition Capability. However, if the real estate interest is one that the NFS does not have authority to condemn, the Federal Government can perform the condemnation on behalf of the NFS.

A relocation plan will need to be completed during PED to address potential relocation activity under P.L. 91-646. There are a number of factors pertaining to relocations that can impact the project both in cost and in schedule. Payments for Housing of Last Resort, which would exceed the standard housing replacement payments, are very likely due to the size of the project and the lack of available decent, safe and sanitary housing in the area. Another factor that could increase cost and impact schedule is the cost of business relocations. Depending on the type of business and the operation, this could involve moving equipment and machinery to new locations. It is necessary to interview each impacted individual and business during Pre-Construction, Engineering and Design Phase to determine the requirements for relocation and to estimate a cost for the relocation.

The availability of decent safe and sanitary housing is a potential problem. Large scale construction of new residences will most likely be required.

4.2.17 Chart of Accounts

The cost estimate for all Federal and non-Federal real estate activities necessary for implementation of the project after completion of the feasibility study for land acquisition, construction, LERRD, and other items are coded as delineated in the Cost Work Breakdown Structure (CWBS). This real estate cost estimate is then incorporated into the Total Current Working Estimate utilizing the Microcomputer Aided Cost Engineering System (MCACES). The Chart of Accounts at Table 4.2.17-1 shows the CWBS for real estate activities.

Table 4.2.17-1.
Chart of Accounts - Harrison County Acquisitions

01A	Project Planning	Federal	Non-Federal	Totals
	Other			
	Project Cooperation Agreement			
01AX	Contingencies (25%)			
	Subtotal			
01B	Lands and Damage/Permits			
01B40	Acquisition/Review of NFS	27,280,000		27,280,000
01B20	Acquisition by NFS		218,240,000	218,240,000
01BX	Contingencies (25%)	6,820,000	54,560,000	61,380,000
	Subtotal	34,100,000	272,800,000	306,900,000
01F	PL 91-646 Assistance			
01F20	By NFS		35,466,000	35,466,000
01FX	Contingencies (25%)		8,866,500	8,866,500
	Subtotal		44,332,500	44,332,500
01R	Real Estate Land Payments			
01R1B	Land Payments by NFS		1,722,841,076	1,722,841,076
01R2B	PL91-646 Relocation Payment by NFS		165,508,000	165,508,000
01R2D	Review of NFS	8,866,500		8,866,500
01RX	Contingencies (25%)	2,216,625	472,087,269	474,303,894
	Subtotal	11,083,125	2,360,436,345	2,371,519,470
	Totals	**45,183,125**	**2,677,568,845**	**2,722,751,970**
	Rounded			**2,722,752,000**

4.3 Jackson County Acquisition

4.3.1 Project Description

High Hazard Zones: The nonstructural project delivery team (PDT) identified several zones within the project area, where due to extreme forces generated by storms and hurricanes, other measures such as elevation of an existing or rebuilt structure would not be prudent and may endanger the future occupants. Within these zones, successful emergency evacuation during a storm event would be highly improbable and dangerous for the responders, elevated structures may be prone to foundation failures due to waves and surge, elevation by placed fill material is prohibited or infeasible, and non-elevated structures would likely suffer total or significant losses. Each of these zones was graphically identified using GIS mapping and FEMA database information. There are three identified zones where permanent acquisition and evacuation of the property is the preferred nonstructural treatment. Those zones are:

The FEMA-identified V/VE Zone displayed on the National Flood Insurance Rate Maps (FIRM) within the project area. This "Velocity" water zone features high-energy wave action that was responsible for much of the building damages during the Katrina event and makes elevating structures or otherwise flood-proofing structures in-place very dangerous.

The FEMA-identified "catastrophic damages zone" which was identified in a "post-Katrina" damage assessment of FEMA insured structures within the project area. This zone included a preponderance of insured structures that had received damages in excess of 50% of the structure's value. Field observations by the nonstructural PDT confirmed that most of those structures in the zone had been totally destroyed or severely damaged (major structural damages). This area includes the V/VE zone within its boundaries.

A flood damage zone was delineated extending 800 feet back from the beachfront within portions of Jackson County. The aforementioned "catastrophic damage zone" established by FEMA was based upon the Katrina event only and therefore did not account for the area of damages that could be expected along Jackson County were a Katrina-like storm to strike at that location. The 800 feet zone approximated the spatial extent of observed total structure loss and severe structural damages observed within Hancock and Harrison counties located closer to the Katrina landfall. Modifications of this zone's extent from the waterline could be made to account for intervening topography that would limit the impacts of surge and waves.

The preferred nonstructural measure in these three high-hazard zones would be permanent acquisition of the property under the general provisions of the Uniform Act. Relocations assistance would be provided to residential landowners and/or tenants of the property to locate and secure suitable replacement housing. Remaining structures, pavements, foundations and utilities on the acquired parcel would be demolished and removed to approved landfills. The vacated property could be reused for ecosystem restoration (wetlands), recreation or other purposes that would be in keeping with the identified flood hazards, the National Flood Insurance Program (NFIP) and the provisions of the Project Cooperation Agreement (PCA). The vacated property would be transferred to a local project sponsor for future OMRR&R.

A High Hazard Area Risk Reduction Plan is currently being considered as a component of the comprehensive plan to address hurricane and storm damage reduction for certain areas within the Advisory Base Flood Elevation (ABFE) zones along the coast defined as high hazard areas. This plan which is supported by the State of Mississippi contemplates acquisitions in identified areas within Hancock, Harrison and Jackson Counties that should be considered for acquisition anticipated to begin in FY 2010 to facilitate relocation of homeowners outside the ABFE prior to their rebuilding. The plan under consideration is not specifically reflected in the nonstructural portion of the Real Estate Appendix. However, the HARP is incorporated in the report at Exhibit "C" to the Real Estate Appendix. Should the plan be authorized, significant adjustments will have to be made to the real estate costs for the acquisition areas initially identified in the MsCIP report.

Non-Flood-proofing Zones: The nonstructural PDT also identified one additional zone within the project area where the preferred method of flood damage reduction would be permanent acquisition and evacuation of the property. This zone is located where water depths at the individual structure location occurring during the specified inundation event would exceed the maximum height of elevation prescribed by FEMA's 550 Guidelines for structure elevation. Those guidelines indicate that elevating structures more than 15 feet from the ground surface in hurricane areas would place the elevated structure in high-velocity hurricane force winds resulting in significant damages to the building. Any structure that would be required to be elevated more that 15 feet to place the first habitable or sales floor above the specified inundation level would be acquired. Using GIS software, a zone of inundation deeper than 13 feet (plus 2 feet of freeboard equals 15 feet) was identified within the project area where permanent acquisition would be the preferred method of nonstructural protection. The area for which permanent acquisition is recommended for Jackson County is shown in Figure 4.3.1-1. The acquisition area is shaded in dark green.

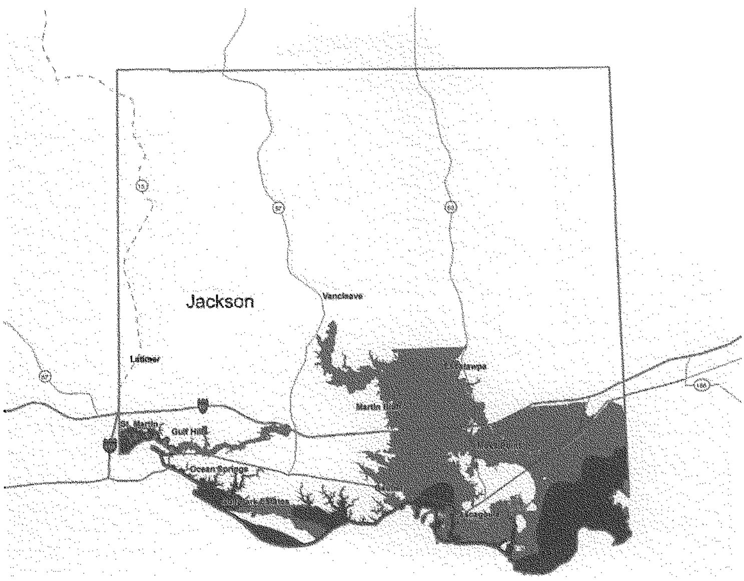

Figure 4.3.1-1.
Location of Acquisition Areas in Jackson County (dark green)

4.3.2 Real Estate Requirements

Real Estate requirements for the Nonstructural Acquisition in Jackson County include lands, easements, rights-of-way and relocations, and disposal/borrow areas (LERRD), and the right to acquire in fee simple approximately 4,434 impacted parcels and 1,047 structures. The project is divided into 14 reaches. The reaches are identified below in Table 4.3.2-1. Based on the number of structures being impacted, the assumption is that there will be 1,047 relocations to include residences and businesses. The plan calls to use an "approved landfill" for disposal of the demolished structures. An assumption is made that the excavated material will be disposed of in commercial or county landfills. In the event that the excavated material is not suitable for a landfill a disposal site will have to be acquired. Typically if disposal sites are required, this would be considered as part of the LERRD requirement. Real Estate would provide an analysis during PED to compare the cost of acquiring an upland disposal site with the cost of using a commercial landfill and make a determination which method is most cost effective.

Table 4.3.2-1.
Jackson County Acquisition Reaches

Reach	Impacted Parcels	Impacted Structures
21	2,108	378
22	61	50
24	220	45
26	37	35
27	53	32
28	961	57
29	147	46
30	90	66
31	51	19
32	1	0
35	12	2
52	285	146
53	399	169
54	9	2
Total	**4,434**	**1,047**

4.3.3 Utility/Facility Relocation

Specific information about relocation of utilities/facilities is unknown at this time. An assumption is made that if required, this work will be accomplished through a relocation contract. This will be further investigated and confirmed during PED. See Chapter 2 Section 2.10 for more detailed discussion.

4.3.4 Existing Projects/Studies

Relevant projects and studies are found in the main report at Section 1.6, History of the Investigation and Section 1.7, Prior and On-Going Studies, Reports and Programs.

4.3.5 Environmental Impacts

See the Main Report, Chapter 6. Environmental Effects of Plans, and the Environmental Appendix, for a full discussion on environmental effects.

4.3.6 Project Sponsor Responsibilities and Capabilities

The State of Mississippi will be the non-Federal Project Sponsor (NFS). The NFS has the responsibility to acquire all real estate interests required for the Project. The NFS shall accomplish all alterations and relocations of facilities, structures and improvements determined by the government to be necessary for construction of the Project.

Title to any acquired real estate will be retained by the Project Sponsor and will not be conveyed to the United States Government. Prior to advertisement of any construction contract, the NFS shall furnish to the government an Authorization for Entry for Construction (Exhibit "A" to the Real Estate Appendix) to all lands, easements and rights-of-way, as necessary. The NFS will also furnish to the government evidence supporting their legal authority to grant rights-of-way to such lands. The NFS shall comply with applicable provisions of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970, Public Law 91-646, approved 2 January 1971, and amended by

Title IV of the Surface Transportation Uniform Relocation Assistance Act of 1987, Public Law 100-17, effective 2 April 1989, in acquiring real estate interests for the Project, and inform all affected persons of applicable benefits, policies, and procedures in connection with said Act(s). A form for the Assessment of the Non-Federal Sponsor's Capability to Acquire Real Estate is at Exhibit "B" to the Real Estate Appendix. The assessment will be made during PED phase.

The non-Federal sponsor is entitled to receive credit against its share of project costs for the value of lands it provides and the value of the relocations that are required for the project. Generally, for the purpose of determining the amount of credit to be afforded, the value of the LER is the fair market value of the real property interest, plus certain incidental costs of acquiring those interests, that the non-federal sponsor provided for the project as required by the Government. The NFS cannot receive credit for the value of any LER, including incidental costs, which were previously provided as an item of cooperation for another Federal project, including projects that preceded enactment of WRDA 1986.

4.3.7 Government Owned Property

There are approximately 34 Government owned parcels within the footprint of the project proposed for acquisition in Jackson County. Most of these lands are within wildlife preserves. Three parcels appear to have improvements. Ownership is listed in public records as United States of America. Specific impacts to Government owned lands and/or structures will be determined during PED.

4.3.8 Historical Significance

See the Main Report, Section 3.2.9 Cultural and Archaeological Resources, for a general discussion on cultural and archaeological resources.

4.3.9 Mineral Rights

There are no known mineral activities within the scope of the proposed project.

4.3.10 Hazardous, Toxic, and Radioactive Waste (HTRW)

Due to the extent of the project, no preliminary assessment was performed to identify the possibility of hazardous waste on the sites. These studies will be conducted during the next phase of work. See Sections 3.2.8 and 6.16 of the Main Report for a discussion on HTRW.

4.3.11 Public Law 91-646, Relocation Assistance Benefits

The Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970 establishes a uniform policy for fair and equitable treatment of persons displaced as a result of federal and federally assisted programs in order that such persons shall not suffer disproportionate injuries as a result of programs designed for the benefits of the public as a whole. A qualified displaced person may be entitled to certain relocation assistance benefits which include reimbursement of moving costs and a replacement housing benefit. Moving expense can be reimbursed either based on actual costs or a fixed moving cost schedule. The replacement housing payment is separated into 3 basic types - purchase supplement, rental assistance and down payment. All replacement housing must be decent, safe, and sanitary (DSS) before a replacement housing payment can be made.

It is estimated that there are approximately 1,047 relocations in Jackson County. No relocation plan has been completed nor has a relocation survey been done. All estimates are based on information from county public records. The number of business relocations as compared to residential relocations is unknown. The availability of decent safe and sanitary housing is a potential problem. Large scale construction of new residences will most likely be required. In order to accomplish the relocation activity in a timely manner, the plan set forth in Chapter 2. Section 2.5 can be used.

4.3.12 Attitude of Property Owners

Real Estate has not interviewed property owners or tenants during the study phase for the MsCIP. However, numerous public meetings have been held at different locations throughout the study area to inform stakeholders and property owners about the study and the protective measures under consideration for the Mississippi coastal area. A number of local newspapers have published articles that discuss the MsCIP study and the perceived positive effects as well as the negative impacts that may occur as a result of the project. Some of these articles can be found on web sites. While many of the locals may welcome the benefits of the proposed project, there are some who oppose the project.

4.3.13 Acquisition Schedule

An acquisition schedule will be developed when plans and specifications become available and more definite information is available pertaining to the specific areas and number of parcels for acquisition. The acquisition schedule will be developed during PED and will be a joint effort of the NFS, the project manager and Real Estate. The schedule will set forth a time line for title, survey, appraisal, negotiation, preparation of documents and closing activity. After acquisition activity is completed certification of lands acquired/owned by the sponsor will be necessary prior to advertisement for construction. The Certification of Real Estate can be accomplished within 30 - 60 days after acquisition. See Chapter 2. Section 2.5. for discussion on an acquisition implementation/management plan.

4.3.14 Estates for Proposed Project

All lands acquired in the buy-out area will be acquired in Fee Simple. The Temporary Work Area Easement will be used for a disposal site if required. The estates recommended are standard estates.

FEE.

The fee simple title to (the land described in Schedule A) I/(Tracts Nos. ____, ____ and ___), subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

TEMPORARY WORK AREA EASEMENT.

A temporary easement and right-of-way in, on, over and across (the land described in Schedule A) (Tracts Nos. _____, _____ and _____), for a period not to exceed ____________________, beginning with date possession of the land is granted to the Project Sponsor, for use by the Project Sponsor, its representatives, agents, and contractors as a work area, including the right to deposit backfill, move, store and remove equipment and supplies, and erect and remove temporary structures on the land and to perform any other work necessary and incident to the construction of the ____________________ Project, together with the right to trim, cut, fell and remove there from all trees, underbrush, obstructions, and any other vegetation, structures, or obstacles within the limits of the right-of-way; reserving, however, to the landowners, their heirs and assigns, all such rights and privileges as may be used without interfering with or abridging the rights and easement hereby acquired; subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

4.3.15 Real Estate Estimate

The real estate cost estimate at Table 4.3.15-1 includes the land cost for acquisition of land, relocation benefits to include a replacement housing payment and fixed rate move expenses, and Federal and non-Federal administrative costs. Administrative costs are those costs incurred for verifying ownership of lands, certification of those lands required for project purposes, legal opinions, analysis or other requirements that may be necessary, during PED. No cost is included for a disposal site. The requirement, if any, for a disposal site will be identified during PED. If further real estate requirements are identified during PED or if there is a significant increase in cost, a supplement to the Real Estate Appendix will be prepared. A 25% contingency is applied to the current estimate.

Table 4.3.15-1.
Jackson County Acquisitions Estimate

a. Lands and Improvements/Permits					
4,434 Ownerships & 1,047 Improvements					483,342,423
					0
				Subtotal	483,342,423
b. Mineral Rights					0
c. Damages					0
d. P.L. 91-646 Relocation costs – 1,047 relocations					29,316,000
e. Administrative Cost					107,617,500
		Relocation	Acquisition	Total	
	Federal	1,570,500	11,085,000	12,655,500	
	Non-Federal	6,282,000	88,680,000	94,962,000	
		7,852,500	99,765,000	107,617,500	
Subtotal					620,275,923
Contingencies (25%)					155,068,981
		Totals			**775,344,904**
		Rounded			**775,345,000**

4.3.16 Summary of Potential Real Estate Issues

In the event that the excavated material is not suitable for a landfill a disposal site will have to be acquired. Typically if disposal sites are required, this would be considered as part of the LERRD requirement. Real Estate would provide an analysis during PED to compare the cost of acquiring an upland disposal site with the cost of using a commercial landfill and make a determination which method is most cost effective.

Any requirements for relocation contracts pertaining to facilities/utilities will be identified and completed during PED.

If the nonstructural acquisition measure is approved, additional time would need to be allowed for staffing up to handle the increased workload for the large number of acquisitions.

Should condemnation of any required real estate interest be necessary, it is the responsibility of the NFS. This issue is addressed during the Assessment of the Non-Federal Sponsor's Real Estate Acquisition Capability. However, if the real estate interest is one that the NFS does not have authority to condemn, the Federal Government can perform the condemnation on behalf of the NFS.

A relocation plan will need to be completed during PED to address potential relocation activity under P.L. 91-646. There are a number of factors pertaining to relocations that can impact the project both in cost and in schedule. Payments for Housing of Last Resort, which would exceed the standard housing replacement payments, are very likely due to the size of the project and the lack of available decent, safe and sanitary housing in the area. Another factor that could increase cost and impact schedule is the cost of business relocations. Depending on the type of business and the operation, this could involve moving equipment and machinery to new locations. It is necessary to interview each impacted individual and business during Pre-Construction, Engineering and Design Phase to determine the requirements for relocation and to estimate a cost for the relocation.

The availability of decent safe and sanitary housing is a potential problem. Large scale construction of new residences will most likely be required.

4.3.17 Chart of Accounts

The cost estimate for all Federal and non-Federal real estate activities necessary for implementation of the project after completion of the feasibility study for land acquisition, construction, LERRD, and other items are coded as delineated in the Cost Work Breakdown Structure (CWBS). This real estate cost estimate is then incorporated into the Total Current Working Estimate utilizing the Microcomputer Aided Cost Engineering System (MCACES). The Chart of Accounts at Table 4.3.17-1 shows the CWBS for real estate activities.

1 **Table 4.3.17-1.**
2 **Chart of Accounts - Jackson County Acquisitions**

01A	**Project Planning**	**Federal**	**Non-Federal**	**Totals**
	Other			
	Project Cooperation Agreement			
01AX	Contingencies (25%)			
	Subtotal			
01B	Lands and Damage/Permits			
01B40	Acquisition/Review of NFS	11,085,000		11,085,000
01B20	Acquisition by NFS		88,680,000	88,680,000
01BX	Contingencies (25%)	2,771,250	22,170,000	24,941,250
	Subtotal	13,856,250	110,850,000	124,706,250
01F	PL 91-646 Assistance			
01F20	By NFS		6,282,000	6,282,000
01FX	Contingencies (25%)		1,570,500	1,570,500
	Subtotal		7,852,500	7,852,500
01R	Real Estate Land Payments			
01R1B	Land Payments by NFS		483,342,423	483,342,423
01R2B	PL91-646 Relocation Payment by NFS		29,316,000	29,316,000
01R2D	Review of NFS	1,570,500		1,570,500
01RX	Contingencies (25%)	392,625	128,164,606	128,557,231
	Subtotal	1,963,125	640,823,029	642,786,154
	Totals	**15,819,375**	**759,525,529**	**775,344,904**
	Rounded			**775,345,000**

3

4

CHAPTER 5. ECOSYSTEM RESTORATION

The Environmental Recommended Plan proposes the construction of two (2) pilot projects at Turkey Creek in Harrison County, and Bayou Cumbest in Jackson County. The restoration will consist of restoring emergent tidal marsh habitat and wet pine savannah habitat. These two pilot projects give a basis for future environmental restoration sites identified to be developed. The Comprehensive Plan envisions the construction of environmental restoration projects that would ensure preservation of fish and wildlife, prevent saltwater intrusion, and provide stabilization of the State of Mississippi's shorelines, in order, to reduce or eliminate coastal erosion and restore lost fish and wildlife habitat by identifying degraded critical components of the vital coastal system. It is important to note that ecosystem restoration sites were chosen in areas where environmental restoration can be performed and at the same time reduce risk of future damages to property by acquisition.

5.1 Harrison County Turkey Creek

Figure 5.1-1 identifies areas recommended for environmental restoration in Harrison County. Should all proposed areas be restored, approximately 1,259 parcels with 251 structures would be impacted at a projected acquisition cost of $223,357,000. This REP however, focuses on the pilot project at Turkey Creek.

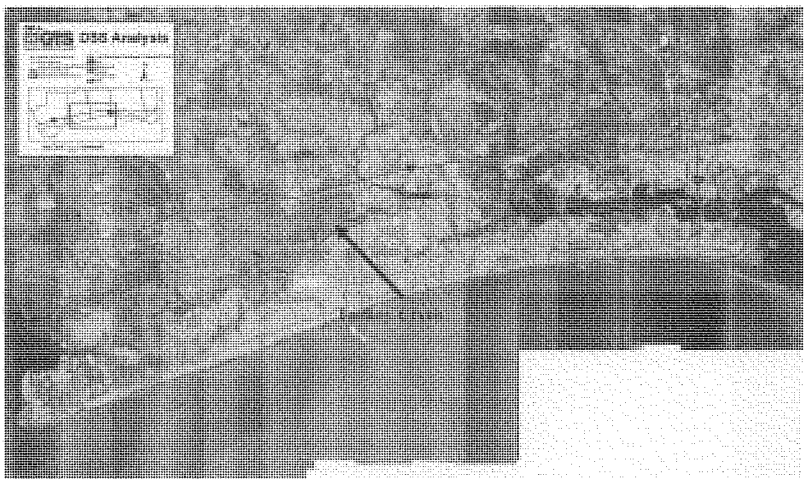

Figure 5.1-1.
Location of Restoration Sites in Harrison County

5.1.1 Project Description

The project site is located north of Gulfport, Mississippi, adjacent to U.S. highway 49, a major north-west thoroughfare, and within the Turkey Creek watershed. The area is becoming increasingly urbanized and development pressures are resulting in increased wetland degradation and loss by the direct filling. The project site as shown in Figure 5.1.1-1 is comprised of 689 acres south (pink border) of the existing railway located on top of an elevated berm. Approximately 190 acres are located north (yellow border) of the railway and functions separately. The combined areas are referred to as Option A, the south area is referred to as Option B, and the north area is referred to as Option C. The site is primarily comprised of a degraded pine savannah wetland. Several miles of ditches have been excavated throughout the site. Additionally the elevated railway berm fragments the wetland habitat and substantially alters the hydrology of the wetlands located to the north. As the areas are undeveloped, no demolition of structures is required. Objectives are to restore native vegetation, restore natural hydrology, restore fish and wildlife habitat, and provide storm water storage protection. The plan calls for mandatory buy-out of lands within the area.

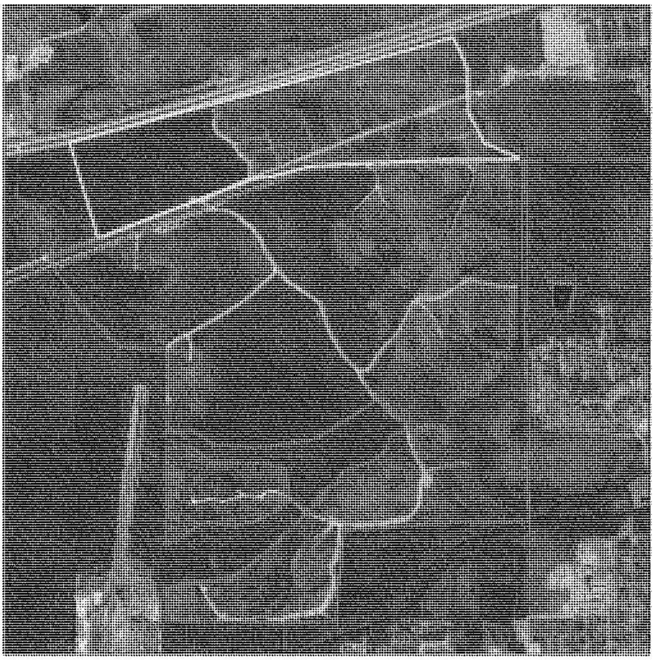

Figure 5.1.1-1.
Turkey Creek, Harrison County

5.1.2 Real Estate Requirements

Real Estate requirements for the Turkey Creek Ecosystem Restoration Site in Harrison County include lands, easements, rights-of-way and relocations, and disposal/borrow areas (LERRD), and the right to acquire in fee simple approximately 13 impacted parcels for Option A, 8 parcels for Option B or 5 parcels for Option C. There are no known structures. No other real estate requirements are known at this time.

EP 1165-2-502, paragraph 7 (m.) states that as a general rule, land value should not exceed 25 percent of total project costs for ecosystem restoration, and that proposals consisting primarily of land acquisition are not appropriate as Civil Works ecosystem restoration investments. This project proposes to reduce risk from future hurricane and storm events and to restore the environment. These are two major objectives of the comprehensive plan. The estimated land value is within 25 percent of the estimated total project cost.

5.1.3 Utility/Facility Relocation

Specific information about relocation of utilities/facilities is unknown at this time. An assumption is made that if required, this work will be accomplished under a relocation contract. This will be further investigated and confirmed during PED. See Chapter 2 Section 2.10 for more detailed discussion.

5.1.4 Existing Projects/Studies

Relevant projects and studies are found in the main report at Section 1.6, History of the Investigation and Section 1.7, Prior and On-Going Studies, Reports and Programs.

5.1.5 Environmental Impacts

See the Main Report, Chapter 6. Environmental Effects of Plans, and the Environmental Appendix, for a full discussion on environmental effects.

5.1.6 Project Sponsor Responsibilities and Capabilities

The State of Mississippi will be the non-Federal Project Sponsor (NFS). The NFS has the responsibility to acquire all real estate interests required for the Project. The NFS shall accomplish all alterations and relocations of facilities, structures and improvements determined by the government to be necessary for construction of the Project.

Title to any acquired real estate will be retained by the Project Sponsor and will not be conveyed to the United States Government. Prior to advertisement of any construction contract, the NFS shall furnish to the government an Authorization for Entry for Construction (Exhibit "A" to the Real Estate Appendix) to all lands, easements and rights-of-way, as necessary. The NFS will also furnish to the government evidence supporting their legal authority to grant rights-of-way to such lands. The NFS shall comply with applicable provisions of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970, Public Law 91-646, approved 2 January 1971, and amended by Title IV of the Surface Transportation Uniform Relocation Assistance Act of 1987, Public Law 100-17, effective 2 April 1989, in acquiring real estate interests for the Project, and inform all affected persons of applicable benefits, policies, and procedures in connection with said Act(s). A form for the Assessment of the Non-Federal Sponsor's Capability to Acquire Real Estate is at Exhibit "B" to the Real Estate Appendix. The assessment will be made during PED phase.

The non-Federal sponsor is entitled to receive credit against its share of project costs for the value of lands it provides and the value of the relocations that are required for the project. Generally, for the purpose of determining the amount of credit to be afforded, the value of the LER is the fair market value of the real property interest, plus certain incidental costs of acquiring those interests, that the non-federal sponsor provided for the project as required by the Government. The NFS cannot receive credit for the value of any LER, including incidental costs, which were previously provided as an item of cooperation for another Federal project, including projects that preceded enactment of WRDA 1986.

5.1.7 Government Owned Property

There are no known Government owned lands within the proposed project.

5.1.8 Historical Significance

See the Main Report, Section 3.2.9 Cultural and Archaeological Resources, for a general discussion on cultural and archaeological resources.

5.1.9 Mineral Rights

There are no known mineral activities within the scope of the proposed project.

5.1.10 Hazardous, Toxic, and Radioactive Waste (HTRW)

Due to the extent of the project, no preliminary assessment was performed to identify the possibility of hazardous waste on the sites. These studies will be conducted during the next phase of work. See Sections 3.2.8 and 6.16 of the Main Report for a discussion on HTRW.

5.1.11 Public Law 91-646, Relocation Assistance Benefits

Not applicable.

5.1.12 Attitude of Property Owners

Real Estate has not interviewed property owners or tenants during the study phase for the MsCIP. However, numerous public meetings have been held at different locations throughout the study area to inform stakeholders and property owners about the study and the protective measures under consideration for the Mississippi coastal area. A number of local newspapers have published articles that discuss the MsCIP study and the perceived positive effects as well as the negative impacts that may occur as a result of the project. Some of these articles can be found on web sites. While many of the locals may welcome the benefits of the proposed project, there are some who oppose the project.

5.1.13 Acquisition Schedule

An acquisition schedule will be developed when plans and specifications become available and more definite information is available pertaining to the specific areas and number of parcels for acquisition. The acquisition schedule will be developed during PED and will be a joint effort of the NFS, the project manager and Real Estate. The schedule will set forth a time line for title, survey, appraisal, negotiation, preparation of documents and closing activity. After acquisition activity is completed certification of lands acquired/owned by the sponsor will be necessary prior to advertisement for construction. The Certification of Real Estate can be accomplished within 30 - 60 days after acquisition. See Chapter 2. Section 2.5. for discussion on an acquisition implementation/management plan.

5.1.14 Estates for Proposed Project

All lands acquired in the buy-out area will be acquired in Fee Simple.

FEE.

The fee simple title to (the land described in Schedule A) l/(Tracts Nos. ____, ____ and ___), subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

5.1.15 Real Estate Estimate

The real estate cost estimates at Tables 5.1.15-1 through 5.1.15-3 include the land cost for acquisition of land and Federal and non-Federal administrative costs. Administrative costs are those costs incurred for verifying ownership of lands, certification of those lands required for project purposes, legal opinions, analysis or other requirements that may be necessary, during PED. If further real estate requirements are identified during PED or if there is a significant increase in cost, a supplement to the Real Estate Appendix will be prepared. A 25% contingency is applied to the current estimate.

Table 5.1.15-1.
Harrison County Turkey Creek Ecosystem Restoration Site Estimate Option A

a. Lands and Improvements/Permits					
13 Ownerships & 0 Improvements					588,692
					0
				Subtotal	588,692
b. Mineral Rights					0
c. Damages					0
d. P.L. 91-646 Relocation costs – 0 relocations					0
e. Administrative Cost					292,500
		Relocation	Acquisition	Total	
	Federal	0	32,500	32,500	
	Non-Federal	0	260,000	260,000	
		0	292,500	292,500	
Subtotal					881,192
Contingencies (25%)					220,298
	Totals				**1,101,490**
	Rounded				**1,101,000**

Table 5.1.15-2.
Harrison County Turkey Creek Ecosystem Restoration Site Estimate Option B

a. Lands and Improvements/Permits				
8 Ownerships & 0 Improvements				421,448
				0
			Subtotal	421,448
b. Mineral Rights				0
c. Damages				0
d. P.L. 91-646 Relocation costs – 0 relocations				0
e. Administrative Cost				180,000
	Relocation	Acquisition	Total	
Federal	0	20,000	20,000	
Non-Federal	0	160,000	160,000	
	0	180,000	180,000	
Subtotal				601,448
Contingencies (25%)				150,362
Totals				**751,810**
Rounded				**752,000**

Table 5.1.15-3.
Harrison County Turkey Creek Ecosystem Restoration Site Estimate Option C

a. Lands and Improvements/Permits				
5 Ownerships & 0 Improvements				167,244
				0
			Subtotal	167,244
b. Mineral Rights				0
c. Damages				0
d. P.L. 91-646 Relocation costs – 0 relocations				0
e. Administrative Cost				112,500
	Relocation	Acquisition	Total	
Federal	0	12,500	12,500	
Non-Federal	0	100,000	100,000	
	0	112,500	112,500	
Subtotal				279,744
Contingencies (25%)				69,936
Totals				**349,680**
Rounded				**350,000**

5.1.16 Summary of Potential Real Estate Issues

Any requirements for relocation contracts pertaining to facilities/utilities will be identified and completed during PED.

Should condemnation of any required real estate interest be necessary, it is the responsibility of the NFS. This issue is addressed during the Assessment of the Non-Federal Sponsor's Real Estate Acquisition Capability. However, if the real estate interest is one that the NFS does not have authority to condemn, the Federal Government can perform the condemnation on behalf of the NFS.

5.1.17 Chart of Accounts

The cost estimate for all Federal and non-Federal real estate activities necessary for implementation of the project after completion of the feasibility study for land acquisition, construction, LERRD, and other items are coded as delineated in the Cost Work Breakdown Structure (CWBS). This real estate cost estimate is then incorporated into the Total Current Working Estimate utilizing the Microcomputer Aided Cost Engineering System (MCACES). The Charts of Accounts at Tables 5.1.17-1 through 5.1.17-3 show the CWBS for real estate activities.

Table 5.1.17-1.
Chart of Accounts - Harrison County Turkey Creek Ecosystem Restoration Site Option A

01A	Project Planning	Federal	Non-Federal	Totals
	Other			
	Project Cooperation Agreement			
01AX	Contingencies (25%)			
	Subtotal			
01B	Lands and Damage/Permits			
01B40	Acquisition/Review of NFS	32,500		32,500
01B20	Acquisition by NFS		260,000	260,000
01BX	Contingencies (25%)	8,125	65,000	73,125
	Subtotal	40,625	325,000	365,625
01F	PL 91-646 Assistance			
01F20	By NFS		0	0
01FX	Contingencies (25%)		0	0
	Subtotal		0	0
01R	Real Estate Land Payments			
01R1B	Land Payments by NFS		588,692	588,692
01R2B	PL91-646 Relocation Payment by NFS		0	0
01R2D	Review of NFS	0		0
01RX	Contingencies (25%)	0	147,173	147,173
	Subtotal	0	735,865	735,865
	Totals	**40,625**	**1,060,865**	**1,101,490**
	Rounded			**1,101,000**

Table 5.1.17-2.
Chart of Accounts - Harrison County Turkey Creek Ecosystem Restoration Site
Option B

01A	Project Planning	Federal	Non-Federal	Totals
	Other			
	Project Cooperation Agreement			
01AX	Contingencies (25%)			
	Subtotal			
01B	Lands and Damage/Permits			
01B40	Acquisition/Review of NFS	20,000		20,000
01B20	Acquisition by NFS		160,000	160,000
01BX	Contingencies (25%)	5,000	40,000	45,000
	Subtotal	25,000	200,000	225,000
01F	PL 91-646 Assistance			
01F20	By NFS		0	0
01FX	Contingencies (25%)		0	0
	Subtotal		0	0
01R	Real Estate Land Payments			
01R1B	Land Payments by NFS		421,448	421,448
01R2B	PL91-646 Relocation Payment by NFS		0	0
01R2D	Review of NFS	0		0
01RX	Contingencies (25%)	0	105,362	105,362
	Subtotal	0	526,810	526,810
	Totals	**25,000**	**726,810**	**751,810**
	Rounded			**752,000**

Table 5.1.17-3.
Chart of Accounts - Harrison County Turkey Creek Ecosystem Restoration Site Option C

01A	Project Planning	Federal	Non-Federal	Totals
	Other			
	Project Cooperation Agreement			
01AX	Contingencies (25%)			
	Subtotal			
01B	Lands and Damage/Permits			
01B40	Acquisition/Review of NFS	12,500		12,500
01B20	Acquisition by NFS		100,000	100,000
01BX	Contingencies (25%)	3,125	25,000	28,125
	Subtotal	15,625	125,000	140,625
01F	PL 91-646 Assistance			
01F20	By NFS		0	0
01FX	Contingencies (25%)		0	0
	Subtotal		0	0
01R	Real Estate Land Payments			
01R1B	Land Payments by NFS		167,244	167,244
01R2B	PL91-646 Relocation Payment by NFS		0	0
01R2D	Review of NFS	0		0
01RX	Contingencies (25%)	0	41,811	41,811
	Subtotal	0	209,055	209,055
	Totals	**15,625**	**334,055**	**349,680**
	Rounded			**350,000**

5.2 Jackson County Bayou Cumbest

Figure 5.2-1 identifies the areas recommended for environmental restoration in Jackson County. Should all proposed areas be restored, approximately 2,402 parcels with 658 structures would be impacted at a projected acquisition cost of $335,009,000. This REP however, focuses on the pilot project at Bayou Cumbest. This area is subject to an ongoing Federal Emergency Management Agency (FEMA) Hazard Mitigation Grant Program (HMGP) to Mississippi Emergency Management Agency (MEMA) and Jackson County to acquire all those repetitively flooded properties in the Bayou Cumbest community. Separate discussion with MEMA indicates they will also acquire properties that do not meet the repetitively flooded criteria to avoid a "piece-meal" acquisition pattern. This activity is currently ongoing with or without the MsCIP. Coordination with MEMA indicated that environmental restoration of the area would be an allowable activity but that FEMA would not provide resources to accomplish restoration. Figure 5.2.1-1 shows those parcels in red acquired through the HMGP. It is important to note that as per Engineer Circular 1105-2-218, paragraph 9. Real Estate Crediting Considerations, dated October 1, 2000, "Where use of lands acquired with HMGP funds for a Corps project is consistent with such policies and procedures, and such lands are provided by the non-Federal sponsor for the Corps project, the non-Federal sponsor shall not receive credit toward its required contribution for the value of such lands or any interests therein.. The non-Federal sponsor also shall not receive credit for incidental costs of acquiring lands provided for the Corps project that were paid with HMGP funds. Similarly, the value of such lands, including incidental costs, shall not be included as part of total project costs for cost sharing or NED plan determination."

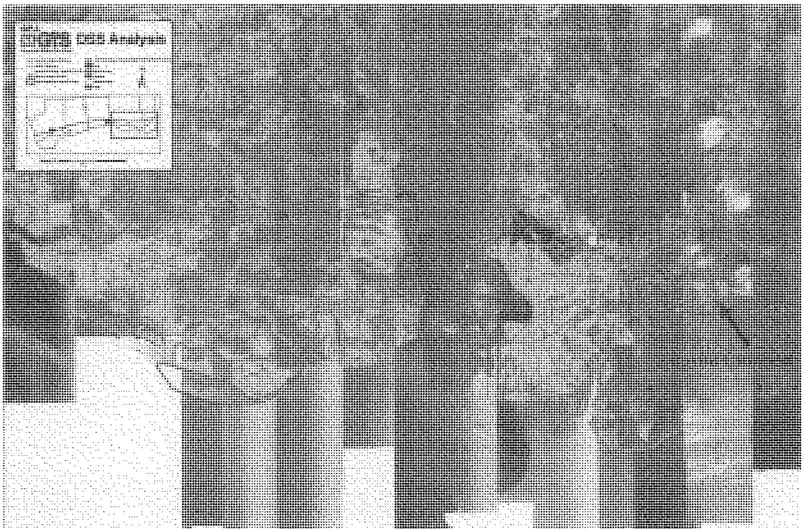

Figure 5.2-1.
Location of Restoration Sites in Jackson County

5.2.1 Project Description

The Bayou Cumbest restoration area contains approximately 148 acres of which 110 acres would be restored to emergent tidal marsh and the remaining 38 acres would remain scrub/shrub wetland habitat. The area is shown in Figure 5.2.1-1. The area presently consists of previously filled areas, some tidal marsh and scrub shrub. Objectives are to restore marsh to historical (pre-development ~1950's) conditions, provide storm surge protection, restore native tidal wetland plant community, provide fish and tidal wildlife habitat, and prevent saltwater intrusion. The plan calls for mandatory buy-out of land and 100% removal of existing structures in the area.

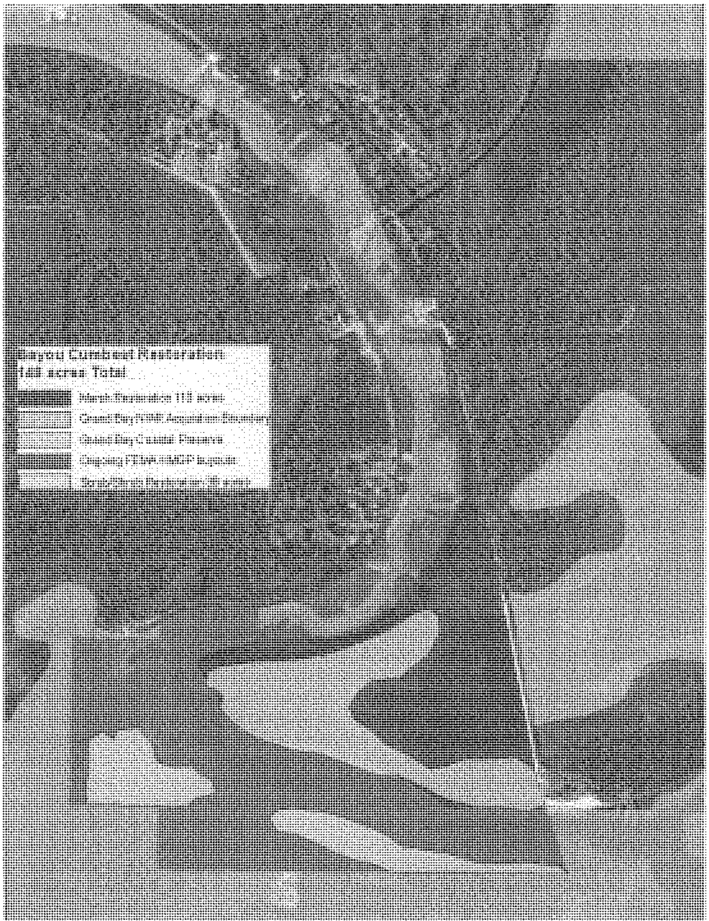

Figure 5.2.1-1.
Bayou Cumbest Jackson County

5.2.2 Real Estate Requirements

Real Estate requirements for the Bayou Cumbest Ecosystem Restoration Site in Jackson County include lands, easements, rights-of-way and relocations, and disposal/borrow areas (LERRD), and the right to acquire in fee simple approximately 61 impacted parcels and 19 structures. Based on the number of structures being impacted, the assumption is that there will be 19 relocations to include residences and businesses. The plan calls to use "approved landfills" for disposal of the demolished structures. An assumption is made that the excavated material will be disposed of in commercial or county landfills. In the event that the excavated material is not suitable for a landfill a disposal site will have to be acquired. Typically if disposal sites are required, this would be considered as part of the LERRD requirement. Real Estate would provide an analysis during PED to compare the cost of acquiring an upland disposal site with the cost of using a commercial landfill and make a determination which method is most cost effective.

EP 1165-2-502, paragraph 7 (m.) states that as a general rule, land value should not exceed 25 percent of total project costs for ecosystem restoration, and that proposals consisting primarily of land acquisition are not appropriate as Civil Works ecosystem restoration investments. This project proposes to reduce risk from future hurricane and storm events and to restore the environment. These are two major objectives of the comprehensive plan. The estimated land value is within 25 percent of the estimated total project cost.

5.2.3 Utility/Facility Relocation

Specific information about relocation of utilities/facilities is unknown at this time. An assumption is made that if required, this work will be accomplished under a relocation contract. This will be further investigated and confirmed during PED. See Chapter 2 Section 2.10 for more detailed discussion.

5.2.4 Existing Projects/Studies

Relevant projects and studies are found in the main report at Section 1.6, History of the Investigation and Section 1.7, Prior and On-Going Studies, Reports and Programs.

5.2.5 Environmental Impacts

See the Main Report, Chapter 6. Environmental Effects of Plans and the Environmental Appendix, for a full discussion on environmental effects.

5.2.6 Project Sponsor Responsibilities and Capabilities

The State of Mississippi will be the non-Federal Project Sponsor (NFS). The NFS has the responsibility to acquire all real estate interests required for the Project. The NFS shall accomplish all alterations and relocations of facilities, structures and improvements determined by the government to be necessary for construction of the Project.

Title to any acquired real estate will be retained by the Project Sponsor and will not be conveyed to the United States Government. Prior to advertisement of any construction contract, the NFS shall furnish to the government an Authorization for Entry for Construction (Exhibit "A" to the Real Estate Appendix) to all lands, easements and rights-of-way, as necessary. The NFS will also furnish to the government evidence supporting their legal authority to grant rights-of-way to such lands. The NFS shall comply with applicable provisions of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970, Public Law 91-646, approved 2 January 1971, and amended by Title IV of the Surface Transportation Uniform Relocation Assistance Act of 1987, Public Law 100-

17, effective 2 April 1989, in acquiring real estate interests for the Project, and inform all affected persons of applicable benefits, policies, and procedures in connection with said Act(s). A form for the Assessment of the Non-Federal Sponsor's Capability to Acquire Real Estate is at Exhibit "B" to the Real Estate Appendix. The assessment will be made during PED phase.

The non-Federal sponsor is entitled to receive credit against its share of project costs for the value of lands it provides and the value of the relocations that are required for the project. Generally, for the purpose of determining the amount of credit to be afforded, the value of the LER is the fair market value of the real property interest, plus certain incidental costs of acquiring those interests, that the non-federal sponsor provided for the project as required by the Government. The NFS cannot receive credit for the value of any LER, including incidental costs, which were previously provided as an item of cooperation for another Federal project, including projects that preceded enactment of WRDA 1986.

5.2.7 Government Owned Property

There are no known Government owned lands within the proposed project.

5.2.8 Historical Significance

See the Main Report, Section 3.2.9 Cultural and Archaeological Resources, for a general discussion on cultural and archaeological resources.

5.2.9 Mineral Rights

There are no known mineral activities within the scope of the proposed project.

5.2.10 Hazardous, Toxic, and Radioactive Waste (HTRW)

Due to the extent of the project, no preliminary assessment was performed to identify the possibility of hazardous waste on the sites. These studies will be conducted during the next phase of work. See Sections 3.2.8 and 6.16 of the Main Report for a discussion on HTRW.

5.2.11 Public Law 91-646, Relocation Assistance Benefits

The Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970 establishes a uniform policy for fair and equitable treatment of persons displaced as a result of federal and federally assisted programs in order that such persons shall not suffer disproportionate injuries as a result of programs designed for the benefits of the public as a whole. A qualified displaced person may be entitled to certain relocation assistance benefits which include reimbursement of moving costs and a replacement housing benefit. Moving expense can be reimbursed either based on actual costs or a fixed moving cost schedule. The replacement housing payment is separated into 3 basic types - purchase supplement, rental assistance and down payment. All replacement housing must be decent, safe, and sanitary (DSS) before a replacement housing payment can be made.

It is estimated that there are approximately 19 relocations in Bayou Cumbest Ecosystem Restoration Site area. No relocation plan has been completed nor has a relocation survey been done. All estimates are based on information from county public records. The number of business relocations as compared to residential relocations is unknown. The availability of decent safe and sanitary housing may be a potential problem. In order to accomplish the relocation activity in a timely manner, the plan set forth in Chapter 2. Section 2.5 can be used.

5.2.12 Attitude of Property Owners

Real Estate has not interviewed property owners or tenants during the study phase for the MsCIP. However, numerous public meetings have been held at different locations throughout the study area to inform stakeholders and property owners about the study and the protective measures under consideration for the Mississippi coastal area. A number of local newspapers have published articles that discuss the MsCIP study and the perceived positive effects as well as the negative impacts that may occur as a result of the project. Some of these articles can be found on web sites. While many of the locals may welcome the benefits of the proposed project, there are some who oppose the project.

5.2.13 Acquisition Schedule

An acquisition schedule will be developed when plans and specifications become available and more definite information is available pertaining to the specific areas and number of parcels for acquisition. The acquisition schedule will be developed during PED and will be a joint effort of the NFS, the project manager and Real Estate. The schedule will set forth a time line for title, survey, appraisal, negotiation, preparation of documents and closing activity. After acquisition activity is completed certification of lands acquired/owned by the sponsor will be necessary prior to advertisement for construction. The Certification of Real Estate can be accomplished within 30 - 60 days after acquisition. See Chapter 2. Section 2.5. for discussion on an acquisition implementation/management plan.

5.2.14 Estates for Proposed Project

All lands acquired in the buy-out area will be acquired in Fee Simple. The Temporary Work Area Easement will be used for a disposal site if required. The estates recommended are standard estates.

FEE.

The fee simple title to (the land described in Schedule A) l/(Tracts Nos. ____, ____ and ___), subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

TEMPORARY WORK AREA EASEMENT.

A temporary easement and right-of-way in, on, over and across (the land described in Schedule A) (Tracts Nos. _____, _____ and _____), for a period not to exceed __________________, beginning with date possession of the land is granted to the Project Sponsor, for use by the Project Sponsor, its representatives, agents, and contractors as a work area, including the right to deposit backfill, move, store and remove equipment and supplies, and erect and remove temporary structures on the land and to perform any other work necessary and incident to the construction of the ___________________ Project, together with the right to trim, cut, fell and remove there from all trees, underbrush, obstructions, and any other vegetation, structures, or obstacles within the limits of the right-of-way; reserving, however, to the landowners, their heirs and assigns, all such rights and privileges as may be used without interfering with or abridging the rights and easement hereby acquired; subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

5.2.15 Real Estate Estimate

The real estate cost estimate at Table 5.2.15-1 includes the land cost for acquisition of land, relocation benefits to include a replacement housing payment and fixed rate move expenses, and Federal and non-Federal administrative costs. Administrative costs are those costs incurred for verifying ownership of lands, certification of those lands required for project purposes, legal opinions, analysis or other requirements that may be necessary, during PED. No cost is included for a disposal site. The requirement, if any, for a disposal site will be identified during PED. If further real estate requirements are identified during PED or if there is a significant increase in cost, a supplement to the Real Estate Appendix will be prepared. A 25% contingency is applied to the current estimate.

Table 5.2.15-1.
Jackson County Bayou Cumbest Ecosystem Restoration Estimate

a. Lands and Improvements/Permits 61 Ownerships & 19 Improvements		1,798,283
	Subtotal	1,798,283
b. Mineral Rights		0
c. Damages		0
d. P.L. 91-646 Relocation costs -19 relocations		532,000
e. Administrative Cost		1,515,000

	Relocation	Acquisition	Total
Federal	28,500	152,500	181,000
Non-Federal	114,000	1,220,000	1,334,000
	142,500	1,372,500	1,515,000

Sub-Total		3,845,283
Contingencies (25%)		961,321
	Totals	**4,806,604**
	Rounded	**4,807,000**

5.2.16 Summary of Potential Real Estate Issues

In the event that the excavated material is not suitable for a landfill a disposal site will have to be acquired. Typically if disposal sites are required, this would be considered as part of the LERRD requirement. Real Estate would provide an analysis during PED to compare the cost of acquiring an upland disposal site with the cost of using a commercial landfill and make a determination which method is most cost effective.

Any requirements for relocation contracts pertaining to facilities/utilities will be identified and completed during PED.

Should condemnation of any required real estate interest be necessary, it is the responsibility of the NFS. This issue is addressed during the Assessment of the Non-Federal Sponsor's Real Estate Acquisition Capability. However, if the real estate interest is one that the NFS does not have authority to condemn, the Federal Government can perform the condemnation on behalf of the NFS.

A relocation plan will need to be completed during PED to address potential relocation activity under P.L. 91-646. There are a number of factors pertaining to relocations that can impact the project both in cost and in schedule. Payments for Housing of Last Resort, which would exceed the standard housing replacement payments, are very likely due to the size of the project and the lack of available decent, safe and sanitary housing in the area. Another factor that could increase cost and impact schedule is the cost of business relocations. Depending on the type of business and the operation, this could involve moving equipment and machinery to new locations. It is necessary to interview each impacted individual and business during Pre-Construction, Engineering and Design Phase to determine the requirements for relocation and to estimate a cost for the relocation.

The availability of decent safe and sanitary housing may be a potential problem.

5.2.17 Chart of Accounts

The cost estimate for all Federal and non-Federal real estate activities necessary for implementation of the project after completion of the feasibility study for land acquisition, construction, LERRD, and other items are coded as delineated in the Cost Work Breakdown Structure (CWBS). This real estate cost estimate is then incorporated into the Total Current Working Estimate utilizing the Microcomputer Aided Cost Engineering System (MCACES). The Chart of Accounts at Table 5.2.17-1 shows the CWBS for real estate activities.

Table 5.2.17-1.
Chart of Accounts - Jackson County Bayou Cumbest Ecosystem Restoration

01A	Project Planning	Federal	Non-Federal	Totals
	Other			
	Project Cooperation Agreement			
01AX	Contingencies (25%)			
	Subtotal			
01B	Lands and Damages/Permits			
01B40	Acquisition/Review of NFS	152,500		152,500
01B20	Acquisition by NFS		1,220,000	1,220,000
01BX	Contingencies (25%)	38,125	305,000	343,125
	Subtotal	190,625	1,525,000	1,715,625
01F	PL 91-646 Assistance			
01F20	By NFS		114,000	114,000
01FX	Contingencies (25%)		28,500	28,500
	Subtotal		142,500	142,500
01R	Real Estate Land Payments			
01R1B	Land Payments by NFS		1,798,283	5,083,421
01R2B	PL91-646 Relocation Payment by NFS		532,000	532,000
01R2D	Review of NFS	28,500		28,500
01RX	Contingencies (25%)	7,125	582,571	589,696
	Subtotal	35,625	2,912,854	2,948,479
	Totals	**672,500**	**4,580,354**	**4,806,604**
	Rounded			**4,807,000**

1700

EXHIBITS

AUTHORIZATION FOR ENTRY FOR CONSTRUCTION

I ______________________________, ________________________ for the
(Name of accountable official) (Title)

(Sponsor Name) _____, do hereby certify that the ___(Sponsor Name) has acquired the real property interest required by the Department of the Army, and otherwise is vested with sufficient title and interest in lands to support construction for (Project Name, Specifically identified project features, etc.). Further, I hereby authorize the Department of the Army, its agents, employees and contractors, to enter upon ______________________
(identify tracts)

to construct (Project Name, Specifically identified project features, etc.) as set forth in the plans and specifications held in the U. S. Army Corps of Engineers' (district, city, state)

WITNESS my signature as ____________________________ for the
(Title)

(Sponsor Name) this __ day of ____________, 20_________.

BY: ______________________
(Name)

____
(Title)

ATTORNEY'S CERTIFICATE OF AUTHORITY

I, ____________________ , ______________________________ for the
(Name) (Title of legal officer)

(Sponsor Name), certify that ___________________________ has
(Name of accountable official)

authority to grant Authorization for Entry; that said Authorization for Entry is executed by the proper duly authorized officer; and that the Authorization for Entry is in sufficient form to grant the authorization therein stated.

WITNESS my signature as ______________________ for the
(Title)

(Sponsor Name), this________day of____________, 20____.

BY: ______________________
(Name)

____
(Title)

Exhibit A

Assessment of Non-Federal Sponsor's
Real Estate Acquisition Capability

I. Legal Authority:

a. Does the sponsor have legal authority to acquire and hold title to real property for project purposes? (yes/no)

b. Does the sponsor have the power to eminent domain for this project? (yes/no)

c. Does the sponsor have "quick-take" authority for this project? (yes/no)

d. Are any of the land/interests in the land required for this project located outside the sponsor's political boundary? (yes/no)

e. Are any of the lands/interests in land required for the project owned by an entity whose property the sponsor cannot condemn? (yes/no)

II. Human Resource Requirements:

a. Will the sponsor's in-house staff require training to become familiar with the real estate requirements of Federal projects including P. L. 91-646, as amended? (yes/no)

b. If the answer to II.a. is "yes", has a reasonable plan been developed to provide such training? (yes/no)

c. Does the sponsor's in-house staff have sufficient real estate acquisition experience to meet its responsibilities for the project? (yes/no)

d. Is the sponsor's projected in-house staffing level sufficient considering its other work load, if any, and the project schedule? (yes/no)

e. Can the sponsor obtain contractor support, if required in a timely fashion? (yes/no)

f. Will the sponsor likely request USACE assistance in acquiring real estate? (yes/no)

III. Other Project Variables:

a. Will the sponsor's staff be located within reasonable proximity to the project site? (yes/no)

b. Has the sponsor approved the project/real estate schedule/milestones? (yes/no)

Exhibit B
1st page

IV. Overall Assessment:

a. Has the sponsor performed satisfactory on other USACE projects? (yes/no/not applicable)

b. With regard to the project, the sponsor is anticipated to be: highly capable/fully capable/moderately capable/marginally capable/insufficiently capable.

V. Coordination:

a. Has this assessment been coordinated with the sponsor? (yes/no)

b. Does the sponsor concur with this assessment? (yes/no) (If "no", provide explanation)

Prepared by:

____
Realty Specialist

Reviewed and approved by:

____
Chief, Real Estate Division

Exhibit B
2nd page

MISSISSIPPI COASTAL IMPROVEMENT PROGRAM (MsCIP)

High Hazard Area Risk Reduction Plan (HARP)

Exhibit C

Real Estate Summary

The MsCIP Study includes a set of structural, nonstructural and environmental features for reduction of risk to life, property, infrastructure and the environment of coastal Mississippi with the goal of reconstructing the project area as a disaster-resilient community. This report recommends a nonstructural component of the study referred to as the High Hazard Area Risk Reduction Plan (HARP) for the purchase of approximately 2,000 parcels interspersed within the high hazard zone of the three coastal counties of Mississippi. The high hazard zone is defined in the MsCIP plan as the combination of the FEMA V and VE zones established by the publication of Flood Insurance Rate Maps and the FEMA designated "catastrophic damages zone" established after Katrina. This zone is shown on Figures 1 - 4. Acquisition of parcels within the high hazard zone to prevent future habitation was determined to be the most cost effective alternative to reduce loss of life and future damages from storms and hurricanes.

The total estimated residential, commercial, and municipal parcels located within the high hazard zone are estimated to be 15,000. The current HARP is proposed as a short term five-year project to begin upon execution of the Project Partnership Agreement for the HARP. In order to maximize benefits under the HARP, it would be implemented first in the most high risk areas and initially with owners who are still displaced and willing to sell. However, eminent domain may be used when necessary to implement the HARP. Acquisition of the remaining parcels within the high hazard zone will be evaluated in further studies with the comprehensive long-term risk reduction plan to be coordinated among HUD, FEMA and the Corps.

The majority of the parcels located within the high hazard zone were occupied by residences that were destroyed by Hurricane Katrina in August 2005. Recent site surveys and data collected indicate that many of these previously occupied parcels have either been rebuilt or are in the process of being rebuilt with the eastern areas of the Mississippi coast showing more development than the western areas. Current estimates of rebuilding within the high hazard zone range from 15% - 25% with many structures being elevated according to the current local floodplain management ordinances. The proposed HARP acquisition for approximately 2,000 parcels over a five year period in lieu of acquiring 15,000 was determined to be a more realistic and a reasonable number of acquisitions to expect after considering impacts to the local county tax base, time allowances for acquisitions, social disruption and project costs. Another major influence in making this determination was based on comments received from other Federal and State agencies, and comments received from owners who voiced their support for an acquisition program.

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TABLES

FIGURES

1. STUDY AUTHORITY/BACKGROUND

The Mississippi Coastal Improvements Program, Hancock, Harrison, and Jackson Counties, Mississippi (MsCIP) and the MsCIP Comprehensive Plan Report was authorized for study by the Department of Defense Appropriations Act, 2006 (P.L. 109-148) 30 December 2005. The authorization was in response to numerous deaths, extensive damage to environmental resources, homes, businesses and industries, exacerbated saltwater intrusion problems, widespread coastal erosion, damage to public infrastructure and the regional economy caused by the Hurricanes of 2005.

During the study, based upon Corps of Engineers' data, FEMA damage estimates, State of Mississippi post-Katrina reports and on-site Corps investigations, a visually distinct zone was identified in which all residential and commercial structures were destroyed or so significantly damaged as to deny re-occupation. The majority of residential and commercial structures within the "high-hazard zone" designated by the Corps were destroyed and have not yet been rebuilt. The rebuilding rate within the surge inundation area and in particular the V/VE Zones as defined by FEMA, has been much slower than might typically be expected following a hurricane.

The comprehensive plan developed by the study team, resource agencies and public contains a recommendation for the implementation of a significant nonstructural alternative for the acquisition and/or floodproofing of properties within the area identified as having a 1 percent annual chance of inundation from hurricane and storm surges, with the goal of reconstructing the project area as a disaster-resilient community. A portion of this area, designated in the study as the high-hazard zone, is regarded as too dangerous for certain types of nonstructural measures that would place a residential structure (using normal building code construction practices), even an elevated residential structure, in the pathway of the surge and waves from a Katrina-like storm. Therefore the high-hazard zone is not considered an appropriate location for floodproofing by elevation while permanent acquisition of properties and removal of structures from that zone is considered an appropriate measure. To implement the acquisition component of the 1 percent annual chance plan the study team formulated an approach referred to as the High Hazard Area Risk Reduction Plan (HARP).

The FEMA designated 100-year floodplain (that is, a 1 percent annual chance of inundation) contains an estimated 58,000 parcels of which an estimated 15,000 parcels are located within the high hazard zone. It is not realistic to consider that this component could be undertaken within a short timeframe due to impacts on the local tax base, social disruption and project costs. However, it is realistic to consider that this component could be phased in over an extended multi-year period. The HARP would include acquisition of approximately 2,000 parcels interspersed within the most high risk areas that could be implemented over a five year period. The long-term nonstructural risk reduction plan is envisioned as a coordinated effort between HUD, FEMA, and the Corps to be applied over a much longer period and would include acquisition of additional parcels within the high hazard zone, floodproofing and/or acquisition of structures and parcels within the 100-yr floodplain. In order to maximize benefits under a HARP, the plan should be implemented first in the most high risk areas and with those owners or tenants who may still be displaced.

2. ADVANTAGES

There are significant advantages to an acquisition plan for residential, limited commercial and municipal parcels within the high hazard zone of coastal Mississippi as follows:

- Reduction of future property losses 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.
- Provides an opportunity as lands are acquired both now and in the future to initiate alternative uses of these lands for fish and wildlife preservation, ecosystem restoration, public recreation and other compatible public uses.

There are substantial additional benefits that can be attained with an expeditious authorization of the HARP and the near-term benefits could significantly be reduced or lost should the program not be authorized until a later date. Prompt initiation of acquisition is more cost effective to the Government than commencing acquisition after parcels have been rebuilt. Acquisition prior to rebuilding also avoids displacement impacts to residents after they rebuild and reduces requirements for other Government-assisted temporary housing programs for those owners or tenants still displaced that may continue to receive financial assistance from the State or Federal Government.

3. Schedule

When identifying the acquisition process for a HARP based on acquisition of approximately 2,000 interspersed parcels, the total time required was estimated to take five (5) years. The HARP acquisition process should require less administrative time and related costs compared to a traditional acquisition project since time spent for negotiations is expected to be less. Based on the strong local support from owners who are very desirous of selling their parcel(s), it is believed that the HARP would be similar to homeowner grant type programs in that interested owners would be applying for the program upon notifications of its authorization.

Considering that many of the estimated 15,000 parcel owners may not participate in an acquisition program, the MsCIP Project Delivery Team estimated that approximately 2,000 of these property owners would likely sell their parcel under a HARP. Based on a five year program, this would average 400 parcels per year and should be a reasonable number of acquisitions to expect with an adequately staffed office.

Since the primary purpose of the HARP is to restructure the project area as a disaster-resilient community, acquisition of properties will prevent future habitation which in turn would aid in reduction of loss of life and structural damages. Purchase of any parcels with residences or former residences would be subject to the owner or tenant also relocating outside of the high hazard area into decent, safe and sanitary housing as defined in 49 CFR 24. Among other eligibility requirements, the owner or tenant would have to show evidence that the new residence would meet the most current local floodplain management ordinance criteria for first floor elevation requirements to be eligible for relocation benefits.

4. Description of Parcels

Information collected from recent site surveys conducted by various MsCIP team members in March 2009 suggested that approximately 15 to 25 percent of the destroyed or seriously damaged homes previously located within the high hazard zone have been rebuilt according to various construction standards and ordinances in terms of storm survivability and elevation of the first floor. It was noted that many of the rebuilt homes within the high hazard zone would likely not survive another major storm event due to substandard construction or insufficient elevation. Even though one would expect that the owners of these rebuilt homes would not be interested in selling and reestablishing their residence within 3 ½ - 4 years of Katrina, recent comments and opinions received at the public hearings suggest otherwise, especially from those owners who have rebuilt within Hancock and Harrison Counties. Hurricanes Gustav and Ike were both grim reminders for many of these owners of the damages and loss of property that can frequently occur from living within these high hazard zones of coastal Mississippi. Many homes within the Hancock and Harrison County areas incurred loss of personal property from flooding within their garages and yards from these recent storms. Other comments collected from the recent public meetings indicated that many owners are now considering selling due to the escalating insurance rates that have doubled or tripled within these areas. In some cases, landowners were denied flood insurance due to the high risks and therefore have not rebuilt. Recent discussions with FEMA representatives also verified that FEMA was not allowing any federal grants for residential or commercial construction within the V or high hazard zones.

The following division of parcels according to their current condition, status of redevelopment and ownership type indicates the array of opportunities provided to the Corps for acquiring high hazard zone properties.

1) Vacant parcels: A large portion of the parcels located within the high hazard zone were vacant prior to Katrina and most remain that way with average lot sizes of 100 x 150 ft. Current estimates based on visual observations range from 25 – 50 % or 3,750 – 7,500 parcels.

2) Vacant but previously occupied parcels: Another large portion of the high hazard zone is comprised of vacant but previously occupied parcels – occupied prior to Katrina. The majority of these parcels have been cleared so that there is little evidence of a former structure other than perhaps a remaining concrete slab or support pilings. The estimated number of parcels that have not been rebuilt upon range from 50 to 75 %, or 7,500 to 10,000 parcels.

3) Residential parcels: Estimates of parcels within the high hazard zone with either rebuilt homes or with homes in the process of being rebuilt range from 15 – 25 % or 2,250 – 3, 750. Estimated values for most of these homes range from $175,000 - $400,000.

4) Commercial Parcels: A small percentage or less than 5 % of the parcels within the high hazard zone are commercial. A few of these have been rebuilt but probably less than 1 %. Depending on the type of business (bait shop, florist, convenience store) and its location, there could be a requirement for acquisition depending on the circumstances. For example, if a small retail type business or parcel were located within a block of parcels so as to render it an in-holding, then it would likely be recommended for acquisition.

5) Tenants: A number of multi-family units were observed to have been rebuilt in the high-hazard zone indicating there may also be persons eligible for tenant occupancy benefits under the provisions of 49 CFR Part 24. Such persons would be considered on a case by case basis in accordance with applicable policy and regulations. Since the eligible reimbursement costs would be minimal in comparison to those that an owner occupant could receive, a separate cost allowance is not estimated for this and should be covered under the 25% contingency.

6) Municipal facilities/parcels: A small percentage estimated at one half of one percent of the total parcels within the HARP limits are occupied by municipal facilities. Four such facilities are located in the municipality of Moss Point and were severely damaged from Katrina. Discussions with Moss Point City officials indicate they are very receptive to relocating into substitute facilities outside of the HARP limits and have not received any other government assistance. Relocation of the Moss Point facilities and other possible municipal facilities is discussed in further detail in the Non Structural Appendix, Section 4.6. The estimated cost to design, construct and relocate the Moss Point facilities is estimated at $11,424,000.

5. Acquisition Costs

Because of the uncertainties regarding the number of parcels that may remain vacant at the time of acquisition and the applicability of occupancy requirements under a typical relocation program, the following data shown in Table 1 indicates the estimated costs of a HARP based upon a mixture of parcels that may be expected during implementation. A Chart of Accounts is shown in Table 2.

Table 1
Estimated HARP Costs

Average Lot and Home Costs

Avg. Cost of Home, RHP, admin, demolition:	$300,000
Avg. Cost of Vacant lot and admin:	$ 75,000
Avg. Cost of Vacant lot, demo of foundation, RHP, admin:	$170,000

Recovery Stats for Residents in FEMA Temp. Units:

	Mar 08	Dec 08	Mar 09
Hancock Co.	1,668 occupied units	398	291
Harrison Co.	3,112 occupied units	815	647
Jackson Co.	1,509 occupied units	446	378
	6,289	1,659	1,316

Total Acquisition Costs based on Mixture of Estimated 2,000 Parcels

Homes	35 %	700	210,000,000
Lots	60 %	1200	90,000,000
Lots/RHP	5 %	100	17,000,000
			317,000,000
			25% contingency
			$396,250,000
		Rounded:	$397,000,000
Municipal Facilities			11,424,000
		Total	**$408,424,000**

Table 2
HARP Chart of Accounts for Acquisition of Approximately 2,000 Parcels

		FEDERAL	NON-FEDERAL	TOTALS
01A	**PROJECT PLANNING**			
	Other			
	Project Cooperation Agreement			
01AX	Contingencies			
	Subtotal			
01B	LANDS AND DAMAGES/PERMITS			
01B40	Acquisition/Review of PS	6,300,000		6,300,000
01B20	Acquisition by PS		41,950,000	41,950,000
01BX	Contingencies (25%)	1,575,000	10,487,500	12,062,500
	Subtotal	7,875,000	52,437,500	60,312,500
01F	PL 91-646 ASSISTANCE			
01F20	By PS			
01FX	Contingencies (25%)		0	0
	Subtotal		0	0
01R	REAL ESTATE LAND PAYMENTS			
01R1B	Land Payments by PS		244,000,000	244,000,000
01R2B	PL91-646 Relocation Payment by PS		24,750,000	24,750,000
01R2D	Review of PS			0
01RX	Contingencies (25%)	0	67,187,500	67,187,500
	Subtotal	0	335,937,500	335,937,500
	TOTALS	**7,875,000**	**388,375,000**	**396,250,000**
	ROUNDED TO			**$397,000,000**
01N00	FACILITY RELOCATIONS		8,573,000	8,573,000
2100	Administrative		566,200	566,200
01BX	Contingencies (25%)		2,284,800	2,284,800
	Subtotal		11,424,000	11,424,000
	TOTAL			**$408,424,000**

Note: In accordance with the provisions of WRDA 1986, as amended, cost sharing would be 65-percent Federal and 35-percent non Federal. Based on these provisions the estimated Federal share of the total cost of this project feature is $258,050,000 and the current estimated non Federal share is $138,950,000.

6. Application of the Uniform Relocation Assistance and Real Property Acquisition Policy Act of 1970, as Amended (URA)

The URA for the acquisition of real property provides various benefits to property owners when their property is acquired for an authorized Federal project. In keeping with the vision of the MsCIP for establishing a disaster-resilient coastline in regards to hurricane and storm surge, any benefit payments such as a Replacement Housing Payment (RHP) under the proposed HARP would be subject to the property owner establishing occupancy in decent, safe and sanitary (DSS) housing outside the designated high-hazard zone. Depending on the flood zone criteria for the area that the owner relocates to, the DSS designation would include the necessity to elevate the first floor of the home in accordance with the most current Digital Flood Insurance Rate Map (DFIRM) data as published by FEMA.

7. Replacement Housing Payment (RHP) Under the URA

Eligibility for relocation benefits under the URA is triggered generally by the occurrence of one of the following actions taken by the Federal Government or by a non-Federal sponsor for a federally assisted project: (1) the initiation of negotiations, (2) the issuance of a notice of intent to acquire, or (3) the actual acquisition of the property, whichever comes first. Generally, persons otherwise eligible under the URA requirements who move from their property, or move personal property, as a direct result of these displacing activities are considered displaced persons covered by the URA. One benefit under the URA available to eligible displaced persons of residential properties is payment of a RHP. The RHP would be in addition to the payment of the fair market value for the land itself.

Because there may still be residential owners and tenants displaced by Hurricane Katrina that may not be occupying the property when the HARP is implemented, the potential for application of a "constructive residential occupancy" theory under the URA and its implementing regulation contained in 49 CFR Part 24 will be considered on a case by case basis in accordance with applicable policies, regulations and criteria developed by the Government.

8. Acquisition Implementation and Management Plan

Specific guidelines for deployment of a HARP should be developed as a part of the authorization process and should be utilized to implement and manage the HARP. Preparation of an Acquisition Implementation and Management Plan (AIMP) in coordination with the Project Sponsor would ensure successful implementation and management of the HARP. The AIMP should be utilized and updated throughout the acquisition program as a working document and should include acquisition schedules, real estate costs, budgets, a relocation plan, program eligibility requirements, contacts, notification letters, applicable state and federal laws, prioritizing of acquisition areas and parcels, appraisal data, closing processes and any other relevant issues. To facilitate the acquisition process, it is recommended that a Draft AIMP be initiated as soon as possible and prior to a HARP implementation.

In order to maximize benefits under the HARP, it would be implemented first in the most high risk areas and initially with owners who are still displaced and willing to sell. However, eminent domain may be used when necessary to implement the HARP.

9. PROJECT SPONSOR RESPONSIBILITIES AND CAPABILITIES

The Mississippi Department of Marine Resources (MSDMR) is expected to be non-Federal Project Sponsor (NFS) for the HARP. The NFS will have the responsibility to provide all lands, easements, rights-of-way, relocations and dredged or excavated material disposal areas (LERRD) and will perform all relocations determined by the Government to be necessary for the project. The Government will have oversight of these activities to ensure compliance with the Uniform Relocation Assistance Act, Public Law 91-646, as amended, and with the Uniform Regulations contained in 49 C.F.R. Part 24. Should the NFS determine that certain circumstances may prevent acquisition in a timely manner, it may request the Government to acquire the LERRD on its behalf. In such event, the decision to acquire the LERRD on behalf of the non-Federal sponsor lies within the sole discretion of the Government. If agreed to by the Government, a Memorandum of Agreement (MOA) would be entered into and forwarded to HQUSACE for coordination, review and approval prior to execution. The Assessment of the non-Federal Sponsor's capability to acquire real estate is attached as Exhibit "A". Based on this assessment, it is highly probable that the NFS will be seeking assistance from the Government for acquisition of the LERRD on its behalf.

10. CONCLUSIONS

The nonstructural program component for a HARP project within the high hazard zone of coastal Mississippi can provide significant levels of protection to the residents in the project area and can be the foundation for development of a disaster-resilient community along the Gulf Coast. When compared to other flood damage reduction alternatives for the project area, the nonstructural components are the most cost effective, environmentally friendly, incremental in deployment but cumulative in benefit accrual, affordable in terms of local sponsor OMRR&R costs, supportive of local NFIP ordinances, and can be integrated into other community plans for energy conservation, new housing development, economic development, public transit strategies, and renewal of public facilities through local Capital Improvements Programs.

Assessment of the
Real Estate Acquisition Capability
Of
Mississippi Department of Marine Resources (MSDMR)

I. Legal Authority:

a. Does the sponsor have legal authority to acquire and hold title to real property for project purposes? (yes/no) **YES**

b. Does the sponsor have the power to eminent domain for this project? (yes/no) **MSDMR does not but the State and local entities do.**

c. Does the sponsor have "quick-take" authority for this project? (yes/no) **Same as b.**

d. Are any of the land/interests in the land required for this project located outside the sponsor's political boundary? (yes/no) **NO**

e. Are any of the lands/interests in land required for the project owned by an entity whose property the sponsor cannot condemn? (yes/no) **NO**

II. Human Resource Requirements:

a. Will the sponsor's in-house staff require training to become familiar with the real estate requirements of Federal projects including P. L. 91-646, as amended? (yes/no) **YES**

b. If the answer to II.a. is "yes", has a reasonable plan been developed to provide such training? (yes/no) **NO**

c. Does the sponsor's in-house staff have sufficient real estate acquisition experience to meet its responsibilities for the project? (yes/no) **NO**

d. Is the sponsor's projected in-house staffing level sufficient considering its other work load, if any, and the project schedule? (yes/no) **NO**

e. Can the sponsor obtain contractor support, if required in a timely fashion? (yes/no) **NO**

f. Will the sponsor likely request USACE assistance in acquiring real estate? (yes/no) **YES**

III. Other Project Variables:

a. Will the sponsor's staff be located within reasonable proximity to the project site? (yes/no) **YES**

b. Has the sponsor approved the project/real estate schedule/milestones? (yes/no) **YES**

EXHIBIT A
Page 1

IV. Overall Assessment:

a. Has the sponsor performed satisfactory on other USACE projects? (yes/no/not applicable) **YES**

b. With regard to the project, the sponsor is anticipated to be: highly capable/fully capable/moderately capable/marginally capable/insufficiently capable. **INSUFFICIENTLY CAPABLE**

V. Coordination:

a. Has this assessment been coordinated with the sponsor? (yes/no) **YES**

b. Does the sponsor concur with this assessment? (yes/no) (If "no", provide explanation) **YES**

Reviewed and approved by:

/s/

Willie L. Patterson
Chief, Real Estate Division
Mobile District

EXHIBIT A
Page 2

Figure 1
High Hazard Zone Project Overview

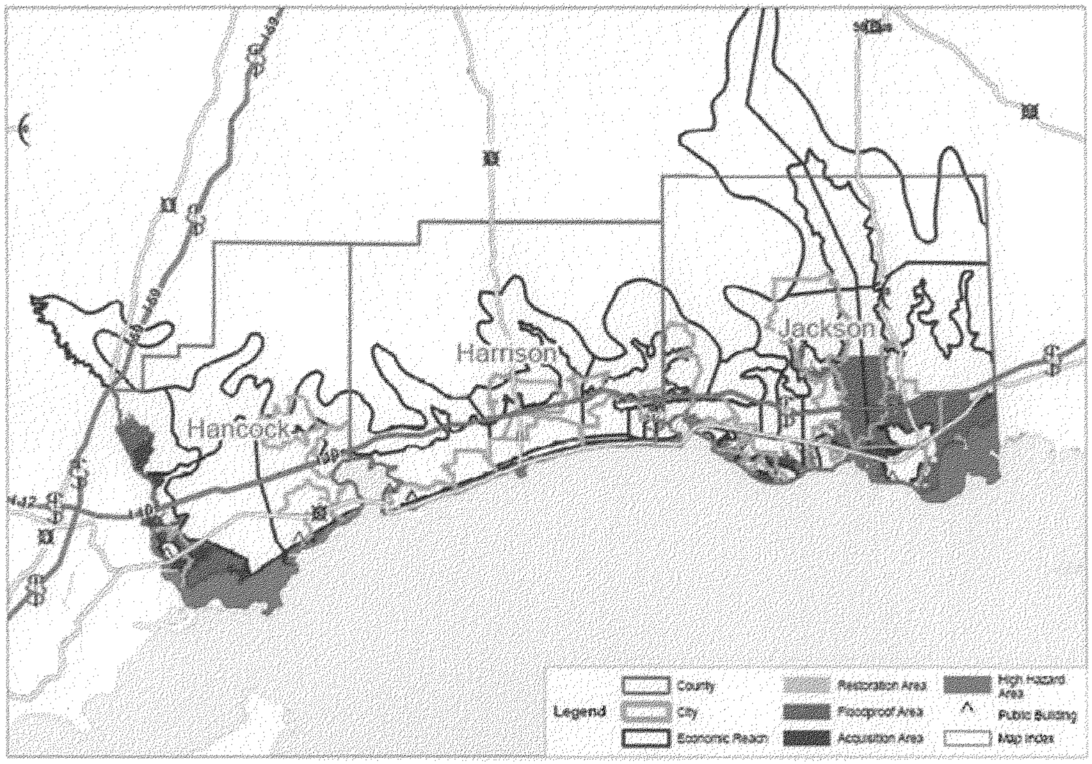


Figure 2
High Hazard Zone in Hancock County

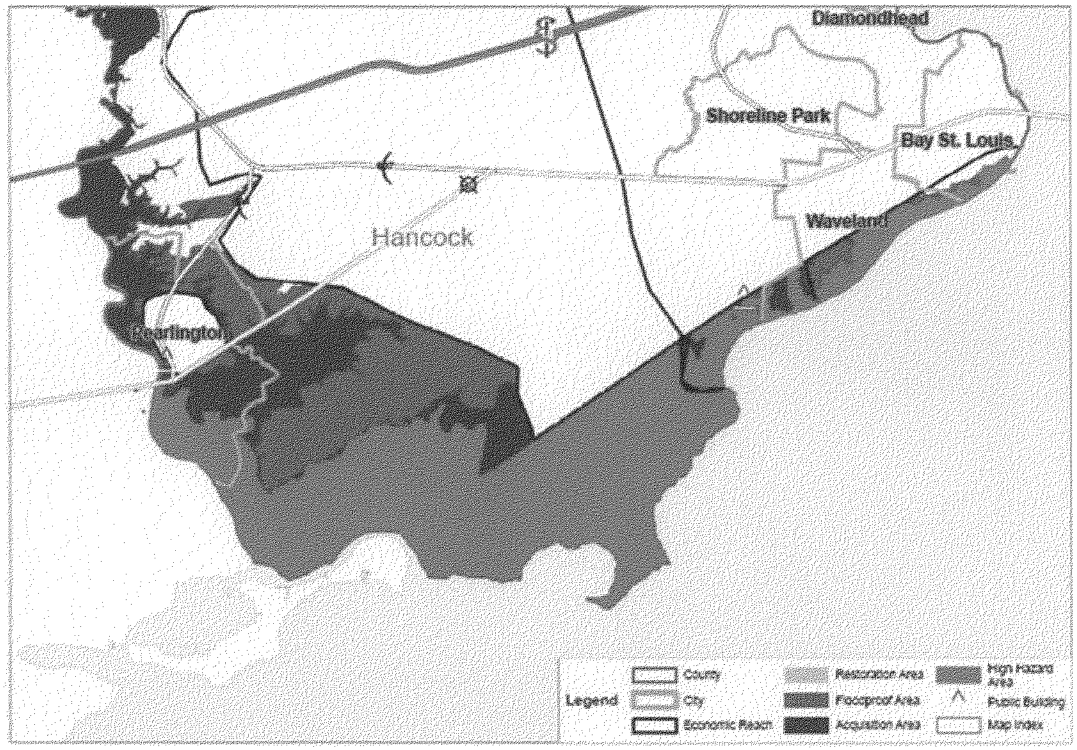


Figure 3
High Hazard Zone in Harrison County

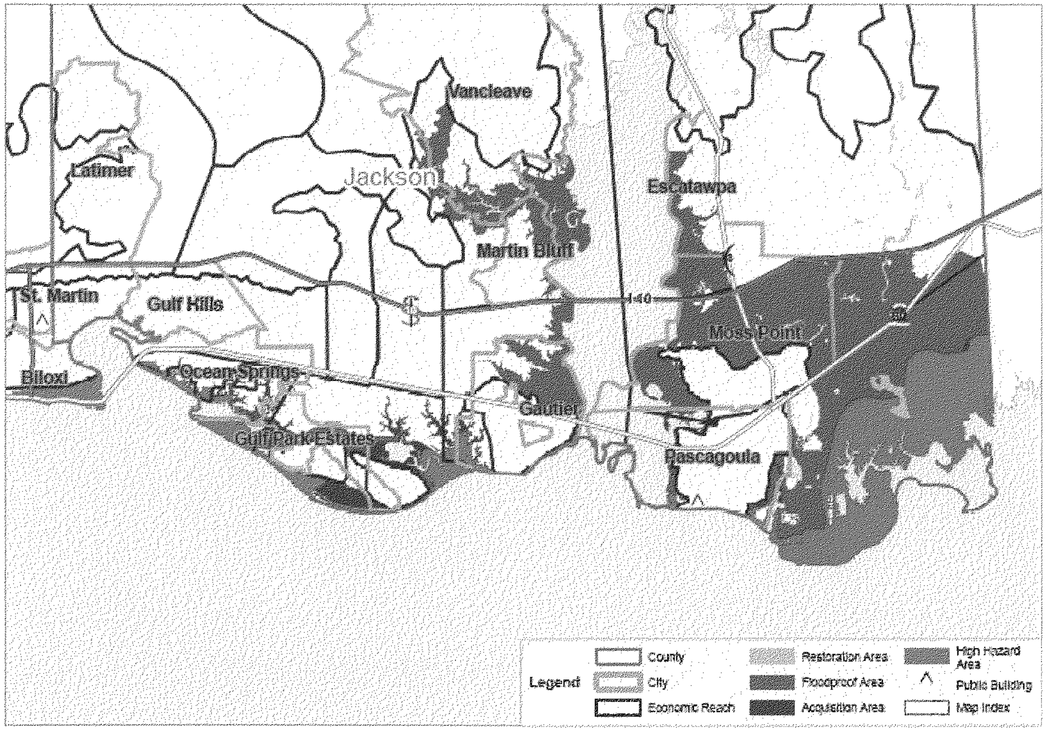
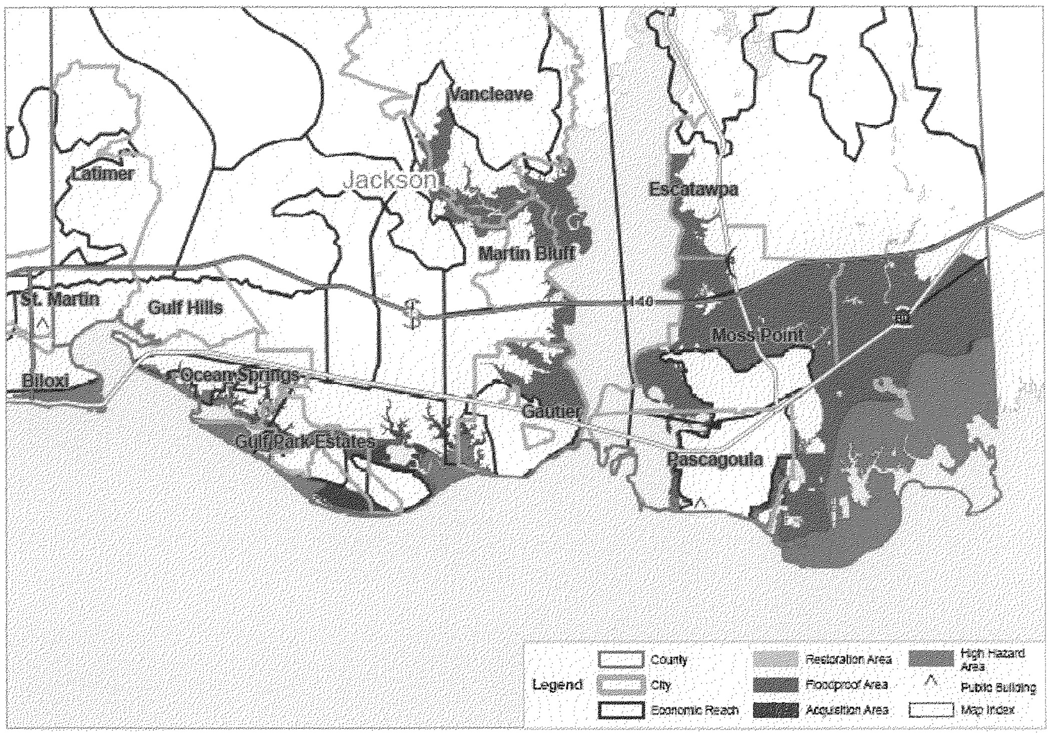
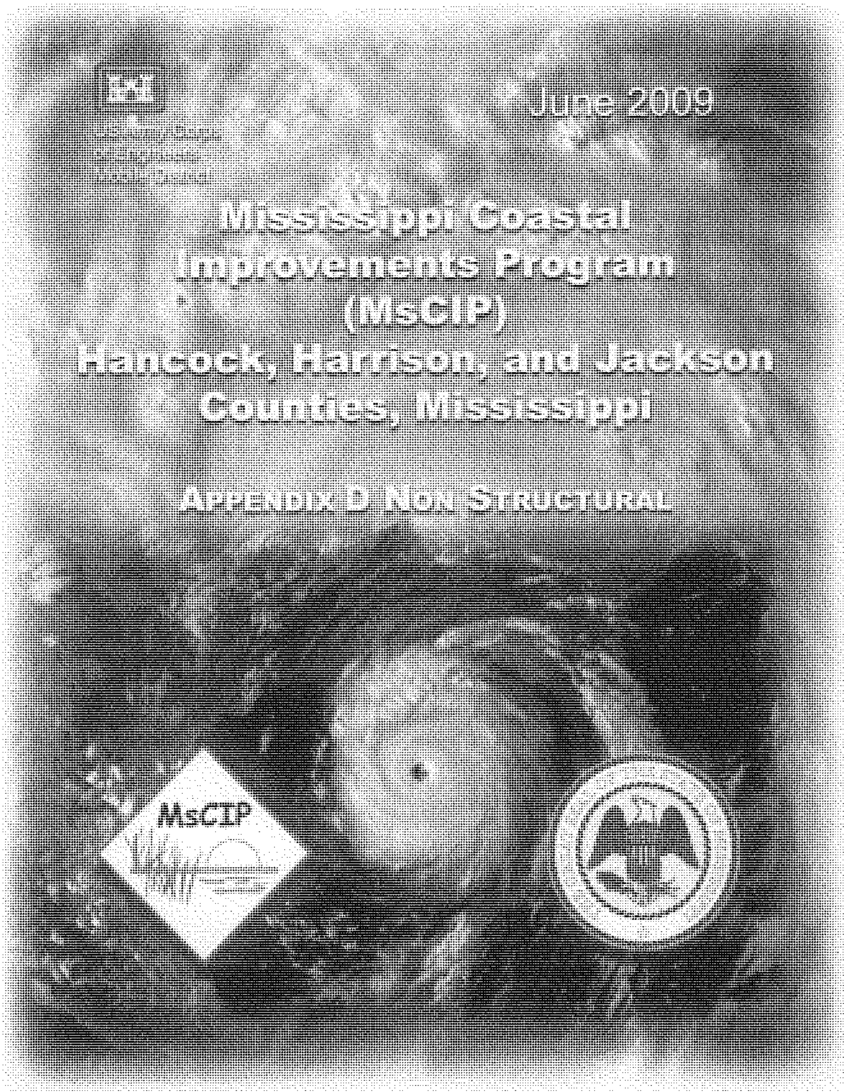


Figure 4
High Hazard Zone in Jackson County

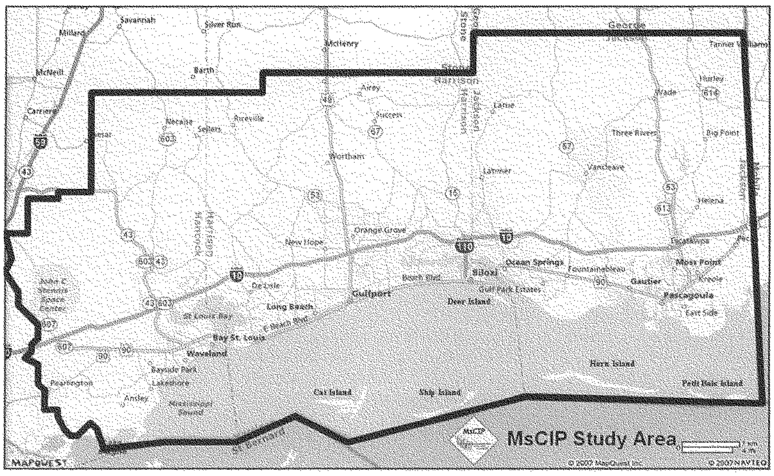



June 2009
Mississippi Coastal
Improvements Program
(MsCIP)
Hancock, Harrison, and Jackson
Counties, Mississippi
APPENDIX D NON STRUCTURAL
MsCIP

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 that 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.

This appendix, the Main Report/EIS, and all other appendices and supporting documentation, were subject to Agency Technical Review (ATR) and an Independent External Peer Review (IEPR). 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.

The report presents background on the counties that comprise the Mississippi coastline most severely impacted by the Hurricanes of 2005, their pre-hurricane conditions, a summary of the effects of the 2005 hurricane season, 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.

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, currently presented as recommendations contained in the Main Report/EIS.

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.

Nonstructural measures are proven methods and techniques for reducing flood damages and loss of life in floodplain and coastal areas threatened by storms and hurricanes. Tens of thousands of structures throughout the coastal fringes of the United States have been protected using nonstructural measures found to be effective in preventing damages, cost effective when compared to other measures and acceptable to the general public. Nonstructural measures can be used as a stand-alone program to create disaster-resilient communities.

Prior to full implementation of the proposed comprehensive nonstructural plans discussed herein, more detailed project implementation plans would need to be prepared in close collaboration with the counties, municipalities, the state and Federal agencies for the project area. In a nonstructural program that spans multiple jurisdictions there could be imbalances in tax revenues as displaced landowners relocate to nearby communities coupled with disparities in public service capacities and unbalanced school enrollments. Agreements between jurisdictions concerning lost/gained tax revenues and adjusted public service areas as well as school enrollment adjustments must be considered before initiating a full-scale nonstructural project. In addition, recent changes in the flood insurance rate maps, establishment of new base flood elevations and enlargement of the V-zone by FEMA would necessitate adjustments of the designated hazard zones where certain measures have been specified in this Appendix. All of these ongoing changes would need to be incorporated into more detailed project implementation reports to better estimate project costs and to identify any significant changes in socioeconomic impacts prior to implementation.

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FIGURES

TABLES

EXECUTIVE SUMMARY

The Mississippi Coastal Improvement Project area contains over 70,000 parcels of property of which a high percentage were, prior to Katrina, occupied by structures. Many of those parcels are now vacated with only slab foundations and FEMA temporary trailers remaining to show where households and businesses once stood. Redevelopment of the project area has been limited due to legal and financial issues with respect to floodplain regulatory determinations and flood insurance payments. Once these issues are resolved, redevelopment of the interspersed vacant parcels may accelerate at a feverish pace. The future-without project scenarios of the comprehensive plan contemplate full redevelopment (residential or residential & commercial mix) of the project area by the year 2012 as described in more detail in the Economics Appendix.

The nonstructural PDT, using data from the USACE Mobile District, FEMA, NOAA, county assessor's offices and local sources has formulated nonstructural measures that, working either independently of structural measures or in concert with them, provide substantial reductions in flood damages. Many uncertainties remain in the nonstructural formulation because of the lack of complete structure-specific data. More in-depth planning in collaboration with the counties and municipalities is needed to address the uncertainties regarding the cost efficiency and effectiveness of the nonstructural measures as well as potential mitigative measures needed to offset unavoidable social and economic impacts.

The primary measures identified for the project area include permanent acquisitions, floodproofing by elevation and other means, replacement of public buildings, flood preparedness and evacuation planning, public education, changes in the current municipal and county NFIP and building codes, a transfer of development rights or purchase of development rights program, changes in land use zoning, development impact fees, and redirection of new development. These measures have been combined into 8 separate plans that can be implemented by either agencies of the Federal government or collaboratively by those agencies and state, county and local governmental units. Only local jurisdictions can implement some of the measures identified in the plans through local police powers.

Seven of the 8 nonstructural plans formulated in the following pages are based upon the Advisory Base Flood Elevation (ABFE), in accordance with currently amended local ordinances, to generate comparison of project costs and benefits. The eighth plan (NSC-6) is a combination of structural and nonstructural measures evaluated through the ABFE, 20 feet, 30 feet and 40 feet levels of inundation for ringwalls and ring-levees at certain communities and the LOD 4 structural project. Total nonstructural plan costs range between $6.1 billion for acquisitions of high-hazard properties alone and $19.1B for a full range of nonstructural measures such as permanent acquisitions, floodproofing, replacements of public buildings, NFIP and building code upgrades, and use of TDR or PDR programs.

Due to the iterative nature of the planning process, LOD 4 was screened out after the Nonstructural Appendix was completed. This measure was screened out due to the high maintenance cost of the associated surge gates, which was beyond the financial capability of the local sponsor. Therefore, the discussions associated with LOD 4 in the combined structural and nonstructural plans (NSC-6d through NSC-6g) within this Appendix should be viewed only as a reference. The combined structural and nonstructural alternatives that include ring-levees and ringwalls with nonstructural measures and that are labeled as NSC-6 through NSC-6c are still valid alternatives.

Comparison of the 8 plans using metrics such as total plan cost, cost per parcel protected, AAD prevented, effectiveness, sustainability, public safety and environmental quality reveals that several nonstructural plans provide substantial benefits (including substantial non-monetary benefits or benefits for which monetary measures have yet to be defined in the plan) to the project area. Due to the lack of detailed information for the project study area, several metrics were not commensurable among the plans at this time. Despite this quantification issue, significant qualitative improvements in public safety, environmental quality, potential long-term growth, community disaster-resilience and future damage reduction point to the overall effectiveness of the nonstructural plans.

A planned feature is the High Hazard Area Risk Reduction Plan (HARP) that provides for purchase of properties located in the high-hazard zone of the three coastal counties of Mississippi. Acquisition would be in accordance with the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970, Public Law 91-646, as amended, and would be implemented initially for 2,000 parcels .

In addition to the proposed HARP, the plan includes two additional projects: one for elevation of 25 residential structures in Waveland, MS in accordance with recent FEMA floodproofing guidelines and another for replacement of 4 municipal structures located within the high-hazard zone in Moss Point, MS as a method of reducing inundation damages. Each of these two early projects would enable testing of key processes and design techniques aimed at reducing flood damages and preventing future loss of life and essential public emergency services during hurricane events. More detailed plans for these projects would be prepared and submitted for approval at Division level prior to implementation.

CHAPTER 1. INTRODUCTION

Coastal areas of the United States are home to a substantial portion of the total population of our nation. Data published by NOAA in 2003 ("Population Trends Along the Coastal United States – 1980 to 2008") indicated that at least 153 million Americans live within the 673 coastal counties bordering the nation – a land area accounting for only about 17% of the nation's total land surface. This segment of the nation represents 53 percent of the total national population living and working in a continent-sized linear pattern that is subject to frequent and damaging storm events. One of those growing coastal areas has been the Gulf Coast in Mississippi.

Although coastal areas of the nation are attractive to commercial, industrial and residential developers, the consequences (as evidenced by Katrina, Rita, Ike and past hurricanes) associated with locating damageable property and unwary residents along the Gulf coast can be extreme. Despite years of regulation through the Federal Emergency Management Agency (FEMA) and other coastal zone management techniques, damageable property still remains in high-hazard areas and people still drown during surge and coastal flooding from hurricanes. Nonstructural measures can be formulated that reduce the flooding risks along the Gulf Coast, but nonstructural measures can also result in impacts to the social and economic fabric of the communities to which they are applied.

In recognition of the potential social and economic impacts of a nonstructural project, citizens of the project area have already voiced their concerns during public meetings about the affects of certain nonstructural measures upon property values for those who may not participate in the project should it be authorized and funded. In addition, there are concerns that the loss of local tax revenues through permanent acquisitions and relocation may financially cripple several of the smaller beachfront communities. Each of these concerns has merit in the planning process and will need to be addressed as more detailed planning proceeds for the implementation of the plans described in this appendix.

Collaborative planning among Federal agencies, the state, counties and municipal jurisdictions will be paramount for successful implementation of the nonstructural plans described in the following chapters. Meaningful and continuous public involvement and consensus building will also be key components of a successful nonstructural program. Few other types of flood damage reduction measures are as personal as are the nonstructural measures and resolving property and land use issues with landowners and municipal and county officials would be challenging.

As a nation we must identify strategies and measures that can be used in tandem to both discourage development in high-risk areas and encourage growth in less hazardous areas of the coastline. Some strategies and measures may be more appropriate for Federal action while others will be more attuned to local regulatory action and administration. In either case, these measures must be effective, socially acceptable, environmentally suitable and mindful of the existing neighborhood and community social and economic systems within which they would be implemented.

CHAPTER 2. NONSTRUCTURAL FLOOD DAMAGE REDUCTION

2.0 Gulf Coast Development.

According to a NOAA report published in 2003 ("Population Trends Along the Coastal United States – 1980 to 2008"), coastal population within the Gulf Coast region was projected to increase between 10 and 15 percent by 2008. Despite the damaging effects of Katrina, Rita and Wilma in 2005, areas of the gulf coast continue to grow in population and shoreline development. Some areas affected by Katrina in the project area have begun to rebound in large measure due to the reopening and success of the major employers and tourist attractions along the coast. Over 1,600 building permits for new single-family home construction were recorded within the 11 communities in the project area in 2006 (City-data.com).

In addition to the permanent households and commercial businesses that live and work along the Gulf Coast, millions of seasonal tourists visit these same coastal areas giving rise to the boom in vacation rental units, condominiums, second homes, and motels and hotels that populate the Gulf region. Tourist's primal attraction to the Gulf coast also feeds development of a plethora of amusement and recreation related uses that congregate on various boardwalks and beachfront property adding to the potential for high damages. Added to this burgeoning of development along the coast is the presence of millions of transient tourists who may be largely unaware of the threat that hurricanes and storms present to them.

2.1 Nonstructural Measures

Flood damage reduction measures are divided into two distinct components: structural and nonstructural. Structural measures in coastal areas usually concentrate on resisting the surge and wave action of storms and hurricanes. Off-shore and onshore barriers, seawalls, levees, flood gates, pumping systems and other structural measures can provide high levels of protection to coastal development. In-place development (residential, commercial, industrial, and institutional uses) is largely untouched during implementation of structural measures with the exception of acquisitions within the construction footprint of the project features. Much has been written about the positive benefits and negative impacts of structural measures along the nation's coastlines. Generally speaking, structural components have performed successfully during storms and hurricanes, but failures can and do occur when the design parameters of either structural or nonstructural components of a protection system are exceeded by extreme storm events.

Application of nonstructural measures or those measures directly associated with modifying the location, construction or operation of property, structures, and facilities located in hazard areas is one method of reducing storm/hurricane-related damages and saving lives that are at-risk. Nonstructural measures can be applied to both coastal and riverine hydrologic systems and have been proven to be affective in reducing damages and saving lives. Where nonstructural measures have been successfully instituted by local governments through floodplain management or other land regulation processes, the benefits and impacts of the protection process have been largely unreported. This lack of notoriety is due in part to the unit-by-unit or lot-by-lot system of protection (not very newsworthy), the relatively low cost when compared to other protection methods and the lack of massive mobilization of political or financial resources to accomplish these low-tech solutions.

Actions to either modify or remove development from at-risk areas to reduce damages can be applied in two general ways: first is to take direct actions towards the at-risk building or facility so as to modify its structural characteristics or location such that damages are reduced, and second is the application of incentives and disincentives through regulatory or economic processes that cause landowners to re-evaluate the costs and benefits of living in a hazardous location more carefully. Many existing regulatory and land valuation techniques exist that can influence individuals' choice of a building location. All of these techniques need to be considered. Nonstructural measures can be divided into several general categories including:

- Flood Preparedness
    - Hurricane/Storm identification, tracking and early warning
    - Temporary emergency evacuation and sheltering
- Modification of structures, facilities and/or the property on which they are located (a.k.a. floodproofing)
- Building construction regulations (building codes)
- Land use regulation by zoning that affects the type and location of land uses
- Floodplain management regulation, hazards zoning and insurance systems (NFIP/CRS)
- Property taxation, special development assessments and development fees
- Transfer of Development Rights and Purchase of Development Rights (TDR/PDR)
- Permanent evacuation of the hazard areas (permanent acquisition and relocation)
- Replacement of public structures and critical facilities

Each of these general categories of nonstructural measures can be applied as single measures or can be applied in combination with one another or with structural measures to address storm damages and loss of life. The range of benefits, costs and residual damages associated with application of each measure is broad. The extent and severity of social and economic impacts associated with the various measures can be likewise broad and must be identified for any plan. Depending upon the nonstructural measures selected for application and the relative percentage of each applied to the planning area, the future land use pattern of the area could be vastly different than that which existed prior to Katrina's landfall.

Finally, the ability of nonstructural measures to be implemented in very small increments, each increment producing flood damage reduction benefits (structure-by-structure), and the ability to initiate and close a nonstructural program with relatively minimal costs are important characteristic of this form of flood damage reduction. Also important is the ability to "tier" measures over long periods of project time such that a layering of measures, each one providing a higher degree of protection, is possible and given both Federal and non-Federal funding constraints probable. In order to affectively implement multiple layers of nonstructural protection within such a large project area, several tiers applied incrementally may be required before complete protection would be realized. The use of "tiering" will be discussed in more detail during plan formulation.

The following chapters will discuss the various nonstructural measures, program eligibility, nonstructural criteria, nonstructural formulation concepts and the applicability of these various measures in several alternative plans to the MsCIP project area.

CHAPTER 3. PROJECT AREA CHARACTERISTICS

3.1 General Description

The MsCIP project area consists of the Mississippi coast from the western border with Louisiana defined by the Pearl River to the eastern border with Alabama generally defined by Middle Bay. Figure 1 shows the distribution of the 11 municipal areas within the project area and several of the major connecting highways. The area is politically divided into three county governments (Jackson, Harrison and Hancock) and at least 11 municipalities. Three of the eleven municipal areas are grouped into two Metropolitan Statistical Areas (MSA). Prior to the arrival of Katrina in August 2005, the area boasted a population of over 220,000 persons. That population decreased dramatically as a result of Katrina, but is making a come back as local employment increases and the housing market slowly recovers.

Figure 1. Gulf Coast Communities (MRF graphic)

This 75 mile long coast has numerous physical features that make it a prime development location including three main inlets at Bay St Louis, Biloxi and Pascagoula, productive estuaries and wetlands, extensive beaches with flat to moderate topography adjacent to the beach area, and several off-shore barrier islands. The beaches draw millions of tourists each year to this Gulf paradise. The entertainment industry in the form of casinos and tourists attractions has spurred much growth along the beachfront areas. Numerous industries, some directly tied to the Gulf waters, populate the project area and several military and Federal Government-related complexes are dotted across the landscape providing employment and revenues to the local economy.

Several major transportation routes cross through the area including Interstate 10, Route 90 and the CSX railway line each running east-west across the area. The majority of the cultural development is concentrated south of Interstate 10 with agricultural and forested lands mainly north of Interstate 10. Each of the three major embayments associated with tributary rivers has extensive wetland areas associated with them.

3.2 Topography

Among the many characteristics of the project area that directly affect formulation of nonstructural measures, the surface elevation of the landscape with respect to the elevation of the Gulf waters is of paramount importance. Since nonstructural measures generally affect each parcel of property and each structure and facility, the ground elevation at each specific structure location is an important aspect of plan formulation. In the case of the Gulf coast, most structures are constructed on slab foundations therefore the ground surface elevation generally reflects the first floor elevation of the structure as well. For the purposes of data collection and analysis the project area was divided into 54 reaches. Using available GIS information and topographic data layers, the elevation of each tax parcel within the 54 reaches was determined. Table 1 shows the average elevation (NAVD 88) of the identified parcels (geographic center-point of each parcel) within each of the 54 reaches with respect to the Gulf surface elevation. Figure 2 is a graded-color representation of the elevations of the 54 reaches with respect to the Gulf surface. The color differences indicate the relative risks of surge inundation in the reaches. More detailed maps of the project area showing this elevation difference with respect to the Gulf waters are included at the end of this Appendix (See Figures 139 to 143).

Table 1.
Average Land Elevation by Reaches

Reach Number	Elevation	Reach Number	Elevation	Reach Number	Elevation	Reach Number	Elevation	Reach Number	Elevation
1	9.65	12	12.36	23	10.54	34	NP	45	NP
2	11.00	13	16.75	24	10.77	35	7.59	46	15.62
3	13.66	14	17.54	25	12.23	36	10.04	47	15.97
4	5.98	15	16.70	26	10.77	37	17.59	48	15.57
5	5.77	16	13.75	27	11.07	38	15.79	49	15.62
6	8.82	17	NP	28	9.47	39	15.74	50	12.47
7	12.05	18	13.60	29	11.70	40	15.45	51	9.58
8	8.81	19	6.21	30	12.20	41	12.04	52	10.29
9	8.32	20	11.99	31	8.60	42	NP	53	5.17
10	14.54	21	9.94	32	9.18	43	11.73	54	6.81
11	17.54	22	13.45	33	NP	44	NP		

NP – Due to the shape of the reach and parcels none of the identified parcel center-points fell within the reach

3.3 Urban and Community Development

3.3.1 Urban Development Patterns

As mentioned above, the project area is politically divided into11 municipalities contained within three counties. Three of the 11 municipal areas, Pascagoula, Gulfport and Biloxi form two Metropolitan Statistical Areas (MSA's) composed of Pascagoula (37700) and Gulfport/Biloxi (25060).

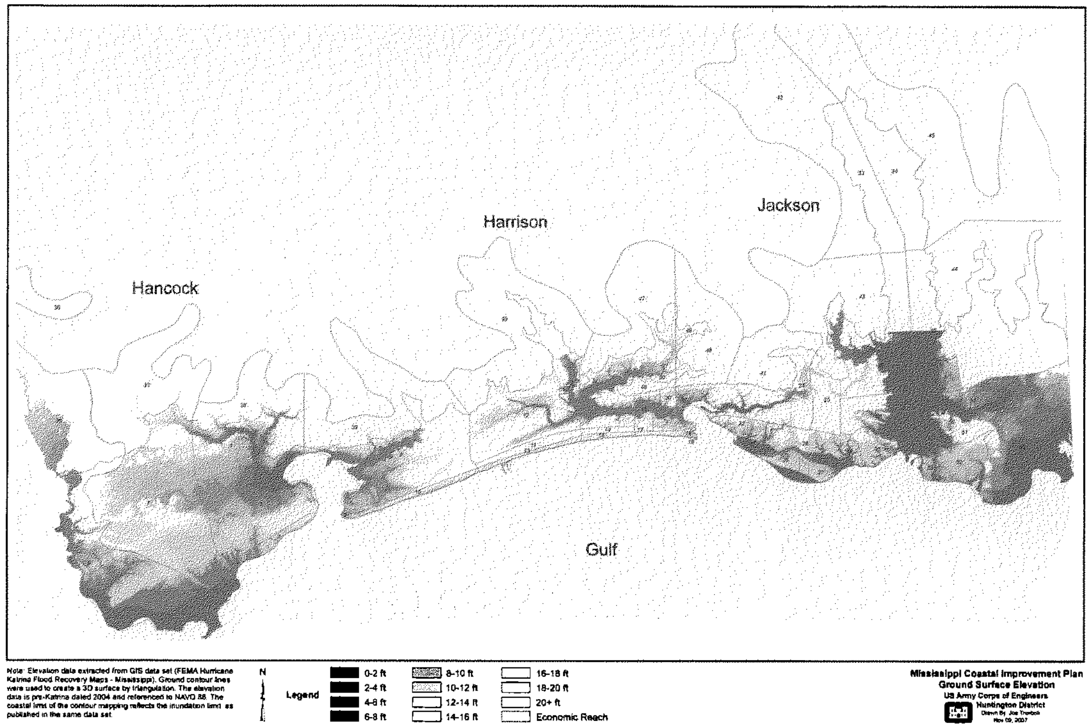


Figure 2. Land Surface Elevations of Economic Reaches w/Respect to the Gulf

MSA's are defined and redefined on a regular basis by OMB, but the basic designation of the MSA is based upon population size. MSA's combine both municipal and surrounding county populations for the purposes of Federal statistics collection. According to the 2000 Census the Pascagoula MSA had a population of 150,564 persons within its economic and social statistical area and the Gulfport/Biloxi MSA had a population of 246,190 persons within that same distinctive boundary.

That statistical designation carries weight when Federal funds are being distributed through social, infrastructure and national security programs. Figure 3 shows the MSA's of Pascagoula and Gulfport/Biloxi (dark green outlined in dark green border) and the 5 county areas included within their statistical boundaries (Picayune within Pearl River County is a separate micro statistical area not included within either the Pascagoula or Gulfport/Biloxi MSA's).

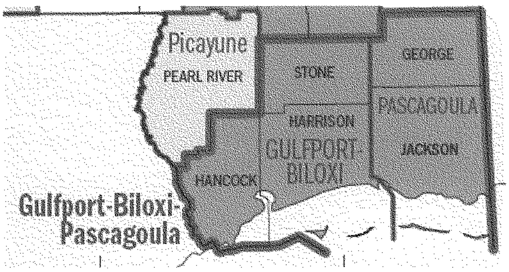


Figure 3. Metropolitan Statistical Areas within the Project Area

These more urbanized communities exhibit relatively large centers of commercial activity and a government core as well as a traditional grid-pattern street layout. All three have older central business districts that have been diminished somewhat by sprawl development that has aligned itself with adjacent transportation corridors (Route 90 and Interstate 10).

The development patterns of the 11 municipal areas are all unique to their location and topography, but most have a defined business/commercial and government center with surrounding various densities of housing and other land uses. Gulfport, Biloxi and Pascagoula have well-defined centers that are conducive to walking and transit services. Primary north-south access corridors from both Gulfport and Biloxi have resulted in a "sprawl" pattern of development emanating from those two centers.

These sprawl corridors have resulted in linear development patterns aligned with the highways. Other communities such as Bay St. Louis, Long Beach, and Ocean Springs have much smaller town centers near the beachfront and conform to a grid-pattern with less apparent sprawl. In some cases, the growing commercial districts of these municipal areas have located away from the beachfront and have aligned with Route 90 and other intersecting highways. Many of the tourist-centered commercial developments (hotels, motels, entertainment areas) migrated to the beachfront highways putting all of them in high-risk locations.

In addition to these older town centers, many of the Interstate 10 intersections bordering the project area have begun to sprout with hotels/motels, service stations, outlet stores and restaurants creating several new centers that attract travelers and offer some competition with the beachfront town centers. Several of the commercial areas near the interchanges have been annexed into the older beachfront municipal areas like Gulfport. Massive residential subdivisions (see below) have sprung up at the interstate intersections creating more flood-safe housing out of the reach of most hurricane surge events. This recent trend in residential development (north of Interstate10) bodes well for what may have to be a long-term strategy to address future hurricane damages while maintaining the robust economic vitality of the region. Should predictions regarding sea level rise (as described in the future without-project condition scenarios) come to fruition, migration away from the beachfront to higher elevations may be an absolute necessity.

3.3.2 Community Development Patterns

There are several planned development communities (i.e. Diamondhead) in the project area that feature upscale housing and recreation amenities as well as several "golf-course communities" and at least one "fly-in" community within the project area. In contrast to the older grid-pattern urban centers, these newer subdivisions, gated communities and planned unit developments display a more curvilinear pattern with multiple cul-de-sacs and looping streets. These newer community structures are more vehicle-oriented. Additionally, there are several major military or military-related facilities in the project area around which some growth (where allowed) has occurred. These relatively stable employment centers provide a boost to the local economy and an injection of highly-talented people that provide leadership and human resources to local service organizations.

There are several industries and commercial establishments that are more attached to the waterfront than other community land uses. The casino complexes and water-related industries (Ingalls, Chevron, etc.) are required either by law or by function to be at the land-water interface and must remain in that location in order to function. By law the casinos are restricted to an 800 feet wide band along the waterfront, a location which places them in harm's way of hurricane surge, waves and winds. Major industrial employers such as Ingalls Ship Building and the Chevron Company must have facilities at the water's edge in order to either construct vessels or maintain oil platforms. Although these locations are highly hazardous, the continued presence of these major employers in the community is of paramount importance to the social and economic health of the project area.

Both Biloxi and Gulfport have substantial central business districts immediately at beachfront locations. Both of these centers as well as Pascagoula have high densities of commercial, business and residential uses with numerous recognizable neighborhoods. Within the counties there are numerous well-defined neighborhoods (many are named) and a few isolated and unincorporated communities scattered out in the estuaries. The amenities of the Gulf Coast have attracted many hundreds of vacation and second home developments contained in grid-street patterns built upon fills adjacent to the estuaries. Several of these subdivisions have a very low density of housing compared to what would be expected given the grid-street pattern. In contrast to the many upscale vacation housing developments, there are several "fishing-based" communities (i.e. Ansley) nestled into the estuary areas that also are subject to flooding.

3.3.3 Critical Facilities

As with any normal-functioning community, there are a plethora of buildings and facilities that could be classified as "critical facilities" within the project area. Included in this category of facilities are fire stations, police stations, emergency response/management facilities, hospitals, schools, medical clinics, transportation facilities, utilities, and public administrative buildings. All of these facilities, besides being a daily necessity to community life are very critical to the safety and protection of citizens during and after emergencies. Their location with respect to their service areas and inundation limits from storms and hurricanes is of paramount importance in the formulation process.

Both community colleges and state post-secondary educational facilities are located within the project area as well. A large number of churches of many faiths are scattered among the communities and have provided physical and spiritual support to their congregations and others following Katrina. Much of the rebuilding occurring in the project area is occurring through the work of missions from allied denominations. The usual mixture of social services (welfare, children, clinics, etc.) and public services (utilities, solid waste, communications) account for numerous buildings and facilities throughout the project area – many of which are subject to inundation damages.

3.3.4 Non-Project Communities

In addition to the 11 communities included in the project area, there are numerous villages and unincorporated communities located just north of the I-10 corridor that serve as "bedroom communities" for the thousands of employees that support the tourism industry and commercial businesses along the coast. Few of these communities suffered from inundation damages due to Katrina, but damages to homes and businesses due to wind and rain were significant there as well. Although these communities may not be directly affected by the measures being formulated for the defined project area, they may be affected indirectly by certain measures such as relocations of residents along the coast through a large permanent acquisition program. A more in-depth look at these adjacent communities is included in Section 4.5.9.9.2 and Table 10 of this Appendix.

3.3.5 Historic Districts

A search of the National Park Service database for National Historic Districts identified 18 Historic Districts within the project area (see Table 2). These historic districts are located within the 11 communities discussed above. A Historic District in the United States is defined as a group of buildings, properties or sites that have been designated by one of several entities on different levels as historically or architecturally significant. Buildings, structures, objects and sites within a historic district are normally divided into two categories, contributing and non-contributing. Districts greatly vary in size, some having hundreds of structures while others have just a few significant structures.

Table 2.
Historic Districts on the National Registry

District Name	Community	County
Front Street Historic District	Pascagoula	Jackson
Krebsville Historic District	Pascagoula	Jackson
Orange Avenue Historic District	Pascagoula	Jackson
Indian Springs Historic District	Ocean Springs	Jackson
Lovers lane Historic District	Ocean Springs	Jackson
Marble Springs Historic District	Ocean Springs	Jackson
Old Ocean Springs Historic District	Ocean Springs	Jackson
Shearwater Historic District	Ocean Springs	Jackson
Sullivan-Charnley Historic District	Ocean Springs	Jackson
Biloxi Downtown Historic District	Biloxi	Harrison
Harbor Square Historic District	Gulfport	Harrison
Scenic Drive Historic District	Pass Christian	Harrison
West Beach Historic District	Biloxi	Harrison
West Central Historic District	Biloxi	Harrison
Beach Blvd Historic District	Bay St. Louis	Hancock
Main Street Historic District	Bay St. Louis	Hancock
Sycamore Street Historic District	Bay St. Louis	Hancock
Washington Street Historic District	Bay St. Louis	Hancock

Source: National Park Service Registry data

Some districts cover one or more city blocks while others contain entire neighborhoods or a defined geographic area. The 18 districts identified in Table 2 are listed in the Federal Registry. Other state and local entities may have identified other Historic Districts on the local level that are not included in the NPS database. Those locally significant districts will be identified in coordination with local organizations during more detailed planning of the nonstructural features.

A number of these historic districts are located in the inundation zones most damaged by Katrina and many of the significant structures contained within the districts have been severely damaged by that event. Efforts are currently underway to stabilize (Pilot Stabilization Program) some of the significant historic structures within the project area, some of these structures are included in the designated districts. Should nonstructural measures be formulated that would impact one or more of the Federally-designated historic districts, extensive coordination with the National Park State and the state historic preservation office (SHPO) would be required as part of the NEPA process. Measures that modify buildings or structures within the district to reduce damages (floodproofing) may be considered so long as the architectural or historical character of the structure is not significantly diminished. Options that would relocate large numbers of structures or the entire district to reduce damages would be more problematic.

3.4 Housing Resources

3.4.1 General

Residential units represent a substantial proportion of the total structure categories damaged by hurricane and storm flooding. Because of their relatively light construction (wood frame or masonry over wood frame), residential structures cannot withstand the rigors of hurricane force winds, surge and waves without attention to newer building codes (post-hurricane Andrew). Due to the preponderance of these structure types in the project area and their tendency to be located in high-hazard areas, damages to this category are significant in a major hurricane. More than 60,000 residential units were destroyed by Katrina's fury within the project area (Governor's Commission Report 2005).

As described above, the project area is composed of numerous communities and neighborhoods each having their own personality and character that visually and socially separates them from one another. One of the distinguishing features that separate communities and neighborhoods is the type, quality, quantity, density and age of the housing stock. The project area has a very diverse mixture of older classic-style residences, seasonal vacation cottages, upscale "mini-mansions" and various types of condominiums, townhouses and row-house resources. The more vernacular architectural types are located in the residential neighborhoods of the older urban areas but newer versions of those local architectural styles (i.e. Acadian-Creole) are being constructed in several areas of the project; some even floodproofed by elevation.

3.4.2 Housing Market and Stock Characteristics

Prior to the arrival of Katrina, the housing market in the project area was brisk with many single-family housing construction permits being issued in each of the communities. Table 3 shows the numbers of building permits that had been issued by each community for single-family home construction between 1996 and 2006.

As the table shows, the strong increases in population described in the Socio-Economic Characteristics Appendix during the past decade are reflected in the numbers of housing units being constructed. Of note are the large numbers of single-family residential units for which permits were issued in Ocean Springs, Biloxi and Gulfport during this period. In total, over 10,200 residential building permits were issued during this 11 year period. Considering that many of these new housing units may have been within the footprint of the regulatory extent of the Base Flood Elevation (National Flood Insurance Program) and constructed so as to reduce flood damages through the local ordinances, the arrival of Katrina (a much greater depth of inundation) probably affected many of these more recent residential structures.

Table 3.
Building Permits Issued for Single-Family Home Construction by Community

Years	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Community											
Pascagoula	22	9	15	30	21	12	7	13	16	30	191
Moss Point	10	16	11	22	19	32	15	28	26	29	28
Gautier	45	54	71	84	55	46	71	95	109	68	145
Ocean Springs	78	79	88	130	121	129	139	152	163	75	87
Biloxi	93	NA	NA	151	139	135	NA	224	NA	120	186
D'Iberville	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Gulfport	264	265	301	406	346	271	307	291	336	228	484
Long Beach	86	68	63	116	66	76	80	82	87	62	99
Pass Christian	50	40	47	74	100	102	65	68	74	59	237
Bay St. Louis	23	34	34	39	37	37	42	45	45	0	0
Waveland	30	46	49	55	68	47	75	120	88	73	192
Total by year	**701**	**611**	**679**	**1107**	**972**	**887**	**801**	**1118**	**944**	**744**	**1649**

Source: City-Data.com NA = Data not available

This consistent rate of residential construction was not abated in 2007. Through June 2007, approximately 1,938 single-family construction permits were issued in the 11 communities and three counties. For communities that appear to be heavily developed already, this level of new residential construction indicates a very healthy and lucrative market for housing construction, mortgage financing and housing contractors in the area. Table 3 does not include building permits issued for multi-family units or condominiums, but field observations of substantial numbers of relatively new multi-family units by the team indicates a strong market in this type of residential construction as well. US Census data indicates that in 2007 (through June) multi-family building permits were issued resulting in construction of over 1,900 new units in the project area.

The 2000 Census data indicates that the average housing stock age across the project area is relatively young. Table 4 shows the relative ages of structures constructed across the project area. Despite the relatively young age of the housing, data indicates that over 6,000 structures still existed in 2000 within the project area that were built between 1900 and 1939. Built long before the use of modern building codes or floodplain management ordinances, these structures remain susceptible to flood and wind damages. Of note is the number of residential structures built during the period between 1970 and the present. Since the communities in the project area (with the exception of D'Iberville) all entered the NFIP in the early 1970's (See Table 7 on Page 44), many homes constructed in this period were subject to the provisions of the initial floodplain management ordinances. Since the year that the initial Flood Insurance Rate Maps (FIRM's) were identified, over 55,000 residential structures have been constructed in the project area.

Table 4.
Housing Unit Ages (2000-1900)

Years	200-99	98-95	94-90	89-80	79-70	69-60	59-50	49-40	39-00
Community									
Pascagoula	47	129	267	874	3094	3161	1641	1022	707
Moss Point	35	68	87	414	1493	2024	1106	607	435
Gautier	81	344	274	995	2150	652	87	28	34
Ocean Springs	263	576	360	1065	2256	1529	597	134	312
Biloxi	613	1742	1550	3253	4734	3535	3433	1823	1464
D'Iberville	294	382	232	411	851	369	337	119	74
Gulfport	542	2362	1819	4455	7507	6174	3303	1782	1649
Long Beach	185	813	297	1317	1831	1939	506	189	218
Pass Christian	96	425	167	419	682	698	333	162	331
Bay St. Louis	90	236	130	576	687	608	451	258	770
Waveland	71	287	170	751	632	713	366	202	290
Totals	**2317**	**7364**	**5353**	**14530**	**25917**	**21402**	**12160**	**6326**	**6284**

Source: 2000 US Census (Compiled by City-data.com)

Residential densities range from 1 unit per several acres to 10-20 units per acre in more urban settings. Table 5 shows the densities of housing units (single-family and condominiums) in each of the 11 communities and the relative sizes of the communities in square miles. According to the Governor's Commission on Recovery, Rebuilding and Renewal (2005), more than 134,000 homes were damaged by Katrina and at least 65,000 homes were completely destroyed by the storm. Another 50,000 had flood damages and only 35,000 of those homeowners had flood insurance. The 2000 Census indicates over 152,000 dwelling units were located within the three county areas prior to the arrival of Katrina. Of those dwelling units, 136,000 were listed as full-time occupancy and 4,600 were listed as seasonal or vacation homes. Median housing values ranged from $80,300 to $92,500 prior to Katrina.

Table 5.
Residential Housing Densities (Units per Square Mile)

Community Name	Density per Square Mile	Land Area (square miles)
Pascagoula	721	15.2
Moss Point	251	25.0
Gautier	379	12.2
Ocean Springs	609	11.6
Biloxi	582	38.0
D'Iberville	647	4.74
Gulfport	520	56.9
Long Beach	722	10.1
Pass Christian	393	8.4
Bay St. Louis	622	6.12
Waveland	511	6.8

Source: City-data.com

3.4.3 Housing Styles and Patterns

According to the Pattern Book for Gulf Coast Neighborhoods (2005), a section of the Mississippi Renewal Forum report, there are several distinctive, residential architectural styles found in the project area. Those architectural styles include Acadian-Creole, Victorian, Classical, and Arts and Crafts. Most of these styles were constructed based upon pattern books popular prior to World War II. Within those 4 general architectural categories are building types such as side-hall or "shotguns", cottages, L-shaped, side gable, pyramid (reflects the roof profile), and townhouses (primarily in dense urban areas). These styles and building types are scattered across the entire project area within the denser urban areas (Biloxi, Pascagoula and Gulfport) as well as the more rural areas of Hancock County. More recent developments across the area reflect modern housing styles such as the one-level "ranch", split-level, and modifications of several classical styles (Georgian, Tudor, and Greek Revival). Nonstructural measures that directly modify the building construction or add structures in close proximity to the building should be aware of the sensitivity of theses types and styles.

As described above, housing is distributed across the project area in a number of interesting development patterns. Urban housing (townhouses) is associated directly with central business districts like Biloxi and Gulfport and is arranged in distinctive and named neighborhoods emanating from the municipal center. Other concentrations of housing occur along linear streets extending from the beachfront to the CSX railway corridor from Biloxi to Pass Christian in Harrison County and in numerous neighborhoods scattered along the back bays. Much of the older housing in Hancock County is concentrated in Waveland and Bay St. Louis between the CSX railway corridor and the beachfront. Many of these older units were devastated by Katrina. Newer subdivision developments are concentrated along Route 90 with the commercial development. Several outlying, isolated communities such as Ansley and Pearlington are located in western Hancock County and are also subject to flood damages. Housing development patterns in Jackson County range from grid-block urban layouts in Pascagoula and Moss Point to the outlying, low-density subdivisions of Belle Fontaine, Gulf Park Estates and the golf course development at St, Andrews.

There are a number of exclusive housing developments scattered throughout the project area. Many of these are associated with golf course developments, airfields, or other recreation facilities (marinas). Housing units within these upscale developments are mostly single-family detached units with some single-family attached condominiums as well. The character of the housing market shifts to a more rural farm style north of Interstate 10 with many large farms and large-lot zoning areas. Some new subdivisions associated with constructed lakes or other amenities are also located north of Interstate 10. Most of these areas were not affected directly by the Katrina surge inundation.

3.4.4 Alternative Living Quarters

Although not directly associated with the housing market, but equally important to formulation of nonstructural measures is the distribution of people living in quarters other than the traditional housing discussed above. Table 6 shows a snapshot of these alternative living arrangements within the project area for communities where census data was available. The 2000 Census lists a number of alternative housing situations for people living in the 11 communities within the project area. Among those alternative housing options are nursing homes, military barracks, correctional facilities, and centers for delinquent or disturbed children and adults, hospital wards for long-term chronic conditions, college dormitories, and non-institutional group quarters.

Table 6.
People Living in Alternative Living Quarters

Alternatives	Nursing Homes	Military Quarters	Correctional Facilities	Mental Health Centers	Hospital Wards	College Dorms	Other Quarters
Communities							
Pascagoula	120	827	257	30	8	0	22
Moss Point	126	NA	16	NA	NA	NA	NA
Gautier	NA	NA	NA	28	NA	NA	24
Ocean Springs	98	NA	4	NA	NA	NA	91
Biloxi	219	2587	NA	20	416	73	108
D'Iberville	NA	NA	NA	NA	NA	NA	NA
Gulfport	243	1137	1059	31	74	93	688
Long Beach	30	NA	NA	NA	161	NA	27
Pass Christian	197	NA	NA	NA	NA	NA	NA
Bay St. Louis	157	NA	133	9	NA	NA	26
Waveland	NA	NA	NA	17	NA	NA	7
Totals	**1190**	**4551**	**1469**	**135**	**659**	**166**	**993**

Source: City-data.com, (US Census 2000). NA = not available

Although the data is incomplete for many areas (many NA's) and types of alternative housing situations (these are not popular community marketing statistics), this data shows that over 9,000 persons, many with disabilities, may be living in specialized centers within the project area at any one time. During a hurricane or storm flood emergency that could affect one or more of these centers, evacuating this segment of the population would be at best problematic. As was evident in the evacuations of hospitals, nursing homes, correctional facilities and other specialized populations during Katrina and Rita in 2005, providing the necessary transportation, security and accommodations for these groups takes pre-planning and good coordination between the evacuated area, transportation providers and the shelters. Having sufficient warning time to evacuate these individuals is critical to reducing loss of life during extreme weather events. Although such evacuations have been successful (with some problems) in the past, other options to permanently relocate these less-fortunate or quartered individuals to less flood-prone areas should be considered in the nonstructural formulation.

3.4.5 Historic Homes and Buildings

A search of the National Register of Historic Buildings database for the 11 communities within the project area identified at least 114 structures, homes, schools, libraries, churches, theaters, hotels, public buildings, taverns, railroad depots, banks, fire stations, commercial and military buildings and sites. Many of these structures were damaged by Katrina and efforts are underway through a MS Pilot Stabilization Program to save the damaged historic structures. Table 37 in this Appendix shows a listing of these historic buildings and sites in the project area. Of those listed, only "Beauvoir" in Biloxi is considered a National Historic Landmark by the NPS. The "site" listings refer to archeological sites for which nonstructural protection measures would not be considered.

In addition to those structures listed or eligible for listing in the National Register, there are a number of structures considered by the State of Mississippi and local organizations to be significant to the region's history. Although not considered important enough to be listed nationally (some may be in that process currently), their importance from a state or local perspective warrants consideration in the nonstructural planning process. Coordination with the state and local organizations to determine the locations, flood-risks, and potential protection measures for these important structures will continue during more detailed planning for the nonstructural measures.

Although unconfirmed at this level of planning analysis, it is possible that a significant number of structures listed or eligible for listing on either the National Register or on state and local historical lists are located within inundation hazard zones where nonstructural protection options (wet or dry floodproofing) may be limited by wave action and surge depths. The numbers of historic structures being considered in the MS Pilot Stabilization Program indicates that many of these precious resources were damaged by Katrina. Floodproofing historic structures by elevation may be possible but maintaining the historic and architectural significance of a structure while raising the first floor 10 feet would be problematic. For obvious visual reasons dry floodproofing such a structure by constructing a ringwall or veneer wall around the building would be limited to a very low level of protection (4 feet or less). In areas where floodproofing would not be considered (high-hazard wave/surge zones), acquisition and relocation could be used to protect the building in another suitable location, but that option would require extensive coordination with the National Park Service and the SHPO. Replicating the building site so that the historic or architectural character of the building is not significantly diminished would be difficult.

Extensive coordination with the Mississippi SHPO and the National Park Service would be required during more detailed planning and engineering studies for implementation of nonstructural measures that would potentially affect structures or sites listed on the National Register.

3.5 Other Federal Disaster Assistance Programs in Coastal Mississippi

There are at least two other significant post-Katrina Federal programs currently operating within the communities of the project area. Both the Federal Emergency Management Agency (FEMA) and the United States Housing and Urban Development Administration (HUD) have ongoing programs within the project area that are designed to reduce future damages or to compensate landowners for damages.

3.5.1. FEMA Assistance Programs

FEMA has been operating several post-Katrina programs designed to compensate landowners for storm-related damages, reconstruct and repair damaged structures and reduce future flood damages and loss of life due to hurricane surge and other storm-related threats. FEMA administers the Individual Assistance Program (IAP), Public Assistance Program (PAP), Other than Housing Needs Assistance Program, Debris Removal Program, Temporary Housing Program and the Hazard Mitigation Grant Program within the project area. Each of these programs is administered locally by The Mississippi Emergency Management Agency (MEMA). Over 350,000 individuals and families have been helped by the assistance programs. Most of these grant programs cover losses or needs over and above any flood insurance payments that may be available to the landowner and the grants are provided tax-free.

The individual assistance program provides grant funds to individuals and families for temporary housing, and the repair, replacement or reconstruction of homes damaged by Katrina. Those repairs must be made in conformance with NFIP requirements according to the local floodplain management ordinances and the funds do not cover losses to second or vacation homes in the project area. This disaster assistance program is implemented under the Individuals and Households Program (IHP) and provides grant assistance for re-establishment of households in the affected areas.

Opportunities for applying flood damage mitigation measures to damaged homes are encouraged by FEMA administrators. However for those landowners without flood insurance, but receiving disaster assistance, the mitigation measures are optional except in those instances where a structure has been determined to be "substantially damaged" as defined by the NFIP. In these cases, a landowner must comply with the NFIP requirements of the local ordinances to elevate the structure regardless of whether or not the landowner has flood insurance. For those landowners with flood insurance, any structures that have been "substantially damaged" as defined by the NFIP would be required to comply with the elevation requirements of the local ordinances. In order to facilitate compliance with local ordinance provisions to elevate structures that have been substantially damaged, funds up to a maximum of $30K are available through the "Increased Cost of Compliance (ICC)" program (a part of the Standard Flood Insurance Policy coverage) to assist landowners in elevating their structures above the BFE. Additional long-term recovery funding can be provided through low-interest loans from the Small Business Administration.

As of April 2008, over 200,000 individuals and families have received Housing Assistance payments and over 130,000 have received Other Needs Assistance grants. Total payments to these two components of the FEMA assistance program have exceeded $1.2 billion. In addition, more than $2.8 billion has been obligated by FEMA in their Public Assistance program helping to reconstruct public buildings and facilities, utilities, roads and bridges and recreation facilities.

The Hazard Mitigation Grant Program is also being administered in the project area through the Mississippi Emergency Management Agency (MEMA). This program provides grant funds to address flood damages for structures and property that are subject to repetitive flooding or were damaged by Katrina and had been identified for acquisition in the state All-Hazards Mitigation Plan. Projects must show savings greater than costs. Some of the activities that can be implemented under the HMGP to protect either public or private property from future flood damages are:

1) Acquisition of property or relocation of buildings to convert the property to open space use

2) Retrofitting structures to minimize damages from high winds, flood, or other hazards

3) Elevation of flood prone structures (elevation under the HMGP is not permitted within the designated V-zone shown in the new published DFIRM)

4) Development and initial implementation of vegetative management programs

5) Minor flood control projects that do not duplicate the activities of other Federal agencies

6) Localized flood control projects, such as ring levees and floodwalls designed specifically to protect critical facilities

7) Post-disaster building code activities that support code officials during the reconstruction process.

3.5.2. HUD Assistance Programs

The Homeowner Assistance Grant Program (a.k.a. HAP) is a disaster recovery program being implemented through the Mississippi Development Authority for those areas specifically damaged by Katrina hurricane surge inundation. The program is generally available to low to moderate income households (up to 120% of the median household income) with limited funding for higher-income households. The program is being implemented in two phases – Phase 1 for those structures located outside the 100-year flood zone established in the FIRM but were flooded by the Katrina surge and Phase 2 for those structures damaged by hurricane surge and located within the 100-year flood zone mapped in the FIRM.

The program has two components. The first component is a compensation grant of up to $150K (Phase 1) to compensate homeowners for losses to single-family, owner-occupied duplexes or mobile homes due to flooding by surge that were not covered by insurance. The percentage of the total grant available is dependent upon the insured value of the home times the percentage of damage determined in a damage assessment. Homeowners may repair, replace or reconstruct homes as they choose with the funds. No local permits for home repair or construction or evidence of the use of the funds for those purposes is required by HUD or MDA. Homeowners must comply with local NFIP requirements for elevating the structure and may apply for the second component of the program – the HUD elevation grant (see description below) – to defray the costs of elevating the home. In Phase 2 of the HAP, the compensation grant amount is limited to $100K.

Neither the compensation grant program nor the elevation grant program restricts any homeowner from rebuilding a destroyed or substantially damaged structure or elevating a damaged/repaired structure in the new DFIRM-designated V-zone. The only requirements for the compensation grant program are compliance with current NFIP guidelines as described in local floodplain management ordinances and current building codes. Any structure being elevated under either program would be raised to the new BFE established in the DFIRM flood zone mapping. In some locations the new BFE may be lower than the surge elevation that came ashore during Katrina. Residual damages during a recurrence of a Katrina-like storm as a result these elevation and compensation programs could be significant.

As of May 15, 2008, the HAP has received 19,401 applications for Phase 1 and 8,534 for Phase 2 of the program and has distributed grant funds to 20,437 of those applicants totaling more than $1.4 billion.

In addition to the Homeowners Assistance Program discussed above, the MDA is implementing, through the HUD Community Development Block Grant (CDBG) program, the Long Term Workforce Housing Program. The purpose of this program is to provide grants and loans for local jurisdictions, non-profits and for-profit organizations to provide long-term affordable housing in the three coastal counties and Pearl River County. These funds can be used to repair, rehabilitate, or reconstruct housing units for low and moderate income families and must include at least 40 dwelling units for each grant or loan request. The program projects that as many as 5,800 housing units may be created in these four counties with only local building code and NFIP local floodplain ordinance restrictions.

Among the program requirements are adherence to local building codes and the NFIP for determining first floor elevations of new or rehabilitated structures. Existing structures considered for repair or rehabilitation that suffered damages more than 50% of the structure value by hurricane surge flooding must comply with elevation requirements through the NFIP and local floodplain management ordinances.

Sections 4.5.8 and 4.5.9.7 of this appendix address the opportunities for integrating the FEMA and HUD programs with the formulated plans in this report.

CHAPTER 4. IDENTIFICATION AND PRELIMINARY SCREENING OF NONSTRUCTURAL MEASURES

4.1 General

There are a number of measures that can be classified as "nonstructural". In some cases such as dry floodproofing by the use of ringwalls or ring-levees, a nonstructural measure can approximate a structural solution when expanded to protect a large contiguous complex (college campus, industry, or commercial area). When judiciously applied, nonstructural measures can result in reductions in inundation damages and losses of life to structure occupants. Corps of Engineers documents and regulations as well as the technical papers and bulletins of other Federal and state agencies that address flooding from storms and hurricanes contain lists of possible nonstructural measures. Generally speaking, each of these identified measures can be applied either singly or in combination with other nonstructural or structural measures to attain project goals and planning objectives. Screening of the measures can be accomplished in a preliminary fashion by considering lessons learned from previous nonstructural projects, potential socio-economic impacts, environmental justice issues, and political realities of implementing certain measures at the local government level.

4.2 Damage Categories

Prior to identifying potential nonstructural measures, a quick review of the damage categories to which the measures may be applied is warranted. These categories generally represent the sphere of land uses and property ownership options in the project area. These categories include:

1. Private properties occupied by residences (single-family and multi-family)
2. Private properties occupied by commercial structures and facilities
3. Public properties occupied by public buildings and facilities (Federal, state, municipal and county owned) or other damageable items
4. Private properties occupied by entertainment structures and facilities
5. Private, interspersed properties that were vacant prior to the Katrina event
6. Private properties that were made vacant by the Katrina event (total structure or facility loss.
7. Public, interspersed properties that were vacant or made vacant by Katrina.
8. Public properties occupied by industrial development
9. Private properties occupied by industrial development
10. Public utility corridors and installations (substations)
11. Public properties occupied by transportation modes
12. Private property occupied by transportation modes
13. Public parks and open space

Each of these damage categories (listed as either private or public property and attendant structures or facilities) can be addressed by one or more nonstructural measures and several categories of land use include contents damages as well. These land uses and associated structures and facilities are already addressed in county and municipal zoning ordinances, comprehensive plans and floodplain management ordinances. However, there remain a substantial number of at-risk structures and facilities subject to flood damages from hurricanes and storms.

4.3 Loss of Life Issues

Damages to private, corporate and public property along the Mississippi coast were in the billions of dollars, but the most compelling losses were those to human life in the state due to Katrina. Estimates are that more than 250 people perished during the storm in the project area and more than 60 were unaccounted for following the storm and presumed to be missing or dead. The combination of surge, waves and wind overpowered many who either attempted to ride out the hurricane or were trying to escape the storm and waited too long to avoid the surge and waves.

Many who were able to ride out Camille in 1969 believed that they could weather Katrina inside their homes only to discover too late that the surge depths far exceeded previous storms and they perished as their homes were destroyed or as they were fleeing in desperation. Personal interviews from survivors during the planning process revealed numerous people were unable to escape because key evacuation routes were submerged during the storm. Many survivors clung to roofs and trees to escape the surge flooding and waves.

Detailed information on the number of dead within each community or neighborhood, locations of the recovered bodies with respect to their place of residence and the cause of death (drowning, heart attack, impact injuries, etc.) are unavailable at this time due to the sensitivity of that information. Hopefully that information can be disclosed by state agencies during later more detailed planning so that identified high-hazard zones where permanent evacuation may be the most advantageous option and the need for timelier hurricane warnings and safe evacuation routes can be better supported for implementation.

Issues of public safety and loss of life during these extreme weather events have become more significant in the planning process since Katrina. The ability to provide timely storm warnings, safe escape routes and safe shelters is a key component of reducing future loss of life along the coast. In some cases, permanent evacuation of some coastal neighborhoods may be the best way to assure public safety and avoid future losses of life. Alternative plans that integrate various nonstructural measures for the purpose of reducing loss of life will be explored during the plan formulation process.

4.4 Goals and Objectives

The main body of the MsCIP report displays a number of project goals and objectives that address the existing conditions listed in the project study authority. Existing problems to be addressed in the study authority include: 1) hurricane and storm damage reduction, 2) prevention of saltwater intrusion, 3) preservation of fish and wildlife, 4) prevention of erosion, and 5) other related water resource purposes. From these problems, the MsCIP team in coordination with project area stakeholders and cooperating agencies developed goals and objectives that would guide the planning process and could be used to evaluate formulated measures and alternative plans. During the study process, one goal began to emerge that summarized the efforts of the team; formulation of alternative plans that as a result of their implementation, would enable the Mississippi coast to become a disaster-resilient community.

Among the many objectives developed to support that emergent goal (disaster-resilient community) are several that can be directly addressed by nonstructural measures. Those include:

1) Reduction of the potential for future storm created flood damages,

2) Reduction of the potential for future storm related threats to life and safety,

3) Reduce costs for storm related emergency services,

4) Provide environmental justice in recommended solutions,

5) Provide complete solutions (in accordance with the P&G),

6) Provide solutions "acceptable" to communities & resource agencies,

7) Provide environmentally sound solutions,

8) Provide solutions that fit within existing laws, policies, regulations, and the general plans of local governments and communities,

9) Minimize impacts to the environment, and

10) Generate opportunities for ecosystem restoration of wetland habitat.

It is for these stated objectives that potential nonstructural measures and their integrated plans are formulated and against which they will be evaluated for effectiveness, cost effectiveness, completeness, acceptability and environmental suitability.

4.5 Potential Nonstructural Measures

The nonstructural measures described below can be grouped into several general categories including:

- Flood Preparedness and Emergency Evacuation
- Floodplain Management, Floodplain Zoning, Flood Insurance and CRS
- Building Codes
- Land Use Regulation and Zoning
- Development Impact Fees, TDR, TPR, and Redirection
- Land Taxation Policies, Special Assessments and Revenue Sharing
- Floodproofing
- Permanent Acquisitions (Evacuation and Relocation)
- Replacements of Public Buildings (Critical Facilities)

In an effort to simplify the formulation of nonstructural plans and reduce repetition of evermore detailed evaluations of the measures, the following paragraphs include a description of the individual measures, how they might apply to the project area given existing conditions, costs associated with the measure, operations and maintenance costs and whether the measure should be carried forward into the more detailed project formulation process (a preliminary screening of the measures).

4.5.1 Flood Preparedness and Emergency Evacuation

4.5.1.1 General

Flood Preparedness includes a multitude of management activities and features that all contribute to a reduction of flood damages and reduced losses of life due to hurricanes and storms. These management activities can apply to the emergency operations of Federal, state and local agencies as well as to the response actions of individual property owners. During the days and hours that preceded the arrival of the identified and tracked storm known as Katrina, agency emergency operations and landowner responses were already taking place that saved countless lives and reduced property damage. That many more did not perish in the event is a testament to the fact that sound flood preparedness and emergency evacuations were successful.

Generally speaking, storm warnings and emergency evacuations fall under the purview of the National Oceanic and Atmospheric Administration (NOAA) and the Federal Emergency Management Agency that includes offices at state and local levels of planning and deployment. Although the Corps of Engineers is not a direct player in these types of flood damage reduction components, the Corps does support these activities as an important part of reducing flood damages and reducing losses of life. The following measures outline the types of storm/hurricane warnings and emergency evacuation management activities that could be implemented by Federal, state and local managers.

4.5.1.2 Research Findings

Among the many post-disaster studies of hurricane-readiness in the project area, a study conducted by the Harvard School of Public Health (2007) using a random sample of 513 residents by telephone interview revealed interesting attitudes and concerns of the local population regarding flood/hurricane preparedness. Besides the 8 demographic questions included in the survey, each respondent was asked 48 questions regarding their individual or household preparations and specialized needs for evacuation in the event of a future hurricane. Most of the respondents (95 percent) had experienced Katrina and either suffered damages to their residence or were aware of damages in the area.

Many of the respondents indicated a renewed interest in preparedness and had equipped their households with substantial resources and supplies in the event of a future storm. A majority of the respondents indicated as well that they would evacuate the area if told to do so by government officials. If an evacuation were necessary, many indicated that they would leave by personal vehicle and would stay with family or friends up to 200 miles away from the coast. For those who indicated that they would evacuate many concerns were expressed about the safety and capacity of evacuation centers to handle the evacuees. Issues of water and food supplies, safety, sanitary facilities, over-crowding, and medical care were expressed by respondents.

For those who may have chosen to remain in hazardous areas during a hurricane, the primary reasons for staying at their residences included: 1) considered home to be well-built and would be safe staying, 2) concerns about theft and damages to the evacuated home, 3) believed that the roads would be too crowded to safely evacuate, 4) believed that evacuation would be dangerous and 5) needed to take care of someone who would be physically unable to evacuate. All of these issues should be addressed as revisions to certain aspects of the evacuation system to assure that residents who may be in serious peril do not feel compelled to remain during a hurricane and those who choose to evacuate can do so safely and with limited stress.

Studies, such as the one described above, give valuable information regarding the concerns and issues confronting the project area population who would face more hurricanes in the future. Formulating a robust flood preparedness and evacuation system that addresses these concerns is one of the objectives of the nonstructural PDT. The many components of flood preparedness and potential upgrades of that system are discussed below.

4.5.1.3 Storm/Hurricane Identification, Tracking and Forecasting

Generally, the majority of hurricanes and coastal storms capable of inflicting significant damages to structures in the V-zone develop over days within the Gulf basin. Fortunately, this developmental period allows the National Weather Service and the National Hurricane Center the opportunity to provide ongoing information on the formation of the storms and their probability of making landfall at one or more areas of the Gulf Coast. The opportunity to identify the storm threat, forecast its probable movements and issue advanced warnings for temporary evacuation of high-hazard coastal areas can lead to substantial lessening of loss of life and property damages.

One can only imagine with horror the potential loss of life and property losses that would have occurred had not Katrina been so well tracked and advanced warnings issued for mandatory evacuation of portions of the Gulf coast. Regrettably many who survived Camille in 1969 decided to weather out Katrina rather than evacuate – their names were listed among the dead or missing. This sad fact points out that a flood warning and emergency evacuation program has many facets - any one or combination of which left uncompleted or unheeded can lead to disaster.

The warning and evacuation system is composed of several components: 1) Threat identification and analysis, 2) Forecasting, 3) Dissemination of threat warning, 4) Threat understanding, 5) Evacuation and 6) Sheltering. Today the ability to see the development of hurricanes and major storms within the Gulf is aided by a great number of sophisticated technology and data sources. Weather satellites, Doppler radar imaging, hurricane hunter aircraft, reports from ships at sea, reporting oil rigs, moored buoys, Caribbean weather stations, and many other proven data sources can track an approaching hurricane, tropical storm or major low-pressure system in real time and generate reliable data upon which forecasts of direction, speed, and intensity can be based. Both polar orbiting and geostationary weather satellites provide storm images in visible light and infrared, as well as showing water vapor images of these storms.

Land, ship or aircraft-based Doppler radar provides a detailed picture of rainfall intensity, speed and circulation characteristics within the storm. NEXRAD or "NEXt generation doppler RADar" is much more sophisticated allowing closer examination of rainfall intensity, storm direction and speed as well as measuring wind speeds (motion of dust particles within the storm) in the absence of rainfall. NEXRAD, with a range of more than 140 miles from the radar site, provides much better information on the intensity and speed of hurricanes and other storms in the gulf. There are NEXRAD stations in New Orleans, LA, Biloxi, MS (Kessler AFB), and Mobile, AL. Radar imagining from these three stations overlaps the entire Mississippi coastal area.

In addition to satellite imagery and land and ship based radars, the on-station telemetric data and information generated by the "Hurricane Hunter" aircraft provides forecasters a more complete picture of hurricanes and other major storms in the Gulf. The Lockheed Martin WC-130J Hercules aircraft, specially out-fitted with sophisticated instrumentation fly repeatedly through tropical storms and hurricanes to collect data such as wind speeds and barometric pressure that cannot be obtained by weather satellites. Flights into major storms begin when storms are still classified as tropical depressions and tropical storms by their barometric pressure and wind speeds.

Using Doppler radar and "dropwindsondes" that are dropped from the aircraft during the flight, readings of barometric pressure, wind speed, air and water temperature, storm direction, and speed are delivered to the National Weather Service by regular interval flights into the storm. The 53rd Weather Reconnaissance Squadron of the Air Force Reserve stationed at Keesler AFB in Biloxi, MS provides these essential services within the Atlantic Ocean, Caribbean and the Gulf of Mexico.

Although severely damaged during Katrina, when the 53rd Squadron flew out of Dobbins Air Reserve Base, Keesler AFB has been repaired and the "Hurricane Hunters" continue to provide weather surveillance data for the Gulf States. These aircraft and their brave crews are an invaluable component of the early warning and emergency evacuation system in the project area.

The National Weather Service (NWS), a department of the National Oceanic and Atmospheric Administration (NOAA), operates and maintains a series of moored buoys in the Gulf of Mexico that provide a real-time stream of weather and oceanic data. The buoys range in size between 12 meter diameter discus buoys and 3 meter diameter buoys and most are tethered to the ocean floor. Other buoy types include spar buoys with multiple moorings and wandering buoys (NOMAD). Because of their size and sturdier construction, the 12 meter discus buoys are more reliable in hurricane and storm conditions resisting capsizing and wave damage to the structure and instrumentation. Figure 4 shows a 12 meter discus buoy being serviced. Larger buoys such as the 12 meter discus buoy are towed into position by Coast Guard vessels. Spar buoys although more expensive in capital and O&M costs are more stable platforms for satellite telemetry than the discus buoys. Information on air and water temperature, atmospheric pressure, wave heights and wave period, wind direction and speed, and other weather data is up-linked to communication satellites and weather stations along the Gulf.

This "hurricane DEW Line" system provides reliable data to the National Weather Service on the speed direction and strength of approaching storms, tropical storms and hurricanes. In addition to the hurricane hunter aircraft that provide atmospheric and ocean condition data from within the storm itself, these buoys relay constant data on weather and ocean conditions at the water surface. The National Buoy Data Center (NBDC) Web Site provides ongoing updates of the buoy data in the Gulf. That web address is: http://www.ndbc.noaa.gov/.

One component of this measure could be buoy system upgrades in the Gulf coordinated with NOAA. Consideration should be given to whether or not additional reporting buoys in the gulf would provide a better picture of the strength, direction and speed of hurricanes, tropical storms and other ocean phenomena that would endanger the coastal area of the state. Having better and more reliable information on the expected height of the storm surge and associated waves would assist emergency personnel in making more informed and quick decisions about which coastal inundation zones are at risk from a particular storm. The inability to correctly select which inundation zones should evacuate quickly erodes the public's confidence in the warning and evacuation systems.

During Katrina's relentless approach to the coast, a number of reporting buoys in the middle of the hurricane broke free of their moorings and drifted from their known positions. Although the buoys kept reporting data, without a reliable position, the NWS had no way to locate where those conditions were in relation to the eye of the storm. Consideration should be given to modifying the existing buoys through NOAA programs so that "break-a-ways" during extreme hurricane events due to huge waves or extreme surge depths will not void the valuable data being relayed to the NWS.

Based on information gleaned from NOAA online sources, the installation of the 12 meter discus buoys cost in the range of $2.5M to $3.5M per buoy depending upon water depth and towing distance. This cost includes buoy construction, installation of instrumentation, towing to the Gulf site and anchoring the buoy. Annual O&M cost for the 12 meter discus buoy is approximately $500,000. Capital and installation costs could be shared between implementing agencies or with a project sponsor and annual O&M cost would be borne by NOAA (cost data supplied from NOAA publications).

Having more precise information on the intensity, location, track and anticipated landfall of severe storms is the basis for any storm warning and emergency evacuation system. Since these measures all contribute to having more precise information on the level of threat that any particular storm or hurricane poises as well as better information to determine where and when the effects of the storm will make landfall, all of these proposed measures should be retained for more detailed formulation.

4.5.1.4 Warning Dissemination

One of the most important factors in being able to successfully and safely evacuate coastal areas is allowing sufficient time between the determinations that a particular storm's track will make landfall at designated locations along the gulf coast and fully disseminating the warning to those in the target area. These predictions are based upon numerous factors of storm speed, direction, intensity, other weather conditions (low pressure and high pressure land systems) in the region. Generally hurricane threat information is distributed to the public as "hurricane watches" and "hurricane warnings" by the NWS. According to NOAA information, a hurricane watch is an announcement by the NWS for specific coastal areas that hurricane conditions are possible within 36 hours. A hurricane warning is a public announcement by the NWS that sustained winds 74 MPH or higher associated with a hurricane are expected at a specified coastal area in 24 hours or less. These watch and warning times are not adjusted according to the strength of the hurricane as the physical radius of the hurricane-force winds from the eye of the storm is usually closely correlated with the strength of the storm (more intense the storm (Safir-Simpson scale) the larger the radius of the storm). In the case of Katrina, the radius of the storm was much larger than previous storms of that intensity (such as Camille).

Information gleaned from various web sites and the three county emergency evacuation plans indicated that at least 36 hours may be required to safely evacuate threatened zones along the coast prior to the larger storm events (categories 4 and 5). Although there is much concern over issuing evacuation orders too soon without sufficient information to accurately determine where landfall will occur, the potential for many people to be trapped on crowded roads when the storm surge arrives or to wait till that last possible moment before evacuating gives some credence to the possibility of issuing a warning in advance of 24 hours when hurricanes reach Categories 4 and 5. A considerable number of people lost their lives while fleeing from Katrina. In addition to the existing dangers of evacuating high-risk project areas, should a nonstructural plan featuring thousands of elevated structures be implemented, having sufficient time available for those households to evacuate safely will be a major component of that plan.

Due to the number of large recreation facilities and operating industrial plants that cannot be moved from high hazard areas, specific warning systems should be developed that notify these people-filled facilities on an ongoing basis about potential threatening storms and expected hazards at their specific locations. Specific evacuation procedures for each of those facilities would be prepared in close coordination with the facility management and local emergency management personnel.

One of the many warning measures that should be investigated further with NOAA and the NWS is the possibility of extending the hurricane warning time from 24 to at least 36 hours in the advance of landfall for the larger more powerful storms with hurricane force winds and surge that extend across larger areas. Especially for any hurricanes in the 3, 4 and 5 categories that affect larger areas of the coast. Based upon all accounts of Katrina's approach to the coast, its size and the extent of damages and loss of life wrought by the surge, a longer warning time may have saved lives.

Other forms of emergency notification of the population living along the coast in hazardous areas are available. Reverse 911 systems that generate phone calls to homes and businesses in selected sections of the coast that are correlated to the current emergency evacuation plans would be an effective way of issuing storm warnings or evacuation orders. In addition, these same systems could use cell phone technology (voice mail, text messaging, paging, etc.) to contact individuals with that service. In either case such notification systems could be effective in issuing evacuation orders and if repeated on a regular hourly basis in advance of storm landfall may decrease the chances for loss of life. Given the diversity of the population within the project area, hurricane/storm warnings should be issued in several languages as well as sign language on public television stations. Other warning dissemination methods should be explored that would address physically and mentally disadvantaged populations in the region as well.

Despite all of the various forms of media available to the population within the project area (i.e. television, radio, internet, cell phones, broadband, etc.), there is no guarantee that individuals will have access to the media, that the media systems will be functional at these critical times, or that individuals would be aware of impending threats from storms or hurricanes at all times. For this reason, other less sophisticated systems should be in place that would provide unmistakable evidence that there is an impending threat approaching the coast.

As a nonstructural measure, a system of sirens located across the project area could provide an emergency signal whose message would be unmistakable given sufficient education of the population of the purpose and meaning of the sirens' use. Mounted on wind-resistant poles located at intersections and serviced with underground power, the sirens could be used in conjunction with other media and communications systems to alert the population to the coming threats. For the hearing impaired, flashing strobe lights could also be installed in neighborhoods so that all segments of the population could be notified of impending danger.

Warning sirens installed on a pole mount range in costs from $15,000 to $25,000 depending upon the anticipated coverage area and required pole height. Battery backup systems are available for that price range. Costs include the siren, pole and wiring plus installation costs. Annual O&M costs are approximately $500 per siren. Flashing strobe lights range in costs from $250 to $500 installed depending upon the wattage and mounting location. Annual O&M costs for the flashing lights would be contingent upon instances of vandalism and theft and would be limited to purchase of a new strobe light and its installation.

Generally the majority of the population within the project area has access to various media (television and radio) that would be carrying information from the National Weather Service on local news stations regarding the threat levels of oncoming storms and hurricanes. However, there are sectors of the population who do not have ready access to media resources and therefore may not be made aware of these impending threats. In light of this situation, a nonstructural measure could be to distribute weather service radios that continually provide weather related information on an impending hurricane or storm event. Considering the growing diversity of the population in the project area, announcements of impending weather-related emergencies need to be broadcast in multiple languages.

The National Weather Radio (NWR) system is a nationwide network of over 900 radio stations broadcasting continuous weather information directly from a nearby National Weather Service office. NWR broadcasts National Weather Service warnings, watches, forecasts and other hazard information 24 hours a day. There are three NWR stations in the project area including Mobile, AL, Gulfport, MS and New Orleans, LA that provide full coverage of the project area through the weather radio system. The special radio receivers or scanners that pick up the NWR information can be purchased from the NWS or many other commercial outlets. For the hearing or sight impaired population, these alert systems can be connected to other alarm systems (flashing lights, sirens, etc.) in the home or business. Standard NWR receivers cost approximately $80 and could be purchased in bulk for distribution to identified sectors of the project area population that would be at risk and lacking the resources to purchase the radios. A significant number of those needing these resources could be addressed with a modest project investment at the current unit price. Annual O&M costs would be limited to battery replacements unless rechargeable batteries are chosen (slight increase in purchase cost).

The ability of emergency services agencies to quickly and decisively issue credible warning is a key element in an effective storm/hurricane warning system. Since all of these measures contribute to that system's effectiveness, all of them are carried forward into more detailed formulation.

4.5.1.5 Evacuation Planning & Public Education

Once the threat of an approaching storm has been determined by the NWS, specific steps can be taken by local communities and emergency services personnel to begin evacuating those families and individuals and their movable contents to safe areas. Emergency evacuation zones of the coastal region have been mapped based upon surge depths, wave action and FEMA flood frequency data. Those families and individuals as well as concentrations of special populations (hospitals, assisted living, schools, jails, etc.) in structures subject to inundation are notified by county or city emergency services to evacuate to safe areas designated by the counties. Specific evacuation routes have been identified by the three counties that will assist evacuees in finding the safest and quickest way to flee the approaching storms.

Each of the three counties has developed emergency evacuation plans that indicate when the various zones must be evacuated, the best available evacuation routes (streets, roadways and highways) and where safe temporary evacuation centers are located. Theses plans need to be better coordinated with Federal and state agencies and departments and better disseminated to the public at large. Telephone, short-wave and cell phone communications enable emergency personnel to coordinate these activities with local police and fire units in the cities.

One of the most important features of any emergency evacuation plan is the education of both the emergency personnel responsible who will be implementing the plan and the citizens who must respond to the emergency evacuation orders posted by local authorities. Many people perished during Katrina because of their lack of information or understanding of the deadly threat that the storm surge and waves would pose for anyone staying within the expected surge inundation zones.

Regardless of the amount or quality of pre-emergency planning and preparation accomplished prior to the next weather-related emergency, the one constant random element remains the reactions/responses of the at-risk population when mandatory or voluntary evacuation orders are issued. Reducing the potential loss of life and injuries to the evacuees depends largely upon the population's understanding of the threat and what appropriate responses to that threat will be effective for each household or individual. Knowing where evacuation routes and safe evacuation centers are located can make the difference between safety and tragedy.

In order to better equip the at-risk population, a series of training and information seminars, media presentations, and other public forums assisted with easy-to-read and understand materials could be implemented as a nonstructural measure. Information on these emergency subjects can be placed in libraries, community centers, hotels and motels, managed-care facilities, hospitals, banks, credit unions and post offices. Applicable web addresses, phone numbers, radio station frequencies, and emergency evacuation routes could be stressed in this public information. The costs of these materials would be minimal since they are already available through Federal and state agencies. Training and information seminars could be hosted by FEMA, MEMA or USACE at minimal costs.

In addition to educating and training the general population, the most effective education for the project area's future would be at the elementary, middle school and high school education levels. Education materials including textbooks, coloring books, workbooks, posters, computer programs and role-playing games could be distributed throughout the school systems to increase the awareness and understanding of all school-aged children (in a non-threatening way) about hurricanes, flooding and emergency responses to these conditions. Generally parents of children made aware of threats at school seem to respond in a more affective and positive way out of concern for their children's safety. Additional resources available through FEMA for children can be found at: http://www.fema.gov/kids.

Obviously this education process cannot be a one-time affair as new citizens move into the coastal area over time and emergency personnel change jobs, retire or move elsewhere for employment opportunities. More importantly is the fact that the project area is visited by millions of tourists each year – people who may be unaware of the potential threat from these storms and who may not have adequate transportation (such as fly-ins) to evacuate safely. Education of the public must occur on a regular basis about the threats that hurricanes and other large storms present and what steps the public can take to protect themselves and their property. Certainly this public awareness needs to be heightened with the approach of each new hurricane season. At a minimum, annual emergency drills and testing of the warning system are the measures that assure quick and affective response to these threats. Education at all levels (elementary through elderly) is important to assure public safety.

An additional concern would be for the many facilities that are inextricably tied to the water's edge either by legal restrictions (casinos and associated facilities) or by their need to operate at the water's edge (Ingalls Shipbuilders, Chevron Oil, MS Power Company, Port of Gulfport, etc.). Special evacuation plans for these major industrial and recreation facilities will need to be developed in close cooperation with the local emergency management offices and the individual facilities themselves. Costs for development of these individual plans would be shared between USACE and a non-Federal sponsor.

The effectiveness of any threat identification and warning system is inextricably tied to the timely and correct response by the general public, agencies and organizations who will be most effected by the threat. An unheeded warning or a warning not taken seriously is a formula for disaster. Since effective and ongoing education of the public to the seriousness and reliability of the warnings that may be issued in the future is the key to a successful evacuation, all of the above measures regarding public education and evacuation planning are being carried forward into more detailed formulation.

4.5.1.6 Evacuation Routes and Signage

4.5.1.6.1 Evacuation Routes

The population of the communities within the project area is increasing daily as households and commercial businesses re-establish in the area. When a hurricane warning is issued by the NWS for certain reaches of the Gulf Coast and particular areas known to be at-risk from surge inundation and waves are notified to evacuate, there would be a massive migration of people in vehicles from the coast. The massive vehicular evacuation experienced in areas of Texas during the approach of Hurricane Rita in 2005 illustrates the importance of having designated routes.

During an emergency evacuation situation, identified evacuation routes are critical to assuring that those families and individuals that are at risk in identified evacuation zones can safely and efficiently leave the danger zone(s) and seek shelter in designated areas. In addition, the evacuation routes provide efficient routes for evacuation of people by buses or other transit vehicles that may not have access to personal vehicles. Generally the routes are streets, arterial roadways and highways designated by the county emergency services agencies in cooperation with the State Department of Highways which in this case is the Mississippi Department of Transportation.

Figure 5 shows the MDOT Hurricane Evacuation Routes (in red) that extend northward from the coast. In selecting the appropriate routes, the distribution of the population within the hazard zones, highway capacity (lanes and roadway width), critical intersections, bottleneck areas (reduced lane-widths) and other parameters are all critical factors. Planned improvements to those critical components of the evacuation routes can dramatically improve the efficiency and safety of the evacuation process.

Of most importance is ongoing education of the public as to the location of the routes and the locations of designated shelters. This process can be woven into the everyday activities of the state DMV regional offices from the testing of new drivers (drivers test manuals) to the annual vehicle registration renewal, (information included in the registration package) and license renewal processes. Public service announcements (television and radio and published media) identifying the evacuation routes by highway number, name and/or by graphics could begin prior to the start of hurricane season (June) and continue on a regular basis through November.

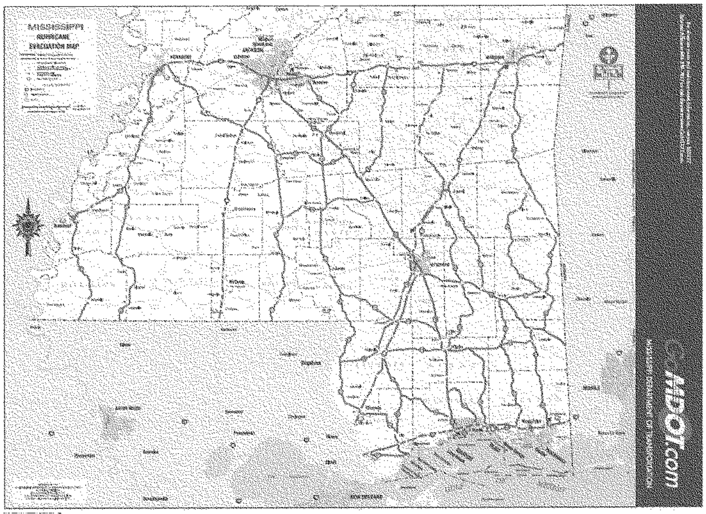


Figure 5. Evacuation Routes MDOT

4.5.1.6.2 Evacuation Route Signage

As important as selecting safe and efficient evacuation routes is the signage of the selected routes such that citizens can quickly identify the appropriate routes and be assured that they are still on an approved route as they travel away from the hazard zone. In addition to full-time residents fleeing an approaching hurricane, a great number of tourists and out-of-region visitors are living in temporary residences (rentals, motels, time-shares, etc.) in hazardous zones as well. Since hurricane season begins in June, the areas beaches and oceanfront properties may be crowded with families and individuals who are ignorant of the threat and the evacuation plans. Their unfamiliarity with the local highways and roadways can make evacuation for everyone a nightmare. Having carefully conceived and wisely installed highway signage that clearly identifies evacuation routes is of paramount importance to successful evacuation. Figure 6 shows a basic hurricane evacuation route sign using the cyclonic logo that is commonly used to designate hurricanes throughout the nation. Placement of theses signs at appropriate intersections and frequently along the evacuation routes could be initiated through a Federally-funded program (Homeland Security) using MDOT as the local sponsor and installer of the signs.

Figure 6. Hurricane Evacuation Route Sign

Costs for the signs range from $250 to $350 installed depending upon the number produced and the installation methods used. Annual O&M costs for the signage are limited to replacement of a percentage of signs due to vandalism or theft.

In addition to the standard metal post signs, other types of signage can be installed that would provide fleeing motorists with information on traffic accidents, available shelters and other important information. Dynamic information signs that flash messages to approaching motorists can be installed along major evacuation routes at strategic locations. Installation options range from smaller pole-mounted roadside signs to multi-lane towers that span 3-4 lanes of traffic. Costs for these installations range from $100,000 (roadside) to $400,000 (multi-lane tower) and annual O&M costs range from $4,000 to $7,000 for the messaging board itself. These signs could be located along the main evacuation routes from the coast to convey up-to-date emergency information to motorists.

4.5.1.6.3 Highway Routing

Reverse-flow traffic routing (also known as "contraflow") of highways during emergency evacuations is an effective method of moving large numbers of vehicles away from the coast in a relatively short period of time. Successful implementation of this measure requires the full cooperation of the MDOT and adjacent states, and local and state police in planning and administering the reverse-flow routing of traffic during these emergencies. Pre-planning of the target routes away from the coast, modification of intersection signaling, additional turning and travel lanes, dynamic messaging boards and highway signs are all components of this measure. As in the case of other flood preparedness measures, public education is a valuable component of this measure and would require repetitive application to maintain preparedness.

Costs for additional traffic lanes, turning lanes or intersection improvements (see below) are not available without more detailed planning and coordination with MDOT. Annual O&M costs would be commensurate with annual O&M costs experienced by MDOT for lane maintenance.

4.5.1.6.4 Intersections and Modal Crossings

During a major hurricane storm event that would initiate substantial numbers of evacuations from the coast, three primary modes of transportation along the coast would be energized to move damageable assets further inland. In addition to the obvious highway routes already identified above that would attract personal cars, trucks, buses, military vehicles and other vehicles exiting the coast, CSX railway and gulf vessels would also be attempting to move valuable assets away from the coast. Where these various transportation routes intersect (at-grade crossings, bridges, overpasses, etc.) evacuation conflicts can occur. Although major highway intersections can be signaled to reduce conflicts between local and emergency evacuation traffic, at-grade railway crossings occupied by railway stock being relocated in advance of a hurricane event can effectively block thousands of fleeing motorists.

Likewise, fishing fleets and pleasure craft seeking shelter in safe anchorages within tributary rivers and embayments that result in raised drawbridges can also block thousands of fleeing families. These inter-modal conflicts can be resolved along major evacuation routes through an intentional program of expenditure by state and private companies. In addition to these inter-modal crossing conflicts, most of the evacuation routes cross multiple streams and rivers that can be reaching flood-stage as pre-landfall precipitation swells these intersecting drainage-ways. A MDOT-led assessment of all culvert sizing at small stream crossings and maintenance of debris removal in stream/creek channels would help to assure that the major evacuation routes are indeed available during an emergency.

Determining costs for eliminating at-grade crossings, drawbridges and other intersection conflicts require more detailed planning and engineering investigations than are possible given the time and resources available for this appendix. Intensive coordination with MDOT could determine capital and O&M costs for these measures.

4.5.1.6.5 Evacuation Route Resources

As Hurricane Rita so vividly pointed out to the residents of Louisiana and Texas and the rest of America through CNN news, there are a myriad of possible accidents and crises that can take place during a full-scale Gulf coast evacuation. Accidents, vehicle fires, breakdowns, medical emergencies, insufficient fuel supplies and many other on-roadway emergencies can occur during the movement of thousands of households and residents. Contingency plans that address possible needs along each designated evacuation route from the Gulf need to be prepared based upon lessons learned from Hurricane Rita and the needed resources (fuel, emergency responders, repair facilities, etc.) either put in place by state emergency offices or county emergency services or provided for through joint agreements with local resource providers. Annual emergency evacuation tests should include mock activation of these in-route resources to assure their availability in the event of a real emergency.

As in the case of other evacuation activities, determining capital and O&M costs for developing these resources along the evacuation route are not possible at this level of planning detail.

The largely successful evacuation of the Texas and Louisiana coasts preceding the landfall of Hurricane Rita in 2005 is a testament to the need for good evacuation route planning, signage and other measures discussed above. Many of the unexpected incidents that occurred during that evacuation and were highlighted on national media can be avoided and measures for that purpose are included above. Since these measures can contribute to a more orderly and safe evacuation from coastal areas, they are all carried forward into the more detailed formulation process that follows.

4.5.1.7 Evacuation Centers/Shelters

In addition to those evacuation centers that may already be listed by the local emergency management agencies, a series of alternative centers should be identified for use by the coastal population. In consideration for the numbers of people that attempted to evacuate the MS coast immediately prior to landfall by Katrina and later Rita in Texas, having an oversupply of evacuation centers available is important. Should there be a number of schools and other large facilities relocated as a part of the implementation of this comprehensive plan, then these additional "safe" resources need to be added to the list of evacuation centers. Location by GPS coordinates and mapped in GIS format would help all emergency managers and resources (police, National Guard, etc.) manage the evacuations. Additional information on the design and construction of community shelters can be found in the publication: FEMA 361 – Design and Construction Guidance for Community Shelters.

Emergency evacuation of families during Katrina and Rita identified needs for accommodations for specific populations requiring special medical care (elderly, children, chronic illness, and hostels) as well as family pets. Provision for these "special" evacuees should be considered at the identified evacuation centers.

Once identified, emergency-use agreements between local emergency managers and facility owners need to be executed for use of evacuation centers so that administrative processes or finances do not hinder the evacuation process when an emergency is declared. Annual review of those agreements as a part of the annual emergency system test would assure updating of the agreements and any financial considerations.

In addition to the identification of usable evacuation centers and execution of use agreements, provision of basic necessities for a relocated population for up to a week need to be considered. Caches of storable food, water, medical and bedding supplies need to be established at or near the evacuation centers. As with other components of the emergency evacuation system, these resources should be evaluated on an annual basis when the system is tested.

Determining costs for rental of potential evacuation centers and their supply with basic necessities requires a more detailed study of the center capacity needs and coordination with owners of available centers.

Generally speaking, sufficient, safe accommodations of sufficient capacity to handle thousands of evacuees in the face of an impending hurricane landfall are not readily available within the project area. The many hotels and motels within the project area are usually booked during a significant portion of the hurricane season and many of those are currently subject to surge flooding or wind damages. Moving north from the coast, sheltering options (hotels and motels) are limited to small communities located along the identified evacuation routes. Other sheltering options are limited to larger schools and community facilities located away from the coast. Being able to locate these optional facilities, pre-arrange for their use in the event of emergencies and assure that sufficient supplies are on hand in the event of a hurricane landfall are all key components of a safe and efficient evacuation. Since all of these measures contribute to those objectives, they are carried forward into more detailed formulation.

4.5.1.8 Safe Harborages/Anchorages

Of the many commercial enterprises that exist along the Mississippi coast, the commercial fishing and seafood industry is one of the most enduring, most profitable and most threatened by hurricanes and storms in the Gulf. Besides the significant affects that these storms can have on the aquatic life and their habitat that these industries depend upon (fish, oysters, scallops, shrimp, etc.), protecting the fleets of corporate and individually-owned fishing boats and trawlers during these damaging storms is a challenge. During Katrina, many of these large vessels were swept into the coastal forests and residential neighborhoods and the waterside infrastructure destroyed by the storm surge and waves. With the approach of large hurricanes that carry significant surge heights, damaging waves and high winds, this fleet is faced with certain annihilation if it stays within unprotected waterfront anchorages. The options are to either move laterally across the coast to eastern or western Gulf ports outside of the storms' fury or move further inland using available tributary channels. In many cases, upstream anchorages away from the coast are blocked by bridges and shallow channels and sailing either east or west along the coast to avoid the storms significantly wears on machinery and crews and increases operating costs.

A solution to this temporary relocation problem may be the establishment of safe harbors or anchorages that fleet, charter, and pleasure craft can seek temporary shelter within. In addition to the commercial fishing and private vessels, charter fishing boats, and rescue/emergency response craft could be berthed at these harbors to allow quick response rescue operations following a hurricane event. A number of these "safe-harbors" could be established within the existing embayments by special authorities or through existing Corps of Engineers' authorities such as Section 107 of the Continuing Authorities Program (CAP).

This standing authority provides an opportunity for the Corps to participate in the development of small boat harbors and navigation improvements. The current maximum limit of Federal participation in this program is $7.0 million per project (WRDA 2007). Local sponsors pay a share of the project cost based upon the depth of the harbor. At a minimum, three safe harborages could be located within the project area. In accordance with the regulations governing this program, the estimated project cost for each of the three safe harborages would not exceed $7.7 million. More detailed analysis of the safe harborages' cost and features would be developed in CAP feasibility study documentation.

Safe harbors could be designed as excavated slips or longitudinal channel-side berths with tie-ups designed to accommodate significant rises in water levels (surge inundation). Landside development would be minimal with security fencing, lighting and roadway access. Prime safe harbor sites would be located adjacent to channels or deep water within the embayments that avoid excavation within sensitive estuary habitat. Extensive coordination with natural and marine resources during site selection and excavation design and construction would minimize ecosystem impacts.

A safe harbor could be developed in conjunction with the Pearlington community redevelopment scenario as part of the required borrow material excavation along the Pearl River. Requirements for channel depth and needed dredging would need to be coordinated with the fishing industry as well as natural resources agencies. Coordination with MDOT plans for any future bridge replacements or elimination of drawbridges for evacuation purposes may benefit the safe harbor selection process. See Figure 7 for an example of a safe harborage or safe anchorage. The provision of safe harborages as a method of reducing damages to commercial and pleasure vessels was suggested in the "Potential Projects List" (item HRR1-06) developed during round one of the public workshops on the Comprehensive Plan.

Costs for safe harborages or anchorages would depend upon the expected number of evacuating vessels and their sizes, draft depths being accommodated, intervening channel deepening requirements and needed security facilities. Determination of the capital and O&M costs for these facilities would require extensive coordination with fleet owners and boating associations in the project area. Annual O&M requirements would be limited to dredging the harbor area and any modified channels between the Gulf and the harborage site.

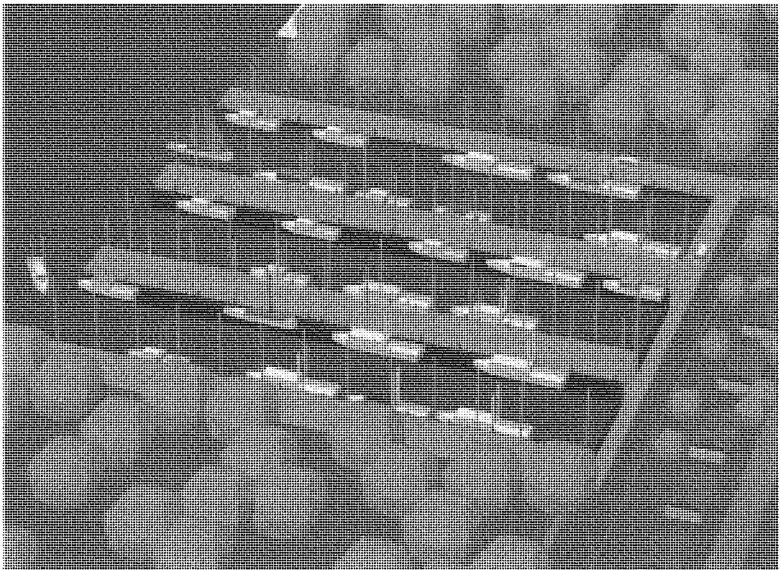


Figure 7. Safe Harborage/Safe Anchorage

The seafood and boating industries are major contributors to the region's economy and are a key component of the tourist trade along the coast. Severe losses such as occurred to the fishing fleets and recreation watercraft during Katrina pointed out the necessity of having sheltering areas for this equipment and facilities. Since safe harborages and anchorages would provide such shelter for this equipment, these measures are all carried forward into more detailed formulation.

4.5.2 Floodplain Management, Floodplain Zoning, Flood Insurance and CRS

Riverine and coastal floodplain management through the auspices of the Federal Emergency Management Agency (FEMA) is one nonstructural measure that has proven to be very effective in reducing damages to structures and losses of life. Generally floodplain management does little to reduce damages to structures grandfathered in their present at-risk location at the time of enactment of the required ordinance, but the awareness that the delineation of the flood hazard zone has upon at-risk residents may lead to retrofits of the structure under existing programs (FEMA HMGP) or other measures that can reduce damages or loss of life.

Floodplain zoning which can be viewed as a distinct overlay zone applied to a standard land use zoning map was established and is regulated by the National Flood Insurance Program (NFIP) under FEMA, an agency within the United States Department of Homeland Security. Under the floodplain zoning program, municipal and county governments can establish flood hazard zones along watercourses or ocean/gulf shorelines according to an analyses of the flood hazard by FEMA. The Flood Insurance Rate Map (FIRM) established for a municipal or county area indicates various levels of flooding, the regulatory floodway or coastal V-zone and elevations of the various flood events. The availability and cost of Federally-subsidized flood insurance to the landowner are based upon this hydraulic data.

4.5.2.1 Existing NFIP Ordinances, Zoning and Insurance

Each of the three counties within the study area and all of the municipal areas are participating in the regular program of the NFIP. Table 7 shows the progressive entrance of these governmental units into the NFIP. In 1969, Hurricane Camille ravaged the Mississippi coast resulting in over 130 deaths,

Table 7.
City and County Participation in the NFIP

Community or County Name	Initial FHBM Identified	Initial FIRM Identified	Current Effective Map	Regular or Emergency Date
City of Pascagoula	09/18/70	09/18/70	03/15/84	09/18/70
City of Moss Point	09/18/70	07/01/74	09/04/87	09/18/70
City of Gautier	09/18/70	04/03/78	08/18/92	11/13/86
City of Ocean Springs	-	09/11/70	08/18/92	09/18/70
City of Pass Christian	05/26/70	05/29/70	08/19/87	05/26/70
City of Biloxi	06/27/70	06/30/70	03/15/84	09/11/70
City of Gulfport	05/26/70	05/29/70	10/04/02	09/11/70
City of Bay St. Louis	07/01/70	09/11/70	11/16/83	09/11/70
City of Waveland	06/27/70	09/11/70	11/16/83	09/11/70
City of D'Iberville	-	08/04/88	08/04/88	11/14/88
City of Long Beach	07/17/70	06/19/70	05/04/88	09/11/70
Hancock County	-	09/09/70	08/18/92	09/09/70
Harrison County	09/18/70	06/15/78	10/04/02	06/15/78
Jackson County	09/18/70	04/03/78	04/16/93	04/03/78

Source: FEMA NFIP data

over 3,800 dwelling units destroyed and damages exceeding $900.0 million. In the preceding year, Congress had enacted the National Flood Insurance Act of 1968. Although in its infancy, the National Flood Insurance Program was beginning to assist counties and communities across the nation that suffered repeatedly from riverine and coastal flooding when Camille hit the coast. Following the catastrophic affects of Camille, the three coastal counties (Hancock, Harrison and Jackson) and all 11 municipal areas affected entered the regular or emergency program of the National Flood Insurance Program by 1978. According to FEMA data, approximately 20,200 flood insurance policies were in affect in the project area prior to the arrival of Katrina.

In the early stages of the NFIP, information on appropriate methods of protecting coastal structures (V-zone) was limited, but engineering standards for raising structures on piling or piers were available and had been proven in many cases to withstand the savage pounding of surge, waves and wind from hurricanes along the Mississippi coast. Hundreds of structures were elevated along the coast to a theoretical 100 yr storm level (Base Flood Elevation) established by FEMA. As Table 7 shows, most of the 11 municipalities and 3 counties in the study area had initial Flood Insurance Rate Maps (FIRM) in place by 1978. In the intervening 26 years between Camille and Katrina, the study area has been visited by several hurricanes and tropical storms (Cindy 05, Elena 85, Georges 98 and Hanna 05) that tested the flood damage reduction measures instituted through the NFIP.

Fortunately, none of these storms was severe enough to cause extensive damages to coastal structures. Not until the arrival of Katrina in 2005 was the Mississippi coast confronted with another powerful hurricane that would test the flood damage reduction efforts of the local population. Post-event assessments and visual images of the damages to both seemingly protected and unprotected structures indicated that not all types of protection schemes were successful in the face of a combination of significant surge depths, wave heights and high winds.

Katrina's storm track traveled squarely over the mouth of the Pearl River at the Louisiana/Mississippi border and across the unincorporated community of Pearlington in Hancock County. This track put the coastal communities of Waveland, Bay St, Louis, Pass Christian, Long Beach, Gulfport, Biloxi, Ocean Springs, Gautier, and Pascagoula at the mercy of the northeastern quadrant of the hurricane where sustained hurricane-force winds, a massive storm surge and powerful waves demolished most unprotected structures. Unfortunately, hundreds of structures raised on various types of piers and pilings were likewise demolished as the huge surge (mimicking Camille in 1969) carried battering waves to the first floors and exterior bearing walls of wood-frame structures. Hundreds of these structures raised in compliance with local coastal management ordinances and constructed according to adopted building codes were unable to withstand this onslaught. Figures 10 through 17 on Pages 67 and 68 show the remnants of structures raised to the 100yr flood elevation (BFE). Observations of the Katrina damages showed that all concrete block and brick masonry columns founded on slab foundations failed. Most failures occurred at the junction of the column and the slab. In some cases, reinforcing bars were bent or ties failed at the junction between the column structure and the slab foundation (see Figures 38 and 39 on Page 79). Generally all wooden pilings and post foundations survived the Katrina surge and waves although in almost all cases the structure was washed off the top of the raised foundation by surge and waves.

As a result of the extreme damages and losses of life caused by Katrina, FEMA immediately began to re-evaluate the current BFE and other established flood levels upon which the existing coastal floodplain management ordinances along the Gulf Coast had been founded. Based upon this re-evaluation, FEMA issued a set of "Advisory Base Flood Elevation" (ABFE) maps for the Mississippi and Louisiana coasts. The new ABFE significantly raised the previous BFE elevation along the coast and inlets to acknowledge the potential damages that could be generated by a second storm that mimicked the surge, waves and wind generated by Katrina and to provide guidance for those who would be immediately rebuilding structures and facilities along the coastal areas.

Several project area communities adopted the ABFE's as the basis for their existing floodplain management ordinances and new construction has been held for the most part to those modified base flood elevations. In some cases, the communities just increased the amount of freeboard between the existing BFE elevation and the first floor of a raised structure to compensate for the differences in the new ABFE elevations. A few communities chose to use both techniques according to the flood threats within their area. Table 8 lists those municipalities and counties in the project area that either adopted the ABFE or modified the freeboard requirements for new construction or structure elevation in their existing ordinances. In addition to adoption of the new ABFE, participation in the flood insurance by area residents increased by 165 percent to around 53,600 policies.

Table 8.
Municipalities and Counties Modifying Existing Ordinances to ABFE

Community/County Name	Adopted ABFE	Modified Freeboard Requirements
Jackson County	X	X
Pascagoula	X	
Moss Point	X	
Gautier	X	X
Ocean Springs	X	X
Harrison County	X	X
Biloxi	X (proposed adoption)	X
D'Iberville	X	X

Community/County Name	Adopted ABFE	Modified Freeboard Requirements
Gulfport	X	X
Long Beach	X	X
Pass Christian		X
Hancock County		X
Bay St. Louis		X
Waveland		X

Source: FEMA Document dated March 2007

FEMA is generating a new set of Digital Flood Insurance Rate Maps (DFIRM's) that will be published for public review and comment by the affected counties and municipal areas. The revised maps will show modified boundaries and heights for the BFE (1% annual chance event) and 500 year (0.2% annual chance event) including revised water surface elevations associated with these zones. It is possible that the revised mapping may include adjustments to the V and VE zone boundaries as well. Once comments are received from the affected county and municipal areas, FEMA will publish the new FIRM's and the local governments will modify their existing floodplain management ordinances to incorporate the new zones and any additional text changes in the ordinances.

In view of these coming changes in the existing floodplain ordinances and recent FEMA design guideline initiatives, there are two potential early-action measures that could be instituted by local jurisdictions to reduce damages to future development along the coast. Each municipality and county should adopt the new DFIRM mapping and ordinance information when published by FEMA. In addition each municipality and county should adopt the *FEMA 550 Recommended Residential Construction for the Gulf Coast* guidelines that describe building methods and flood-resistant materials to be used in elevating or otherwise floodproofing structures in the coastal and inlet inundation zones. These guidelines could be adopted as a part of the undated building codes (see Section 4.5.3 below) or by reference in the floodplain management ordinances. Use of the FEMA 550 guidelines for future coastal construction could substantially reduce damages from future storms. Costs for both of these measures are minimal and are local administrative and legal costs.

4.5.2.2 Community Rating System (CRS)

The Community Rating System (CRS) is a voluntary program for communities that participate in the regular program of the NFIP. The primary objectives of the CRS are to reduce flood losses, facilitate accurate insurance ratings, and promote the public's awareness of flood insurance. The rating system provides a list of incentive activities that would take a community beyond the basic requirements of the NFIP to provide a higher level of protection to at-risk structures. Application of the incentive activities by the community results in discounts on flood insurance premiums for all insurance holders. The rating system ranges from 10 (lowest ranking and a 0% discount on premiums) to 1 (highest ranking a 45% discount on premiums). The incentive activities are grouped into four categories including Public Information, Mapping and Regulation, Flood Damage Reduction and Flood Preparedness. As a community implements incentive activities from one or more of these categories in their community, all participating landowners receive greater insurance premium discounts. Table 9 below shows the communities and counties within the project area that are included in the CRS program and their current ratings. Of the three counties and 11 municipal areas in the project area, one county and 8 municipal areas are participating in the program.

Table 9.
Municipalities and Counties Participating in the CRS

Community Number	Community Name	CRS Entry Date	Current Effective Date	Current Class	% Discount for SFHA	% Discount for Non-SFHA	Status
285251	Bay St. Louis	10/1/95	1/01/00	7	15	5	C
285252	Biloxi	10/1/96	10/1/03	7	15	5	C
280332	Gautier	10/1/94	04/1/00	8	10	5	C
285253	Gulfport	10/1/96	10/1/01	8	10	5	C
285255	Harrison County	10/1/03	10/1/03	8	10	5	C
285257	Long Beach	10/1/00	10/1/00	8	10	5	C
285259	Ocean Springs	10/1/92	10/1/02	8	10	5	C
285261	Pass Christian	10/1/93	10/1/03	6	20	10	C
285262	Waveland	10/1/93	10/1/06	5	25	10	C

Source: FEMA documentation

An effective nonstructural measure would be to encourage the remaining counties (Jackson and Hancock) and the 3 municipal areas (Pascagoula, Moss Point and D'Iberville) to participate in the CRS and realize the discounts in insurance premiums for their participating landowners. Implementation of several of the identified nonstructural measures would significantly increase the participating communities and counties current ratings and further reduce their insurance premiums. Costs for entering the CRS and complying with the requirements are minimal and local.

4.5.2.3 Potential Modifications to the National Flood Insurance Program in Coastal Mississippi

The NFIP is a complex Federal program of floodplain zoning regulations, construction and retrofitting guidelines and flood insurance requirements that is largely administered by local jurisdictions. In general the availability of government subsidized insurance for structures located in the nation's floodplains is contingent upon a county's or municipality's willingness to establish a local floodplain management program based upon the identified flood risks and to accept establishment and enforcement of floodplain zoning ordinances. Over the years since the program first began (1970), there have been numerous modifications of the NFIP based upon changes in insurance coverage, percentage of government subsidy, experiences in enforcement of the program nation-wide and major flood damage events such as Katrina. In view of these changes, other modifications to the NFIP could be possible in the project area that would, over time, result in changes to the development pattern and therefore reduce the potential for flood damages in the project area. These modifications would be affected through Congressional legislative and Federal agency administrative actions. Some of the possible modifications to the program that can be considered as nonstructural measures are discussed below:

4.5.2.3.1 Suspension of the Flood Insurance Program

Many structures along the nation's coast are only located in a hazardous location because of the opportunity to have the costs of flood damages offset by claim reimbursements from FEMA through the NFIP. Although FEMA has established limitations on the amounts of insurance coverage (more about that feature below) and significant structure damages require certain building modifications to reduce future damages, many structures only remain on a hazardous site because of the presence of insurance. In many cases, without that insurance coverage, landowners would eventually abandon their high-risk sites for more flood-safe locations. Usually, federally subsidized home mortgages and business loans require flood insurance on the structure when it is located within a defined hazard zone. In view of this, removing the flood insurance program either in part or totally for the entire coastal area in MS would have a direct impact on individual landowner's decisions to locate or remain in these hazardous areas. The insurance program for all zones could be dropped or just in the high-hazard zones (VE and BFE zones) or the zones could be dropped in a multi-year phase-out program starting with the VE zone.

Although somewhat "Draconian" in nature, this measure would place the full burden for repairs and recovery solely on the landowner whose home or business was damaged and on public institutions in the case of damaged public buildings. Certainly, removing the flood insurance coverage for homes and businesses in these areas would impact the lending institutions which have based their financial investment in the at-risk structure on the existence of flood insurance coverage that offsets the financial losses to the property and maintains the value in case of future ownership transfers. Depending upon the reaction of the lending institutions to the loss of flood insurance, the movement away from the coast could be rather sudden as at-risk mortgages were voided or remaining mortgage balances were required of the owners.

Should the reaction of the lending institutions not be quite so sudden, in time, gradually and based upon the number and severity of future storm events, landowners who were faced with a severely damaged home or even with frequent minor damages to their home would look for other flood-safe locations. Without a specific timeline for removal of these structures from the flood risk area, there is not an accurate method of determining when the flood damage benefits of this measure may occur. Since the gradual movement away from the coastal area would be event determined and since most large hurricane events are very infrequent, flood damage reduction benefits generated through this insurance driven migration from the coast could take decades to realize.

Although from a theoretical standpoint, abandoning the NFIP for this project area would in time result in a movement away from the hazard areas and a realization of flood damage reduction benefits, the administrative and political actions required to affect such a change in the NFIP would be loathsome to local officials and political interests. The billions of dollars of investment in coastal development within the project area supported by this insurance system would be left at the mercy of Gulf storms and the financial losses could be disastrous to the local economy. Therefore, suspension of the NFIP for the project area will not be carried into the formulation process as a realistic measure.

4.5.2.3.2 Reduced or Suspended Federal Subsidy

Another NFIP-based measure would be to significantly reduce or drop the federal subsidy on flood insurance policies for structures grandfathered into the NFIP when it was enacted within each community or county. Reductions in the Federal subsidy for flood insurance have occurred in the past. Without the federal subsidy or a substantially reduced subsidy, landowners would be faced with paying the full or nearly full actuarial rate for the insurance based upon the risk level for their home or business. This increased "land rent" cost would influence many to move away from the high-hazard areas. For wealthier landowners whose structure is located in a relatively low-risk zone (i.e. 500 yr zone), this reduction or loss of the subsidy would be a moderate impact on their disposal income, but for those less fortunate with a home or business in a higher risk zone (VE or BFE zones), this loss of subsidy may result in "forced" relocation to a less expensive piece of land.

This difference in measure impact calls up issues of equity and environmental justice in its application (may disproportionately affect low-income, fixed-income and minority populations) and may not be justified for that reason. Therefore reducing or suspending the Federal subsidy as a flood damage reduction measure is not being carried forward into the formulation process as a realistic measure.

4.5.2.3.3 Skewed Premium Rate Structure

Current flood insurance rates are based upon actuarial rates founded on the risk of damages from a series of flood events. When the insurance rate is established, landowners are required to pay a set-rate monthly or annual payment to cover the risk. Unless there is some change in the insurance program or flood risk, the monthly or annual payment remains consistent throughout the term of the insurance policy. Under this flat-rate policy it is possible that an insurance provider could suffer a significant loss on a damaged property early in its coverage period that would not be covered by paid insurance premiums.

To provide more protection for the insurance provider and challenge the landowner's decision to build a structure in a high-risk zone, the insurance payment schedule could be modified to require much higher up-front payments based upon the risk. For example, if a normal policy would require an annual payment of $2,500 ($208 per month) over a term of 10 years ($25,000 total), the revised policy (as a nonstructural measure) might require $10,000 in the first year, $7000 in the second year and the balance ($8,000) over the last 8 years. Under this method, the insurance provider would recover a larger amount of the total payment sooner to cover possible early-term losses and landowners would be faced with a financial disincentive to develop in a high-risk zone. The skewed rate structure could be based upon the increased level of risk with development in the VE zone or BFE zones having greater payments up front and structures in lower risk zones (500 year) having less premiums up front.

Again like the option of increasing the landowner costs for flood insurance by reducing the subsidy, skewing the payment schedule to collect a larger percentage of the total premium up-front may have a disproportionate impact on the low-income, fixed income and minority sectors of the coastal population and brings up issues if equity in its application. Wealthier landowners could absorb the larger initial payments while low income owners would be unable to afford such payments. Adjustments to the skewed rate schedule could be made to account for disproportionate impacts on low-income and minority populations, but surge inundation and wave impacts do not take into account one's bank statement. For these reasons, measures that would adjust the flood insurance premiums payment rate will not be carried forward into the formulation process.

4.5.2.3.4 Mandatory Flood Insurance

Although not an effective method of reducing flood damages or reducing losses of life, flood insurance is an effective way of reducing the financial impacts of flood damages to landowners and public entities. Many structures exist within the project area that do not have flood insurance and were damaged by Katrina. Not only does that uninsured condition place landowners in a difficult financial position regarding repair and re-occupancy of the structure but impacts the community by loss of property value (reduces property tax revenues over time) and potentially loss of business taxes.

In most cases, new home construction and occupancy is financed by a mortgage from one of a number of various financial institutions (banks, credit union, etc.). Under Federal law, new homeowners of structures determined to be within a flood hazard zone are required to secure flood insurance to protect the investment of the financing institution. Failure by the financial institution to assure the purchase of flood insurance for the new structure exposes that company to severe financial penalties. For this reason most new home and business construction found to be in a flood hazard zone is covered by flood insurance. However, in certain circumstances where a mortgage is not required to construct the building, this flood insurance step may be circumvented by the landowner.

In addition to the financial necessity of acquiring flood insurance, all county and municipal areas that participate in the NFIP will require a floodplain permit for any structure placed or constructed in an identified flood hazard zone. That permitting requirement will normally trigger the requirement for purchasing flood insurance by the building owner. However, in some areas of the coast, the oversight and enforcement of the existing floodplain management program is not at a level that assures full insurance coverage and many structures are placed or constructed without a permit and without insurance.

In some areas either dated flood hazard mapping or the lack of sufficient mapping results in new structures being placed or constructed in heretofore unidentified flood hazard zones. These structures, located in ignorance of the hazard, remain unprotected by insurance or appropriate building methods commonly used in flood hazard zones. This problem could be reduced by updating the flood insurance rate mapping in previously unmapped areas, but funds for that FEMA-supported process are limited.

In order to assure that all new and existing construction is adequately protected from the financial losses associated with storm and hurricane inundation and waves, all structures located within defined flood risk zones could be required to purchase and maintain flood insurance on the building and its contents. This mandatory feature would need to be instituted by the state, the counties or municipal jurisdictions for the project area as a more restrictive requirement over and above what is required by FEMA on a national scale. Such action by the local jurisdictions would provide financial benefits to the at-risk property owners as an upgrade to the local floodplain management ordinances through the CRS (see above). This mandatory requirement (no exceptions and regardless of the structure financing arrangements) for flood insurance in all zones with associated severe penalties (financial or administrative) for non-compliance would at least reduce the financial losses associated with large storms and hurricanes.

Mandating flood insurance for all structures located within an identified flood zone would reduce financial losses to landowners and other charitable organizations that frequently shoulder the financial losses due to flooding. However, merely having flood insurance coverage does not in and of itself reduce flood damages or the chances of loss of life. Many insured structures and their occupants were lost during Katrina. Since the objectives of the project are to reduce flood damages, not just to recover the financial losses due to flooding, mandating flood insurance coverage on all structures is not carried into the detailed formulation process.

4.5.2.3.5 Reduction in Maximum Insurance Coverage for Eligible Structures

Currently, the maximum flood insurance coverage per structure through the NFIP is $250,000 for residential structures (plus an additional $100,000 in personal property (contents) damages) and $500,000 for commercial business structures (plus an additional $500,000 for commercial building contents). Special options are available for condominium structures whereby blocks of unit coverage at $250,000 each can be purchased with the additional $100,000 contents damages coverage for each unit as well.

These upper limits on insurance coverage promote construction of large and expensive residential structures as well as condominium units and relatively large retail and office structures in high hazard zones. A modest condominium development of 50 units located in a high hazard flooding zone could place upwards of $12.5 million dollars worth of potential structure damages and $5.0 million dollars worth of personal property damages in jeopardy of loss. The recorded insurance losses from Katrina and similar storms along the Gulf Coast are a testimony to these liberal limits placed on individual structures and contents.

An affective nonstructural measure could be a significant reduction in the insurance coverage allowed for all structure types and personal property (building contents). Were insurance coverage limits to be reduced to a more moderate level ($80,000 per residential structure with $32,000 contents coverage - same ratio of contents to structure coverage as provided presently), there would be far less expensive residential structures and condominiums located in high hazard flooding zones. Similar reductions in insurance coverage for commercial structures (for example...$100,000 per structure with $50,000 contents coverage) would significantly reduce high value commercial/business development in high hazard zones. Although flood damages would still be possible, the financial losses to the flood insurance program would be lessened significantly in time and the lower limits may steer some types of development away from the waterfront entirely.

An alternative to reducing the overall coverage limits for all hazard zones would be reducing the insurance coverage commensurate with the level of flooding threat. For example, reductions in insurance coverage could be greatest in the VE zone with lesser reductions in the BFE and 500 yr zones. This method would better recognize the varying levels of risk associated with flooding along the coast and allow substantial growth to occur in the less risky areas.

Reductions in insurance coverage could be phased in over a 5 year period allowing landowners the opportunity to adjust their structures, contents, and locations to account for the percentage of structure and content value that would actually be covered by insurance in hazard areas. Concurrent changes in mortgaging terms by financial institutions to account for the reductions in insurance coverage would further encourage development to abandon the high hazard flood zones.

Reducing the insurable limits on floodplain development so that high value development is not encouraged in high-hazard areas and thus subject to loss would be a good method for reducing the financial losses due to storms and hurricanes. Reducing the limits of insurance coverage on residential and commercial structures would not directly result in a reduction in actual flood damages due to these storms but only compensation of the landowners for their losses. This measure also does not directly result in reduced risk of loss of life and in some ways may contribute to those losses in the future. Since the project objectives emphasize reductions in actual flood damages and loss of life rather than compensation for losses, reducing the insurable limits of flood insurance as a nonstructural measure is not carried forward into the formulation process.

4.5.3.2.6 Cumulative Damages or Cumulative Improvements as a NFIP Compliance Trigger

Currently under the NFIP regulations, any structure suffering storm/hurricane damages whose dollar value is greater than 50 percent of the assessed value of the structure triggers the requirement that the structure come into compliance with the NFIP regulations and the local floodplain management ordinance. That requirement could include elevation of the first habitable floor of the structure to the base flood elevation (BFE) identified in the current FIRM. Generally that damage calculation is completed and measured on an event-by-event basis and is not cumulative over several events.

Information from MEMA indicates that the State of Mississippi requires that counties and municipalities in the NFIP gather information on the value of structure improvements in the project area. When the dollar value of those improvements exceeds 50 percent of the assessed structure value, the structure is required to meet the requirements of the NFIP and local floodplain management ordinances. In addition to this state requirement, based upon information also from MEMA, the City of Pascagoula requires under their local floodplain management ordinance that storm-related damages used to trigger compliance with the NFIP and local floodplain ordinances be accounted for cumulatively over a ten-year period. Should the dollar value of the damages accumulated over that ten-year period exceed 50 percent of the assessed dollar value of the structure, that structure must be brought into compliance with the NFIP and local ordinances regarding the elevation of the structure's first floor with respect to the BFE.

Given the potential for a series of storm/hurricane events to result in significant but not substantial damages (as defined by FEMA to be greater than 50 percent of the assessed value of the structure) to a structure, thus indicating a structure in a location where repetitive damages may be possible, using the accumulation of damages over a period of time (say ten years or the lifetime of the structure) may result in more structures being brought into compliance or more structure owners deciding to move out of areas that receive more frequent flooding.

In light of these existing requirements, a modification of the local ordinances of each of the three effected counties and 10 effected municipalities (Pascagoula already using the cumulative damages process) would be to adopt the process of cumulative damages (over a period of time chosen by the local community or county) as a trigger for requiring compliance with the NFIP and local floodplain management ordinance. According to MEMA, the state requires collecting cumulative costs of improvements for each structure, local jurisdiction information that is made available by owners through the building permit process. The fee amount for the building permit is based upon the value of the improvements and there are financial penalties for undervaluing the cost of improvements. Using the dollar value of cumulative damages as a NFIP compliance trigger in combination with improvement values would help to assure that more structures come into compliance with the NFIP and that future damages are reduced.

4.5.2.4 Training and Education of Floodplain Ordinance and Code Administrators and Officers

Each of the three counties and 11 municipalities in the project area is participating in the regular National Flood Insurance Program. Under the regular insurance program, each of these governmental units has an adopted floodplain management ordinance and floodplain zoning maps of their jurisdiction. Once adopted by the general population of the city or county, the ordinance and all of its requirements (floodplain development permits, zoning variances, mapping, etc.) must be enforced and administered by a designated individual (Floodplain Administrator, Building Administrator, Zoning Officer, etc.) or office of that jurisdiction. In some cases communities contract out these services to specialized firms in zoning and ordinance administration, but generally this work is accomplished by the hired staff of the jurisdiction (i.e. planning and zoning department, public works, community development, etc.). In some cases, staff assigned to these positions are newly hired or do not have all of the up-to-date training available from FEMA and other sources.

Interpretation and administration of the zoning ordinances and use of the flood insurance rate maps requires specific skills and training to be proficient in their application and to avoid unnecessary legal actions. In addition to the basic tenants of the floodplain management program, changes in the NFIP occur on a regular basis requiring someone at the local level to be responsible for making necessary changes in the local ordinances and mapping to maintain compliance with the newest FEMA requirements.

FEMA provides ongoing training for local floodplain management officials as well as real estate brokers, insurance agents and those seeking certification in floodplain management and administration. Training classes are offered at selected sites throughout the USA as well as in FEMA regional offices. Some training is offered on the Internet or through home study by FEMA supplied materials.

A nonstructural measure that could be implemented at a relatively low cost would be jointly sponsored USACE/FEMA training classes for local floodplain management staff, mayors, county supervisors, city councils, Chamber of Commerce, hotel/motel associations, real estate brokers, surveyors, architects, engineers, and financial institutions. This training could be held on an annual basis or as new regulation or mapping changes emerged that affected the project area.

Costs for this measure would be confined to USACE and FEMA employee labor and travel costs to attend and administer the training classes. Annual O&M costs would be repeat training costs for new floodplain managers entering the system.

Considering the relatively low cost of providing this training and the potential benefits to the coastal residents that a better educated cadre of floodplain managers and zoning administrators would generate, these measures are all carried forward into more detailed formulation.

4.5.3 Building Codes

Like land use zoning, the adoption and enforcement of building codes is a police power of local governments enabled by state legislation. Building codes normally are limited to structure design and construction methods and materials selection to meet building use requirements and both environmental and weather conditions at the building site. Structure foundations, structural integrity, site grading to promote positive drainage, and utilities are all part of a comprehensive building code. Provisions for addressing flood-prone locations in the design and construction of structure foundations are an important feature of a well-prepared code and make its use in coastal areas imperative.

Application of building code requirements to the design and construction of structures has been proven to significantly reduce damages due to inundation, wave action and winds. Generally, building codes are enacted and enforced through municipal and county ordinances. In some cases code application and enforcement occurs through city and county planning offices, community development departments or public works departments. Local adoption of building codes is encouraged by insurance companies, fire marshals, building contractors, mortgage financing institutions and real estate brokers. In flood hazard areas including V-zones, FEMA encourages all communities to enact and enforce these codes as a preventative measure in reducing insurance losses under the NFIP.

Over the years of code enactment and enforcement, a number of different code standards have been promoted. At the turn of the century, the insurance industry developed what many consider to be modern building codes in response to major urban fires in the United States. The National Board of Fire Underwriters published its National Building Code in 1905 as a model code; that is, a standard code that could be adopted by any locality. Localities could add additional construction restrictions but the basic model was the minimum standard for building construction.

During the first half of the twentieth century, three major regional model code organizations evolved. Building Officials and Code Administrators International, Inc. (BOCA) founded in 1915, International Conference of Building Officials (ICBO) founded in 1926, and Southern Building Code Congress International, Inc. (SBCCI) founded in 1940. The International Code Council (ICC) was established in 1994 as a nonprofit organization dedicated to developing a single set of comprehensive and coordinated national model construction codes. That ensuing "International Building Code" is now generally accepted as the national standard for building construction and its requirements for building construction in flood hazard zones (including V-zones) is widely acclaimed as a major step in construction technology.

As a nonstructural measure that would be effective in reducing future flood damages, each of the 11 municipalities and three counties should adopt the latest version (2006) of the International Building Code (IBC) and Residential Building Code (RBC) as their standard building codes and especially enforce those sections (or Appendices) of the codes that pertain to construction of residential and commercial buildings in flood hazard areas. Adoption and enforcement of the IBC would assure to a certain extent (with qualified inspections during construction) that structures built or additions to buildings in flood hazard zones are able to withstand the forces of water, waves and wind generated by storms and hurricanes and that water-resistant materials are being used in the construction.

Based upon a search of the city and county government Internet sites within the project area, several of the municipalities and counties have already adopted the 2003 version of the International Building Code as their standard building code. The code administration offices of each county and municipality should be encouraged to adopt the updated 2006 IBC (residential and commercial versions) which includes special considerations for flood-resistant construction. Based upon the ICC publication "Code Changes Resource Collection – 2006 IBC" dated June 2006, there have been numerous code changes between the 2003 and 2006 versions of the IBC. Many of these changes are specifically aimed at reducing damages to structures that would be located in flood hazard zones. Additional changes have been incorporated into the 2006 version of the IBC and RBC that address wind damages as well.

In addition to the adoption of the updated IBC in the project area, special education classes should be established in local Vocational/Technical Centers, universities and colleges that offer training in the use of the updated IBC to code administrators, contractors, architects, building inspectors, and landowners contemplating significant repairs to their structures that would require a building permit.

As a nonstructural measure, the recent publication of the FEMA guidelines for construction in Gulf Coast flood hazard areas should be adopted by the counties and municipalities as a part of their floodplain management zoning code and/or their building codes., The FEMA 550 *Recommended Residential Construction for the Gulf Coast* provides valuable design and construction guidelines for various types of residential buildings including building and site evaluations, construction processes, foundation designs, flood resistant materials, engineering data and information sources. In 5 chapters and several appendices this publication provides sound technical information for elevating structures in flood hazard zones.

The FEMA 550 guidelines give technical information on elevating residential structures in the V-zones although the recommendations in this nonstructural plan are strictly to avoid that practice because of the dangers posed by storm surge, waves and hurricane-force winds that would be prevalent in the V-zone. In view of the potential for storms and hurricanes larger than the design event used to formulate the nonstructural plan in this appendix, elevating residential structures in the V-zone could lead families to occupy their homes during an event that would exceed the design specifications of the construction resulting in total failure of the building foundation or walls and loss of life.

Costs for upgrading building codes is confined to purchasing the new codes from the ICC or other sources and administrative and legal costs for incorporating the codes into the existing municipal and county ordinances. Annual O&M costs for this measure are administrative (enforcement and variances) and local. Since local jurisdictions can charge fees for building permits, their costs to update and maintain the IBC and perform inspections of construction can be recovered.

The revision of existing building codes is a relatively inexpensive method of assuring that new construction, building additions or rehabilitation will be constructed in such a manner as to significantly reduce flood and wind damages to structures in the project area. Since the revision of building codes contributes to reducing hurricane and storm damages they are carried forward into more detailed formulation.

4.5.4 Land Use Regulation and Zoning

Land use regulation, more commonly referred to as zoning, is a measure frequently used by local entities (counties and municipalities) to arrange and regulate various land uses within their jurisdiction. Enactment and enforcement of land use zoning helps to avoid conflicts between uses (i.e. industrial and residential), reduce traffic congestion, maintain property values and promotes other social, economic and environmental objectives.

Zoning of private property, like building codes and other land use regulation is one of the police powers granted to local jurisdictions by the states. This method of land use control has been upheld in the judicial system (State, Federal and US Supreme Court) and has helped to shape the physical, economic and social pattern of many cities and counties in the USA. Local zoning is usually required by state enabling legislation to be preceded by a comprehensive plan for the community or county area that includes an official map or plan of the community's land uses and projected development pattern. Also, significant rezoning of property normally requires a preceding, and approved change in the approved official map in the comprehensive plan.

Title 17 of the Mississippi Code authorizes the dividing of property within any municipality or county into specific zones to accomplish the goals and objectives set forth in the comprehensive plan (or official plan) and to fulfill other purposes as described in the Code. In particular, Section 17-1-7 states *"Except as otherwise provided in Article VII of the Chickasaw Trail Economic Development Compact described in Section 57-36-1, for the purposes set forth in Section 17-1-3, the governing authority of each municipality and county may divide the municipality or county into zones of such number, shape and area as may be deemed best suited to carry out the purposes of Sections 17-1-1 through 17-1-27, inclusive. Within the zones created, the governing authority of each municipality and county may, subject to the restrictions with respect to agricultural lands and farm buildings or structures as set out in Section 17-1-3, regulate and restrict the erection, construction, reconstruction, alteration, repair or use of buildings, structures or land. All regulations shall be uniform for each class or kind of buildings throughout each zone, but regulations in one zone may differ from those in other zones."*

Zones or districts are labeled by the predominant land use type allowed within that zone such as residential, commercial or business, industrial, institutional or public, parks and recreation, transportation, vacant, and open space. Each general use zone can be further divided into density sub-zones (R-1, R-2, C-1, B-1, etc.) denoting units per acre or floor area ratios of each use type. Special overlay zones can be added to the normal zoning pattern to address sensitive environments, architectural aesthetics, economic development, environmental hazards, agricultural or historic issues or developmental programs. Zoning ordinances normally describe the types of uses allowed in each zone or district and prescribe certain other limitations or development requirements for each zone. Zoning ordinances can be used to limit development in certain high-hazard areas or areas with sensitive environmental resources.

Under the umbrella of this state enabling legislation, each of the three counties and 11 municipalities being studied in this report may (and have) established land use zoning ordinances for their jurisdictions to fulfill the goals and objectives of their comprehensive plans. As an example, Figure 8 shows the land use zoning map for the City of Biloxi, MS. The color coding identifies the various land uses (residential, commercial (business), industrial, central business district, waterfront and others) and the interfaces between the uses. In the example below, shades of yellow denote residential uses; red and orange indicate commercial uses and dark blue denotes the Biloxi central business district (CBD) at the Gulf shoreline. The designations of B-1, B-2, RM-10, etc. for each color indicate land use densities such as dwelling units per acre or as an expression of floor area ratio for commercial uses on the parcel.

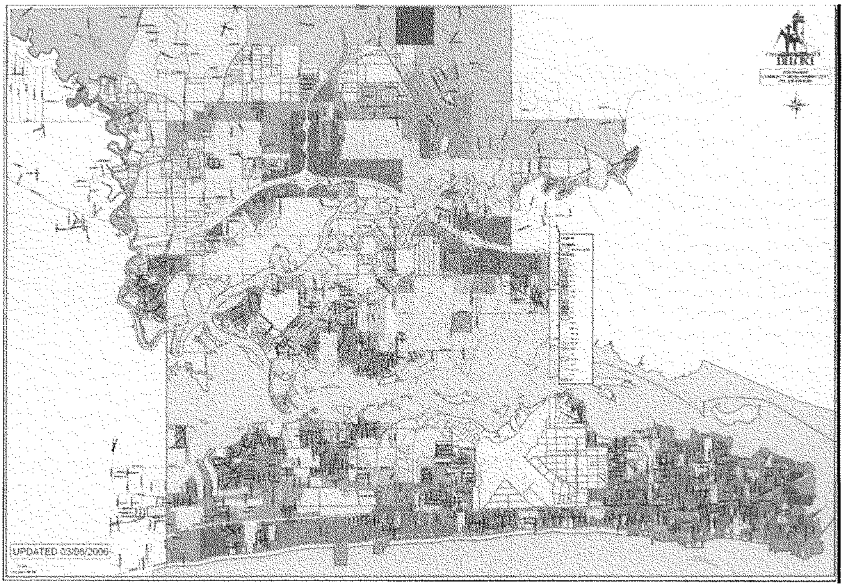


Figure 8. Biloxi Zoning Map

The courts have overturned numerous zoning ordinance determinations by communities and have stricken numerous zoning ordinances where zoning restrictions on private property have literally removed all reasonable use or economic value of the property to its owner. Courts have ruled that such Draconian zoning ordinances constitute a "taking" of private property and require reimbursement of the property value to the owner or retraction of the ordinance itself. Zoning private property that is subject to natural hazards (flooding) such that its value is significantly reduced borders on a taking that may require acquisition of the property at fair market value. See Section 4.5.2 - Floodplain Management, Floodplain Zoning, Flood Insurance and CRS on the application of zoning measures in the floodplain.

Generally speaking, land use zoning or rezoning as a measure for reducing flood damages is largely ineffective in many cases because of the amount of existing at-risk development that has been "grandfathered" into the zoning ordinance at the time of its enactment. These "non-conforming uses" cannot be totally removed through the zoning ordinance process unless they are destroyed (declared unsuitable for occupancy or a hazard) and then reconstruction is possible so long as the new structure and its use conform to the zoning district requirements. Again, overly restrictive covenants on the property would constitute a taking and require compensation of its value to the landowner. Only in the application of floodplain zoning and then only in the case of the regulatory floodway can such absolute redevelopment restrictions be upheld in the courts.

In areas where no development has taken place (interspersed vacant land) or where development has been largely removed (total loss areas), zoning or rezoning of the property could accomplish several project objectives. Property devoid of structures only retains its basic land value as dictated by market forces. That land value is influenced to some extent by the natural hazards that may endanger any development that would be constructed on the property. In the case of the study area, there are vast numbers of privately-owned tracts where the structure has been totally destroyed leaving only a concrete slab or wood pilings from the previous foundation. In these cases, rezoning the property for other land uses more adaptable to and compatible with the natural hazards may indeed accomplish several program objectives.

Zoning of high-risk properties bordering the coast and some of the inlet areas could be used to reduce the incidence of damages to certain types of development or all development. As discussed earlier, overly restrictive zoning that removes all economic opportunity of the property to its owner would be found to be a taking under the 5th Amendment and require just compensation. Attempts to rezone property previously zoned as residential or commercial uses for which the land may bear an economic return for its development or sale to park, open space or environmental uses zoning would raise that red flag of a taking.

Although a single zoning action that would prohibit all development within a specified area along the coast would significantly reduce flood damages in the project area, without full compensation of the fair market value for the property such zoning could be stricken in court. Significantly reducing the density of development from four dwelling units per acre to one dwelling unit per acre may be possible, but a court ruling may still consider that action to be a taking and the current ownership pattern may void any opportunities for actual implementation of such a rezoning change. In effect such restrictive zoning is no different than a complete mandatory buyout of the high-hazard zones.

Another option for rezoning the high-risk coastal and inlet areas may be to recognize the ability of higher density type development (development which commands a higher economic return for the property) to financially meet or exceed the restrictive building codes and extra requirements imposed by FEMA guidelines for development in these high-risk zones. While single-family homes, private-owner motels and chain restaurants generally do not have the financial resources to meet the restrictive construction guidelines or cannot be architecturally adapted to the guidelines, a mixture of high-density commercial and residential units may be able to meet those guidelines and still return a significant economic return to the owners.

Zoning the coastal areas for mixed-use commercial and residential at per-acre densities that would force building construction to be predominantly vertical combined with FEMA guidelines for first floor elevation could result in a number of multi-story buildings perched above parking garages along the beachfront. A mixture of residential condominiums, casinos, retail shopping and other associated uses perched on multi-decked parking garages would allow intensive reuse of what is now largely vacated land except for residential single-family foundation slabs and FEMA trailers.

In addition to reuse of these uneconomic properties, this form of redevelopment would generate significant tax revenues, employment opportunities, windfall profits for existing beachfront landowners and produce a significant structural wind break for development landward of this corridor. The nonstructural team observed these "wind-shadow" effects (as well as surge/wave-shadows) along the coast where more substantial building construction along the beach protected numerous residential and commercial structures located just landward of that building line – in effect a building "line-of-defense".

More importantly than the potential benefits to intensive use of the beachfront properties through rezoning is the fact that such zoning would not be viewed as a taking requiring compensation. This rezoning would be considered as a financial windfall for existing landowners whose property would become exceedingly valuable to new developers. Similar in some respects to the TDR concept, coastal land otherwise of little value would have far higher value in this new market situation thanks to rezoning. Properties found to have potential for ecosystem restoration as wetlands could be purchased and developed as buffer areas landward of the high-density beachfront and integrated with golf-courses or other passive uses (trails, etc.).

In addition to zoning, another frequently used land regulation mechanism is Subdivision Regulations. These regulations prescribe requirements for the subdivision of land into individual lots for construction of either or both residential and commercial uses. The regulations address design and construction of all land improvements within a subdivision including platting of subdivided land, site grading, drainage, streets, utilities, site hazards, right-of-ways, easements, and lot setbacks. Developers wishing to subdivide land into individual lots for residential and/or commercial use must submit development plans (prepared in accordance with the subdivision regulations) to the Municipality or County where the site resides for approval. Usually both a preliminary plat and final plat that address all of the concerns listed in the regulations must be submitted for approval before any construction may begin.

Subdivision regulations can be modified such that the inundation threats for each lot can be delineated on the developer's submitted plat map and the regulations themselves can place certain restrictions or requirements on the developer to assure that the future landowners within the subdivision are either protected from defined inundation depths or made fully aware on their property map of the potential inundation threat on their lot. Since construction of any subdivision (where such regulations exist) depends upon approval of the submitted plat map by the local government, these restrictions and requirements with respect to inundation threats can be very effective for any new growth in the project area.

Costs for changes to zoning ordinances or subdivision regulations are local, administrative and minimal in nature compared to other alternative measures. Normally, municipal or county planning or engineering staff personnel, or planning commission or zoning board members administer zoning actions (variances, meetings, reviews, etc.) and subdivision application reviews.

Considering the level of control that these land use regulations can assert on the development and use of land within each jurisdiction in the project area, land use regulation (zoning and subdivision regulations) have been carried forward into more detailed formulation of nonstructural plans.

4.5.5 Development Impact Fees, TDR, PDR, and Redirection

4.5.5.1 Development Impact Fees

Communities nationwide use monetary development impact fees to address external costs resulting from land development projects that impact associated community services and amenities. Normally these impact fees address additional loadings on school systems, libraries, infrastructure (utilities, roads, collection services), fire, police and emergency services and other public services that support new development (especially residential and commercial development that use those services most).

Generally development impact fees have been upheld in the courts provided that they are levied fairly by an governmental entity legally able to collect such fees, that they are collected for addressing a legitimate public purpose, and that the method of collection most closely resembles the objective for the fee so as to not approximate a taking. In this case, support of a redeveloped and robust emergency services system that would be applied to many types of hazards (especially hurricanes and floods) would be a legitimate purpose for the fees. As such an emergency facility would be directly related to structures and families living on the flood-prone lots from which fees were collected, the legal nexus would be sound.

These monetary impact fees could be applied to new land development or subdivision development on a per lot basis to address municipal or county costs associated with flood emergencies and the aftermath cleanup in damaged areas. The level of fees assigned per lot would be directly related to the level of flood risk at the individual subdivided lot – greater the flood risk, the higher the fees (i.e., V-zone - $10,000/lot, A/AE Zone - $8,000/lot, B zone $4,000/lot). Developers of the subdivided sites could reduce the fees by receiving local planning commission approval on specific, bonded measures that reduced the flood hazard on the lots.

Costs for instituting development impact fees are local and administrative in nature.

4.5.5.2 Transfer of Development Rights (TDR) and Purchase of Development Rights (PDR)

Transfer of Development Rights (TDR) and Purchase of Development Rights (PDR) are land use control mechanisms predicated on the concept that landowners' rights to develop their property can be separated from other land rights (mineral, air, surface, etc.) and traded or purchased within a market-like system. Generally speaking any land use controls (zoning, etc.) that significantly decrease the market value of property or remove an opportunity to receive some economic value or use from the property have been considered a taking under the Constitution and require compensation to the landowner. TDR has been found in the nation's courts to be a legal device for transferring that portion of a landowner's rights to the property for compensation in a market-like process that avoids the "takings" issue. As the programs are strictly voluntary in nature, the takings issue is set aside. The ability of local governments to establish and operate either a TDR or PDR program is normally enabled by enactment of state legislation.

In TDR, the landowner's right to develop certain property (sending lot) that may be environmentally sensitive, historic, scenic, prime agricultural land or flood-prone, can be offered as a market item to be purchased (monetary transaction) by other landowners whose land (receiving lot) is not restricted by the same environmental, hazard or historic parameters. Normally the receiving property is provided a density bonus whereby more units of housing or commercial floor space development can be permitted on the same land area with the purchased development rights. TDR programs are popular within the United States and have been used successfully (i.e. Maryland) to reduce losses of sensitive environmental landscapes, historic buildings, and agricultural land or restrict development on hazardous property while allowing land development and the tax revenues associated with growth to increase.

A TDR program can be established by a local unit of government, such as a county within which both the sending and receiving property are located. Based upon documented parameters, sending properties are identified and values associated with the development rights are established. A number of properties in the sending area can be formed into a "sending district". Landowners of potential receiving properties (which are designated as "receiving districts") are given the opportunity to purchase (monetary transaction with the sending landowner) those rights. The owner of the sending property retains ownership of the land but is not able to develop the property under the terms of the transaction. Normally, property taxes on the sending lots are reduced substantially to reflect the loss of potential development. The sale of the development rights is documented on the property deed and encumbers the deed in future land transfers.

Establishment of a TDR program in the project area would require the enactment of state enabling legislation. Examples of that legislation are available from other states and the costs for instituting and operating the program are local and administrative. All other costs are contained within the land development rights transfer market. The establishment of a TDR program was one of the 180 suggestions offered by the public and cooperating agencies.

Purchase of Development Rights (PDR) accomplishes the same objectives as TDR but requires a unit of government (county or municipality) to purchase all or some (development easements) of the development rights of the subject property. Generally the value of the development rights reflects the appraised value of a structure type (residential or commercial) that would be permitted under existing land use zoning. The value and limited use of the land and its reduced property tax burden remains to the landowner. This development rights purchase program is unlike the TDR program in that the development rights are not resold or traded through a market mechanism, but held in a public trust and used for public uses (recreation, etc.) or left in their present land use (historic preservation, ecosystem, scenic easement). A successful PDR program is operating in Lexington, Kentucky where development rights of horse and agricultural farms surrounding the metropolitan area are being acquired to preserve the scenic quality of the landscape and forestall subdivision development outside of the municipal water and sewer service area. The value of the development rights is being established through a comparison of tax assessments displaying both with and without future development values of the tracts.

As is the case with TDR, a PDR program would require enactment of state enabling legislation. Costs for instituting the program would be local and administrative or could be operated through a non-profit organization. Costs to operate a PDR program would require sizable sums of capital with which to purchase the development rights of interspersed vacant lands in the project area. Funds could be secured from the state or through local taxes or assessments to fund the land purchases.

Both TDR and PDR could be used in the project area to acquire development rights of parcels subject to frequent inundation or that are environmentally sensitive. Properties subject to inundation by surge and waves or that are prime ecosystem habitat could be designated as the sending district and property located above the 500 year event or the Maximum Probable Intensity Hurricane surge-plain could be designated as receiving districts. Monetized property development rights could be designated in the sending district and sold by the administrating agency to eligible property owners in the receiving district – a transaction that restricts development in otherwise hazardous or environmentally sensitive areas with compensation provided through a private market process. More dense development in the receiving district would offset property tax losses in the sending district. Tax-sharing agreements between the sending and receiving districts could offset losses in the TDR sending areas.

Since both of these programs are voluntary in nature and are essentially market-driven processes, they are not easily scheduled as other more proscribed measures (acquisitions or floodproofing). Given this characteristic, both TDR and PDR may be more applicable to high-hazard, interspersed properties that were vacant prior to the Katrina event where development pressures are not as high. These properties are less likely to be redeveloped in a short period of time giving the process time to acquire the development rights. Using either TDR or PDR to restrict development of these properties would accomplish many of the planning objectives without direct Federal expenditures.

Both of these measures should be carried forward into a more detailed nonstructural plan formulation process. Requirements for state enactment of the required enabling legislation would have to precede implementation of the measure by local governments.

4.5.5.3 Land Development Redirection

Land development redirection considers that rational Federal, state, county; municipal, corporate and private landowners when confronted with ongoing natural or man-made threats that result in damages to fixed assets will over time migrate to locations that avoid such continuing losses. In situations like Katrina, where physical damages are catastrophic and there are losses of life, some migration out of necessity would occur at least temporarily. Reconstruction back within hazardous areas does occur so long as the risks of future events can be mitigated or the risks are ignored by landowners due to cultural, social or financial influences. As discussed in Section 4.5.2 above, certain loss off-setting programs such as flood insurance can delay that long-term permanent migration so long as the insurance carrier chooses to continue reimbursements for damages. As is now evident by the many court battles between landowners and insurance carriers along the coast, that continuing reimbursement for damages may be ending soon.

For public facilities (schools, fire stations, police stations, hospitals, emergency services, public works facilities, etc.) that are: 1) more expensive than residential or commercial uses to repair following damaging events, 2) that need to maintain continual services (some emergency services) to thousands of citizens, and 3) have to be repaired with either disaster mitigation money or local taxes, maintaining such facilities in hazardous areas becomes a burden on the financial and political resources of the community. Both county and municipal governments can, over time, successfully relocate certain public facilities out of hazardous areas through judicious use of funding authority in their Capital Improvement Programs.

Capital Improvement Programs (CIP) are enabled by state legislation and allow local governments to construct new facilities or rehabilitate existing facilities to serve public purposes or in some cases purchase very expensive equipment (vehicles, pumps, electronics, etc.) that would be beyond normal purchase limits under local annual operation and maintenance fund accounts. Local governments establish capital improvement programs based upon approved public facilities plans either through a comprehensive planning process or some other process provided for in the state enabling legislation. Under this CIP, a county or municipality could issue bonds, borrow funds or use tax receipts to fund replacement of public facilities that are located within hazardous flood zones and have been repeatedly flooded or are reaching the end of their useful design life. Generally, substantial redevelopment/replacement of public facilities by local governments is a long-term process due to the high costs involved and the political processes necessary to resolve service area disputes and other social issues.

Although careful exercise of land development policies, regulations and programs (such as the CIP) can result in eventual changes in land use that decrease development in high hazard zones and increase growth in less threatening areas, more direct action can be taken that accomplishes the same objectives in a much shorter time period. Specific actions that redirect growth and redevelopment into less hazardous landscapes can be supported with capital investments in land acquisition and infrastructure development and either Federal or State supported mortgaging assistance.

In a relatively stable housing market such as existed prior to the landfall of Katrina in the project area, new housing starts away from the coastal floodplain were sufficient to handle consumer demands for larger and more amenity-filled homes. Relatively new developments such as Diamondhead and other PUD's away from the coastal floodplain were based upon an exclusive housing market demand and lack of sufficient and affordable vacant land within walking distance of the beachfront.

Prior to Katrina, residential development along the coastal floodplain was required by ordinance to adhere to FEMA regulations and the latest version of the municipal or county FIRM. Following Katrina, the establishment of the Advisory Base Flood Elevation by FEMA, disagreements on insurance settlements, lack of flood insurance and insufficient personal capital have resulted in little redevelopment of destroyed housing along the coast. Katrina and the loss of tens of thousands of homes resulted in a severe housing shortage to accommodate displaced landowners and any new arrivals. The past demand turned overnight into a housing need that did not have sufficient available flood-safe residential lots, infrastructure, construction capital, or mortgaging funds. Fortunately many of the displaced population left the area entirely reducing some of the burden on the already damaged housing market.

In order to address the shortages of available residential lots and selected commercial redevelopment that would support construction of new residences, a government-assisted program (county, state or Federal) of new redevelopment sites could assist in redirecting growth away from the coast and to flood-safe sites. This method of redirecting growth has been used successfully in other flood damaged areas where the housing market is unable for whatever reason to recover and provide needed replacement units. Adding flood-safe units to the housing market not only opens up additional resources for displaced homeowners to return to the project area but provides relocation housing for those whose property may be purchased as a result of applying either structural or nonstructural measures as part of a Corps project. Increasing the availability of reasonably priced development lots also eases the cost pressure on limited market opportunities.

Numerous redevelopment sites can be selected, planned, designed and constructed at a designated flood-safe elevation that would entice people living in FEMA trailers on property where only a concrete slab remains to move upland and away from future flood damages. Necessary site improvements (land clearing, grading and drainage) and infrastructure (utilities, roads, etc.) would be provided with mortgage assistance available through government-sponsored relocations and housing programs. These types of relocation and redevelopment projects have been successfully implemented in other regions as part of nonstructural and structural projects.

In-fill developments within existing communities that are less flood-prone could help to reduce the social and economic impacts of relocations. Several opportunities for in-fill developments were identified during the community assistance design charrettes conducted in 2005 and 2006 under the Mississippi Renewal Program. These in-fill projects would absorb a number of relocations with floodproofed structures within urban areas featuring existing infrastructure and services. Collaboration with local planning commissions and development authorities for in-fill projects would help to assure successful integration of relocatees into the existing community fabric. Care must be taken to assure that in-fill relocations do not overtax schools or other public services within receiving communities. Section 4.5.9 - Permanent Acquisitions contains a more in-depth look at infill developments as a redevelopment concept.

In some communities such as Waveland, Pass Christian and Bay St. Louis where a mandatory acquisition plan applied to high hazard properties along the coast would result in large scale relocations of the population to less-flood-prone areas, another redevelopment plan may be in order. In these special cases, relocating whole neighborhoods or communities as an intact social entity should be considered. In the absence of planned community relocation, these municipal areas would merely be dissolved in time due to a lack of human resources and a crippled economic base.

Planned community relocations would provide the opportunity to accommodate all existing flood-prone land uses into a flood-safe location in a coordinated way that would maintain many of the basic social and economic associations now thriving in the present community. Developing planned communities could also reduce the impacts of a dispersed population impacting public facilities (schools) and services (police, fire, garbage, etc.) in the destination communities.

The challenges in planning large-scale relocation communities in a developed region center on aggregating sufficient land on which to design a coherent community layout. A review of available aerial photography for the project area shows limited development opportunities of any appreciable scale south of Interstate 10 except for a few isolated parcels. Moving north of Interstate 10, there are opportunities that can be explored for relocation communities. These sites would be investigated in greater detail for their possible use as Housing and Community Redevelopment Sites as an adjunct to the permanent acquisition measures.

Obviously redirection of land development can be more successful in coastal areas that are less urban in character, where sufficient flood-free land is available for the redirected community development to occur and where recent events such as a major hurricane have resulted in significant damages to coastal structures and communities. In areas of the Gulf coast that were not directly affected by Katrina or other recent hurricanes, this strategy would be more difficult to implement given the lack of incentives or necessity to move away from these high-hazard areas. The inertial forces associated with a non-threatening, highly aesthetic coastal location are formidable. Formulation of protection strategies for these non-impacted, urban areas may concentrate on measures that emphasize protection in place rather than redirection of development.

Costs for redirection of growth in the project area would be substantial. Site acquisition, site improvement and infrastructure costs could range between $25,000 and $45,000 per subdivided lot. Depending upon the number of lots developed and the amenities provided redevelopment communities (500 units) could cost between $10.0 and $20.0 million each. Implementation of this process would take several decades depending upon funding constraints and the willingness of the project participants. In view of the potential for "tiering" of the nonstructural measures, land development redirection would fall into the later tiers of implementation.

Development impact fees, TDR and PDR and Land Development Redirection are all techniques that act as incentives or disincentives to redevelopment in hazardous coastal areas. Because they are proven methods for reducing damages to potential future growth they are carried forward into more detailed plan formulation.

4.5.6 Land Taxation Policies, Special Assessments and Revenue Sharing

4.5.6.1 Land Taxation Policies

The taxation of private property through the *ad valorem* tax process, besides being a method of raising revenues with which to operate county and municipal services, can be used as an economic system of incentives and disincentives for directing land use development. Normally, private property taxes are established based upon categories or classes of land use (residential, commercial, agricultural, industrial, and vacant) and their location within or outside of municipal areas. Property taxes are a reflection of the assessed value (a percentage of fair market value determined by the tax assessor) of the land and improvements and locational aspects of the property. Normally property is taxed at a percentage of its true assessed value. Properties are divided into taxing districts that reflect values and which taxing authorities (schools, services, etc.) apply to that location. Different millage rates are applied to each district.

Property taxes are calculated using millage rates determined by the tax assessor's office. The millage rate is determined by dividing the amount of total revenues needed to operate and maintain county and or municipal services (that portion supported by taxes) by the total assessed value of all property within the county (excluding exemptions) or a particular district. The millage rate or "mill" represents one dollar of tax per $1,000 of value of assessed value on the property. Adjustments to the rates are made based upon the property classifications and units of government (county or city) where the property is located.

Since revenues derived from property taxes are a reflection of the costs of maintaining services that support that property, additional costs for maintaining certain classes or locations of property could be defrayed by increasing the assessments or millage rates applied to those "high-maintenance" properties. In other words as the tax district budget increases due to responses to flood events, the millage rate is adjusted to capture those costs from property taxes. Properties located in flood-prone areas that require a higher percentage of public services for support could be taxed at higher rates to reflect that increased service demand. This economic disincentive on development would in time discourage growth in that area. Likewise, for certain aspects of property maintenance provided by a municipal or county that are cheaper because of their location (flood-safe), taxes on those properties could be lowered as an incentive to encourage building in those safer (less-costly) areas.

Costs to modify tax millage rates are local and administrative/legal in nature. The costs to modify the rates are not as compelling as the public reaction would be to making the changes.

4.5.6.2 Special Assessments

In addition to modifying existing millage rates for property taxes in high hazard areas, special assessments on flood-prone property could be used as a disincentive to further development. In theory, taxes from individual land uses should be set such that the costs of delivering public services to that use are offset by the annual taxes accruing to each parcel. In practice property taxes rarely collect sufficient revenues to fully capture all of those costs, but in situations where a property or properties are subjected to recurring damages (such as flooding) including damages to infrastructure that services that property, those costs far exceed the property tax revenues. In these cases, special assessments can be levied against those properties to capture additional revenues for the higher costs of services delivery, infrastructure repairs or to capture windfall benefits accruing to property due to some public improvement that services that property. A special assessment tied to the higher costs of services delivery in a hazardous taxing district would raise the tax burden on properties in that hazard area and in time redirect growth away from those higher cost properties. The special assessments would be added to the existing millage rate of that tax district to support higher costs of service delivery or repairs to infrastructure. Basically used as an additional revenue producer for the public services provider, special assessments can also act as a disincentive for future growth in hazardous areas.

Like modifying tax millage rates, the costs of enacting special property assessments are local and administrative/legal in nature. The public reaction to the assessments (perceived by many as a tax burden) would be much more problematic.

4.5.6.3 Revenue Sharing

An ongoing malady confronting many municipal governments is the rush of downtown businesses and residential growth to more rural county locations. This shift of property tax revenues from municipal to county areas further exacerbates the plight of deteriorating downtowns. This process has been occurring for many years as new transportation opportunities and development sprawl extend growth into non-municipal areas. The affects on the nation's cities are evident everywhere as the thresholds of commercial and public services for losing and gaining communities are approached. Many unique strategies to mitigate the economic and social effects of these migrations have been implemented across the nation. Those strategies include establishment of metro-governments and revenue sharing.

In the case of the project area, use of TDR, PDR, rezoning, taxation polices, changes in the NFIP, planned acquisitions and relocations, all affective nonstructural methods of reducing damages, would in time gut the economic hearts of the existing cities on the coast. Municipal areas like Pascagoula, Biloxi, Gulfport, Pass Christian, Bay St. Louis and Waveland could experience massive reductions in private property ownership and the taxes produced by that property as development is acquired and/or redirected north towards the I-10 corridor and beyond. In an effort to offset these losses, two strategies are possible.

First is the establishment of metro-governmental structures whereby the county and municipal governments are joined into a more regional structure that can address the equitable delivery of public and social services and more evenly distribute tax revenues collected throughout the new jurisdictional boundary. Metro-governments are used across the nation to address the economic effects of sprawl and migration of business and residential taxes from municipal to county governments. Another strategy that can be instituted to defer the heavy losses of revenues associated with business and residential migration is revenue sharing. Municipal/county agreements could be negotiated whereby all or portions of tax revenues generated by relocated facilities could be shared between the receiving counties and losing municipal governments. Sharing of the tax revenues would enable municipal areas to maintain a minimum level of services to remaining households and businesses that have not been removed. At a later date when the relocation of the majority of the taxable base has been accomplished, the revenue sharing ceases and the municipal area as a separate jurisdiction is abandoned.

Although revisions to local property taxation rates and special property assessments can be formidable methods of discouraging continued land occupancy in high-hazard areas, they tend to be regressive in nature. Given the wide disparities between the income levels of occupants along the coast, increasing property taxes as a financial disincentive to maintain occupancy in a high-hazard area would fall heavily on low-income and fixed-income households. Low-income residents consistently expend disproportionate shares of their limited income to pay property taxes and other land occupancy costs than do their wealthier counterparts. Using the property tax rates to accomplish changes in the land uses and occupancy of high-hazard areas may result in environmental justice issues with a disproportionate share of the costs falling upon the low-income and fixed-income segments of the general population.

In addition, property tax rates are normally capped at certain levels set by state codes, local ordinances or through popular referendums and substantially extending those limits to accomplish a project objective may entail major revisions to already politically sensitive legislation or ordinances. For these reasons, modifications to the property tax rates and the application of special property assessments to discourage development in high-hazard zones will not be carried forward into more detailed formulation. However, should permanent acquisition and relocations of residential, commercial and institutional structures be part of a final nonstructural or combined plan, measures for sharing tax revenues between the counties and municipal jurisdictions are being carried forward in the formulation process to offset tax revenue losses.

4.5.7 Floodproofing

4.5.7.1 General

Floodproofing is a very broad term that describes an array of building construction techniques that can be used to reduce flood damages to structures. This method of protection can be applied to new building construction or can be applied to existing buildings commonly referred to as retrofitting. Structures of different construction types (wood frame, masonry over frame or solid masonry), sizes, uses (residential, commercial, and institutional) and foundation types (slab, crawl space, or basement) can be floodproofed in one of several ways described below.

Unlike permanent acquisition and evacuation (discussed below), floodproofing measures result in the continuation of the structure's functions on-site in some modified condition so that normal functions of that structure or facility can continue (with post-flood cleanup) shortly after the conclusion of a storm event. Although this rebound capability is a plus for families and communities attempting to recover from a major storm event, the risks associated with the determination of appropriate levels of protection and both design and construction parameters are many. Full consideration of risks and uncertainty in establishing the appropriate level of protection and building design parameters is important in the formulation of the floodproofing measures.

Also important to floodproofing is a reliable and timely flood warning and emergency evacuation program so that residents of floodproofed structures can safely evacuate their protected structures. Generally speaking, occupants of floodproofed structures and facilities should not inhabit the building during a flood event. The uncertainties surrounding the prediction of surge depths, wave heights, and other deadly components of approaching hurricanes and storms are too great to risk weathering such events in an at-risk location. Regrettably when the threat of building failure is greatest, rescue is nearly impossible and any rescue attempt would place responders in extreme peril.

Floodproofing has been used extensively across the nation within government-sponsored mitigation programs, as a component of local floodplain management plans or as a private structure owner initiative for communities in both coastal and riverine situations. Thousands of homes, commercial and institutional buildings along the nation's coasts have been retrofitted or newly constructed so that the first habitable or sales floor (commercial) is elevated above a specified flood level. Initial data indicates that as many as 25,000 parcels within the project area may be eligible for structure elevation as a risk reduction measure.

4.5.7.2 Floodproofing Types

Floodproofing is generally divided into two types: 1) dry floodproofing where no water enters any portion of the structure, and 2) wet floodproofing – where water (floodwaters or clean water) is allowed to enter some portion of the structure temporarily without damages to the structural components of the building or the contents.

Methods of dry floodproofing include constructing watertight enclosures surrounding the building including veneer walls, applied sealants to existing walls and either ringwalls or ring levees that prevent water from reaching the interior of a structure and its contents. Placing fill materials on the building site as a means of elevating the first floor can also be effective although the NFIP requirements for the use of fill materials on individual lots in V-zones is very restrictive (erosion concerns). Several structures in the project area that had apparently been raised on engineered fills withstood the storm event with moderate water damages to the first floor. Ringwalls and ring-levees can also be effective methods of dry floodproofing but calculating the appropriate level of protection is full of risks and uncertainties.

Wet floodproofing can include allowing floodwaters or clean municipal water to enter portions of the structure that are so designed that immersion does not damage flood–resistant building materials or contents. The most common method of wet floodproofing is raising or elevating the first habitable floor of an existing building (a.k.a. retrofitting) or constructing a new building on a foundation that elevates the first floor above the specified flood level. Figure 9 shows an elevated residential structure that weathered the surge and winds of Katrina with minor damages.

Figure 9. Elevated Residence in Project Area

Under the National Flood Insurance Program, that specified flood level is normally referred to as the Base Flood Elevation (BFE) which normally has an annual recurrence probability of 1 percent (known commonly as the 100 year frequency flood event). Structures can be elevated to higher levels providing greater levels of protection and further reducing risks, but the BFE is the minimum level specified by FEMA to be in compliance with the NFIP.

In accordance with the NFIP and regulations promulgated by FEMA, many structures in the project area had been wet floodproofed by elevating the structure on wood pilings, piers, masonry columns and other foundation types thereby elevating the structure's first habitable or sales floor to or above the BFE. Areas beneath the raised first floor whether enclosed or not remained subject to flooding. The majority of structures was residential uses and was wood frame or masonry over wood frame construction. Prior to the arrival of Katrina, these structures were able to withstand other high-water events (surge and waves) generated by less powerful hurricanes and tropical storms with minimal damages. Their survival depended upon the elevation of the first floor and vulnerable residential-type stud-wall construction above the storm surge and waves.

Generally, when structures are elevated to a level where the storm surge and pounding wave action cannot impact the building's first-floor substructure or the first floor walls, their survivability increases dramatically. In an elevated condition, only wind forces become a threat to the structure. Application of hurricane-tested building code construction methods and materials use can reduce wind damages to raised structures.

4.5.7.3 Katrina Damages to Existing Floodproofed Structures

The massive surge and waves associated with hurricane Katrina either swept (lateral forces) or lifted (buoyancy forces) many elevated structures off their foundations or the pier foundation itself failed resulting in loss of the structure during the storm. Although hundreds of residential and commercial structures had been elevated according to acceptable FEMA standards proscribed in the NFIP guidelines, the combination of surge levels far exceeding the BFE and waves transported on the surge into the first floor walls and substructure of those elevated structures resulted in their destruction. Several elevated structures that survived Katrina showed signs of wind damage and inundation damages, but they were largely intact. Figures 10 through 13 show the damages to elevated structures resulting from Katrina.

The residential structure shown in the Figures on the top left was not located within the V-zone. The structure had inundation damages within the first and second floors but withstood the surge. The other three residential structures shown in the figures were located in areas classified by FEMA after Katrina as the "catastrophic damages zone" and have now been included in the enlarged V-zone within the new DFIRM's. Their level of damage is far greater than the structure located outside of the V-zone.

Figures 10, 11, 12 and 13. Damages to Elevated Structures

Observations of the structural damages due to Katrina indicated that many of the unit masonry construction columns and piers failed resulting in total loss of the elevated structures. Improper design and construction methods may have contributed to some of the failures, but in many cases even what appeared to be well-designed and constructed foundations failed due to the extreme forces brought about by Katrina. In these cases, the proscribed level of protection (BFE) was insufficient to prevent the battering forces of waves and debris from crushing the sidewalls of standard residential construction. In several cases concrete block columns and poured concrete, steel-reinforced cylindrical columns both failed resulting in total building loss. Based upon field observations, driven wood piling and deeply set wood poles seemed to survive the combined forces of surge and waves. In most cases the elevated structures themselves had been destroyed, but the wood post foundation, main supporting beams and cross-bracing survived the storm event. Figures 14 through 17 show these remnant foundations and the extent of damages inflicted by surge and waves.

Figures 14, 15, 16, and 17. Remnant Foundations

4.5.7.4 Floodproofing by Elevation (Raising-in-Place)

4.5.7.4.1 General

Elevating the first habitable or sales floor of a structure above specified flood levels is an effective way to reduce damages to a structure and its contents. This method of floodproofing can be applied to both new construction and existing structures (retrofitting) using several techniques including an extended foundation system or an engineered fill. Extended foundations can be accomplished by the use of pilings, piers, columns, or solid walls. The particular type of foundation used is dependent upon the building construction type (wood frame, masonry), building weight, and height of raise, the location of the building with respect to wave action and surge, and cost effectiveness.

In accordance with NFIP guidelines, solid wall foundations are not permitted in V-zones due to the destructive wave forces that can be brought to bear on wall surfaces resulting in foundation failure. However, solid wall foundations could be used in areas where flood damages would only be caused by inundation of the structure (no waves).

In addition to extending the foundation to elevate the structure, floodproofing requires extension of utilities serving the structure (electric power, water, sewerage, gas, telephone, and telecommunications) and modification of access from the ground surface up to the elevated first floor. In special cases (handicapped or elderly) some options for assisted access (chairlifts) can be included in the elevation design. Although these associated construction components constitute a smaller proportion of the total floodproofing construction process and cost, they are sensitive to the height of raise and determine the livability of the structure. NFIP regulations for coastal areas allow a maximum 300 square feet on enclosed space beneath an elevated structure for securing access to movable storage and as a utility chase.

Closely allied with retrofitting existing structures by elevation is the concept of "rebuilds" on site. In many cases, existing structures that have been found to be eligible for elevation with regard to the allowable water depths at the site cannot be raised because of structural integrity issues due to storm damages or building deterioration. In these cases, rebuilding a new elevated structure on site may be cheaper than either acquisition or rehabilitation of the existing structure. Successful "rebuilds" accomplish the basic objective of reducing flood damages to structures as well as increasing the value and conditions of the housing stock in the project area. All "rebuilds" are designed and constructed to building code specifications and elevated according to local floodplain management ordinances.

This additional option for landowners makes the floodproofing measure very attractive. Opportunities for "rebuilds" are probably numerous throughout the project area, but without detailed data on the conditions of individual structures, an estimate of their number is problematic at this level of detail. More detailed documentation of eligible structures within the project area would be able to capture the number of these potential rebuilds. Costs for rebuilds have been included in the floodproofing section of this appendix since they are identical to elevating new structures on eligible vacated lots.

4.5.7.4.2 Level of Protection

Floodproofing through elevation of the structure is very sensitive to the selected level of protection and storm hazards of the building site. In coastal V-zones and riverine floodways, floodproofing by elevation is generally to be avoided due to the immense physical forces that moving water can exert on building foundations and both building floor and wall systems. In addition to these dynamic water forces, the presence of water-driven debris adds to the extreme battering that standard residential wood-frame construction can be exposed to during a hurricane. Normal wood frame and masonry on frame building construction cannot withstand the dynamic forces imposed by wave and run-out impacts and surge. Even solid masonry construction built to accepted building codes can sustain significant damages and even experience failure under these extreme conditions.

The determination of the appropriate level of protection is a significant parameter for floodproofing by elevation. The NFIP standard requirement for floodproofing is elevation of the first habitable or sales floor (commercial) to or above the Base Flood Elevation (BFE). Additional elevation of the structure above the BFE, where practical, reduces the probability of damages thus reducing premiums on an owner's flood insurance. Although additional elevation of the structure's first floor above the BFE can substantially reduce insurance premiums and improve community ratings under the Community Rating System (CRS), this additional increment of protection is rarely undertaken by landowners. All of the local floodplain or coastal zone management ordinances in the project area indicate the BFE as the minimum level of protection for structures within the flood zone.

Immediately following Katrina, FEMA published the Advisory Base Flood Elevation (ABFE) mapping for the project area. This mapping displayed a revised BFE for the project area that incorporated the affects of Katrina in the new water surface elevations for the purposes of setting the first floors of new construction along the coast. A number of communities and counties in the project area adopted the ABFE into their existing floodplain management ordinances as interim measures. It was anticipated that revised flood mapping (DFIRM) would be issued by FEMA in the near term.

4.5.7.4.3 Building/Structure Elevation within the Identified High Hazard Zones

Due to the immense forces of high velocity water associated with waves, wave run-out and surge inundation, the nonstructural PDT decided that no floodproofing by elevation would be recommended in the project area for the V-zones delineated by FEMA. Observations of Katrina damages within the mapped V-zones supports the contention that forces in that zone are too extreme to risk residential building construction – few structures survived intact. More importantly, elevated structures in this area could result in their owners attempting to "ride-out" future storms and risk their lives in the process. At the point where the elevated structure may fail, the conditions of surge, waves and wind velocities would significantly reduce the chances for survival by the occupants. In addition, the lives of emergency personnel attempting to rescue those remaining in elevated structures under hurricane conditions would be placed in extreme jeopardy as well.

In addition to the mapped V-zone, the PDT identified an additional zone along the coast referred to in post-Katrina FEMA reports as the "catastrophic damage zone" wherein the majority of insured structures suffered damages greater than 50 percent of the structure value. This linear zone included the V-zone but extended further inland from the beachfront. Observations of damages within this zone by the nonstructural PDT confirmed that the majority of the structures within this zone were either totally destroyed (only the slab foundation remained) or the remaining structure had been severely, structurally damaged and would probably be demolished rather than repaired. Due to the extent of the damages caused by surge inundation and wave action in this zone the nonstructural PDT decided that floodproofing by elevation should not be recommended in this area.

Since the FEMA designated "catastrophic damage zone" was directly related to the actual Katrina event itself, the nonstructural PDT decided to duplicate that zone (most prominent in Waveland, Bay St, Louis, Pass Christian, Long Beach, Gulfport and Biloxi) along the entire coast within the project area. Based upon measured distances back from the beachfront in those areas, an 800 foot zone extending inland from the normal tide waterline was applied to the coast in Jackson County as well. The nonstructural PDT decided that floodproofing within this 800 feet wide buffer zone would not be safe due to the extreme forces that could attack elevated structures in this zone. These high hazard zones (combined and designated with the acronym HHZ) are shown in Figures 58 through 62 .

Elevation of structures (residential, commercial and institutional) within the FEMA-designated A and B zones (100 yr and 500 yr respectively) could be supported under the current guidelines for coastal construction. Floodproofing through elevation for structures in the FEMA-designated A and B zones is a nonstructural measure that should be carried into the final planning formulation.

4.5.7.4.4 Building Elevation Limitations and Parameters

Limitations on the height that structures can be elevated are based in part upon several factors including cost to elevate the structure (compared with its acquisition cost), high-velocity wind loading on raised structures, structural stability of elevated buildings, occupant accessibility, visual impacts and architectural suitability. Since the costs of protection measures and alternatives being considered in plan formulation would be compared to identify the most cost-effective solutions, the cost of floodproofing a structure would be compared with the cost to either acquire the structure or rebuild a new elevated structure on the same site. Once the cost to elevate the structure exceeds the cost to either acquire or rebuild a new structure on site, the elevation of the existing structure comes into question just based upon economics.

Powerful natural forces during storms and hurricanes place tremendous stresses on all structural components of the building and its supporting foundation. The elevated structure is positioned between the devastating forces of saltwater from the ocean and the equally damaging forces of high-velocity winds and wind-driven debris. Numerous structures that survived inundation by surge and waves from Katrina were ripped to pieces by hurricane-force winds and wind-driven debris.

Elevation of a structure above the ground places the building in the pathway of hurricane force winds that are undisturbed by ground-clutter. Trees and other surrounding structures (all ground-clutter) can affectively reduce wind velocities at ground level. Constant winds in excess of 120 mph can destroy most unprotected residential construction. Other than structures that have been built to more recent building codes (post-hurricane Andrew) that account for hurricane force winds, most residential structures are not built to handle high-velocity winds. Older structures that can be elevated probably would require some retrofitting of the structure roof and wall systems and windows to survive in the high-velocity wind environment.

The constant battering of wave run-out and surge-transported waves on the supporting columns/pilings and floor substructure of the building during storm/hurricane events raise concerns of sustainability and safety. Among the many forces at work are scouring around the bases of columns/pilings at the ground surface and impact forces of waves on the columns/pilings themselves. Wave run-out that occurs as storm surge brings breaking waves around the base of the structure can easily undermine columns and pilings as well as slabs exposed to this high-velocity water. Waves borne upon the surge can impact extended columns and pilings resulting in material failures or racking of the supporting structure. Assuring that the buried depths of the columns/pilings is sufficient to reduce failure and installing protected-edge concrete slabs surrounding the columns or pilings can reduce the affects of scour. Impact forces on the supporting substructure must be considered in the cross-section design and reinforcing components of the system. Racking can be addressed with cross-bracing between columns/pilings and perimeter stabilization components.

Tradeoffs between the issues of safety and costs of raising buildings to extreme heights and the ability to maintain vestiges of coastal communities in their current location must also be considered. Accounting for the removal of many existing structures and prohibition of rebuilding many structures in high-hazard wave zones (V-zone, etc.) discussed below, overly restricting the height of elevation can result in extensive evacuation of buildings and facilities from communities.

In addition, occupant accessibility (especially for physically challenged occupants) to the elevated home is a critical component of the elevation process. Exterior stairways in excess of 12 steps require intermediate landings per the building code and too many steps make the elevation option too laborious for older occupants. For those structures sited on narrow urban lots, situating access stairways with landings may not be feasible. Structures can be relocated on-site to enable easier access options, but these additional operations also increase the cost to elevate.

For those landowners with physical handicaps, an elevated structure poses significant access problems. Although there are several options for addressing handicapped access to an elevated structure, the costs of installing some of these options can be very expensive and require frequent OMRR&R by the landowner. Basic ADA specifications for access ramps for wheelchair users require a maximum slope of 1:12 or 8.33% for the ramp and intermediate landings every 30 inches of rise. Ramps must be at least 36 inches wide and landings must be at least 60 inches long. Using these component requirements, a wheelchair access ramp would have to be approximately 210 feet long to reach a first floor elevated 15 feet. On narrow urban lots, the use of access ramps for handicapped occupants would have limited application.

Although coastal communities around the nation have a somewhat "different" look visually because of the need for elevation of first floors, there are some limits to the visual quality boundaries of an elevated home or business. The overall dimensions of the structure (height versus width and length) can become unbalanced leading to a visually unpleasant building whose value could quickly plummet on the market. In some cases, community association guidelines or local building codes could prohibit extreme elevation of structures. Elevated residential buildings raised in full increments of one-story (8-10 feet) keep the visual balance of the structure (depending upon the architectural style) up to three-stories. The relationship of the lot size to the building size and the size/bulk of adjacent structures can also influence the visual quality of the raised structure. Visual quality is a significant criteria in determining the market value of structures, and landowners will take the resulting market value of their home or business into account when deciding to participate or not.

There are a variety of architectural styles present in the project area. Those styles include Acadian-Creole, Victorian, Classical and Arts and Crafts. The Acadian-Creole style is indigenous to the local area, but a few of the styles have been imported from other regions, countries and time periods. The more indigenous architectural styles, styles that were developed in recognition of the potential for flooding may be more conducive to elevation while the more classical styles developed in less flood-prone areas would not be as favorable from an architectural viewpoint to elevation. Structural styles that are traditionally multi-story could probably be raised successfully in one-story increments while architectural styles (ranch style) that are traditionally thought of as one floor would not be as favorable to elevation. Consideration for building massing in zoned areas and building proportions of height to footprint in some styles may dictate special requirements in elevation design. In a voluntary program of elevating structures in place, the architectural style of the home or building may be a determining factor in the landowner's choice of program participation.

Many agencies and local governments have proposed raising structures no more than one story (8-10 feet) while others have advocated 12 feet as a maximum height standard. Normally, the one story rule of thumb was applied so that vehicles could be stored beneath a raised structure, one-story increments look appealing visually and to avoid building materials waste. Issues of cost, accessibility, structural stability and visual impacts have been the focus of debates on maximum heights for elevation.

Guidelines established by FEMA in the recent *"FEMA 550 Recommended Residential Construction for the Gulf Coast"* recommend a maximum height of 15 feet for elevating residential structures along the Gulf Coast. This height recognizes the relationship between forces of moving water and hurricane velocity winds that can affect a raised structure. Proven engineering methods for the design and construction of stable, supporting foundations for structures elevated to 15 feet are included in the FEMA 550 guidelines. Since the guidelines are supported by sound engineering principles and field testing results in extreme conditions, the nonstructural PDT decided to accept the 15 feet maximum height limitation for floodproofing in the project area. The FEMA 550 guidelines can be accessed online at: [http://www.fema.gov/library/viewRecord.do?id=1853]

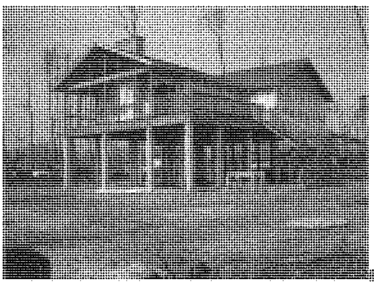
4.5.7.4.5 Mobile Homes

Mobile homes (a.k.a. trailers) present a unique problem in floodproofing by elevation. Generally speaking, mobile home construction is insufficient to withstand the hurricane force wind speeds that would be encountered by an elevated unit. Although the unit may be raised above the surge inundation limit and largely safe from flooding or waves, the raised unit would be subjected to extreme wind loading such that severe structural damage could occur. Comparatively speaking, standard stick-built and manufactured homes built to the International Building Code (IBC) with provisions for hurricane force wind loading would sustain minor damage in an elevated condition. Expending Federal funds to elevate mobile homes that may be totally destroyed by high winds during a future storm event is an unwise course of action and other options are available.

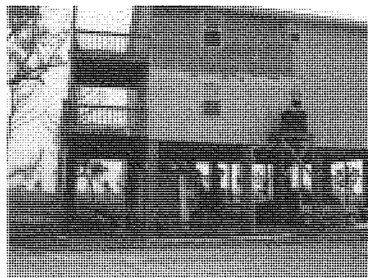
For this reason, the nonstructural PDT recommends that mobile homes not be elevated in the floodproofing program, but that owners of existing mobile homes that were inundated by Katrina and that could be elevated on site (water depths equal to or less than 13 feet) be given the option of an elevated rebuild using a manufactured home constructed to IBC standards. The manufactured home would be of a similar size to the existing mobile home featuring similar amenities and would be elevated on a driven wood piling foundation (the cheaper form of floodproofing). Since the floodproofing program is voluntary, owners could choose not to participate in the rebuild option or be purchased in which case they would be offered relocation benefits similar to other structure owners. The preferred option would be to maintain a tax-producing land use within the community that keeps the family connected to employment and schools while upgrading the overall housing stock and reducing future hurricane damages.

4.5.7.4.6 Foundation types

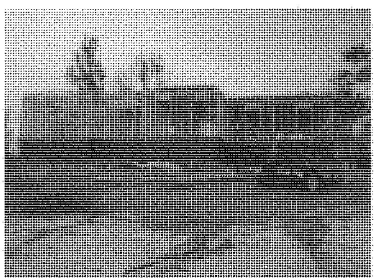
There are a wide variety of foundation types and materials used to elevate structures in the project area. The choice of foundation type is based in part on regulatory requirements, construction and OMRR&R costs, visual quality, building size and weight, architectural suitability, and availability of materials. In many cases, the foundations appear to have been constructed as retrofits of existing homes requiring lifting of the structure to construct the supporting foundation. More recent residential construction observed in the area indicates elevated foundations constructed during the building process and those appear to be more integrated in the design of the building. Figures 18 through 21 show some of the foundation types observed in the project area.



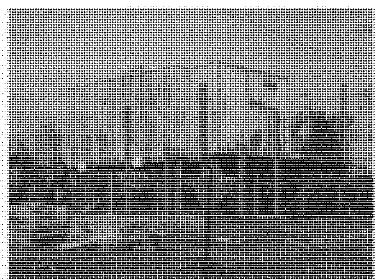
Concrete Piers



Concrete Block



Concrete Block Enclosure

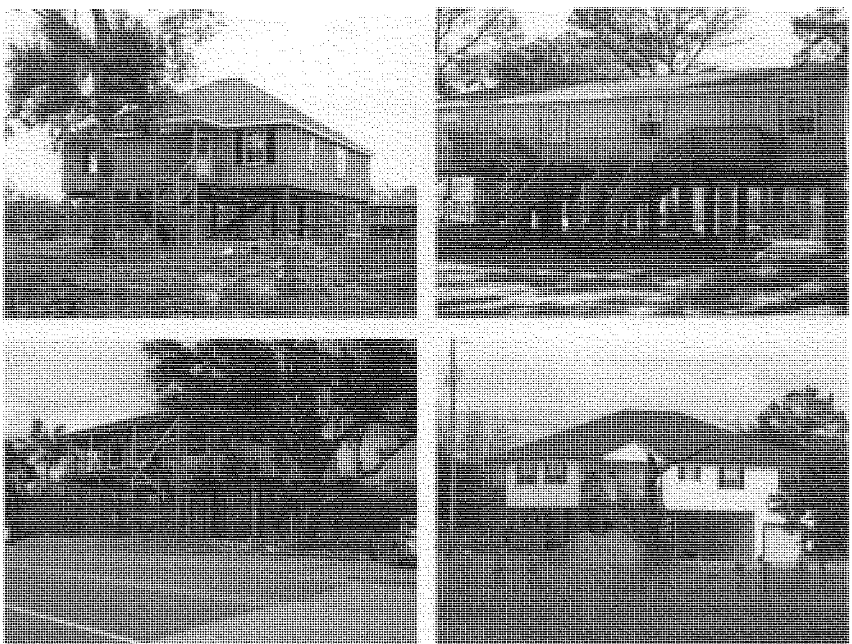


Wood Post and Piling

Figures,18, 19, 20 and 21. Predominant Raised Foundation Types

There are two main foundation types for elevating structures: open and closed. Open types depend upon numerous upright columns or pilings that support critical bearing points beneath the structure. Typically an array of wood or metal beams and joists attached to the vertical members provide support to the first floor. The open foundation allows water to pass through largely unimpeded resulting in less stresses on the foundation members but everything below the first floor is subject to inundation forces. Where moving water may be present, the open foundation is more favorable. Open foundations also maintain good air circulation beneath the structure allowing for more affective drying following a flood event and less potential for mold and mildew growth where sunlight does not penetrate. As stated earlier, NFIP regulations provide for a maximum of 300 square feet of enclosed space beneath the elevated structure for movable storage, access to the first floor and utility chase. Generally in northern climates where cold air circulation beneath the structure can increase heating demands and require insulation beneath the raised first floor, open foundations are not favored. In milder southern climates, the open foundation does not significantly increase heating requirements, so it is more acceptable.

Many examples of open foundations are present in the project area (see Figures 22 through 25). Closed foundation types depend upon solid masonry walls (poured concrete, concrete panels, unit masonry) or some other enclosing, perimeter wall system that supports the exterior walls of the elevated structure. Structure walls are fastened onto wood sill plates anchored into the masonry wall structure. Perimeter bond-beams can be used to tie the top of a unit masonry wall system together



Figures 22, 23, 24, and 25. Open Foundation Types

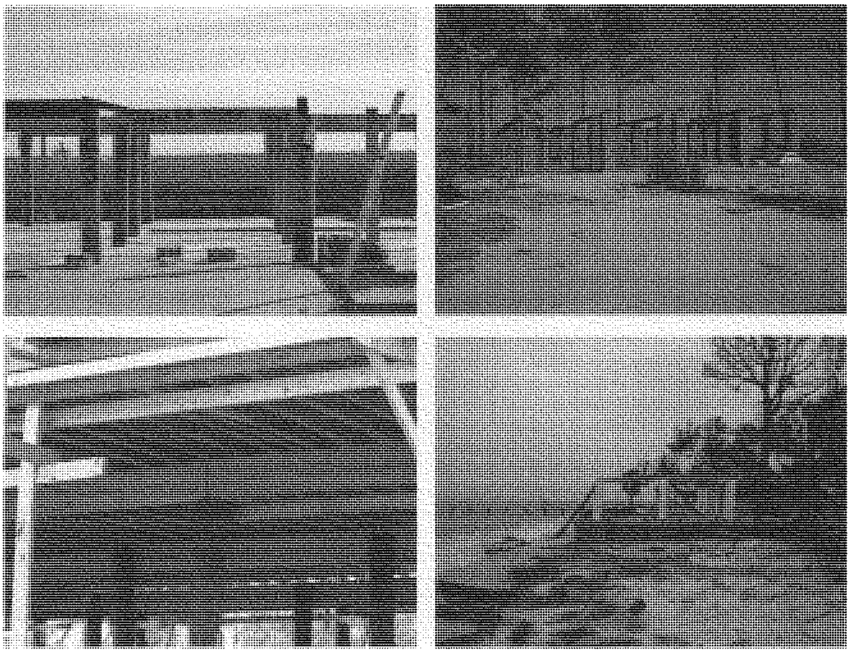
to avoid racking of the walls during water or wind stress. Interior posts/columns with a system of beams and joints provide support of the first floor. Enclosed foundations do provide a measure of perceived security beneath the elevated structure and movable storage items are not in plain view of passer-bys. Also, closed foundations reduce airflow beneath the structure which can be a good feature in colder climates, but the enclosed foundation does present several problems. First, the closed foundation does represent a large obstacle to flowing water – an obstacle that can create significant impact forces on the wall surfaces from flowing water or wind. These forces can be offset to a certain extent by allowing the enclosed area to be flooded thus equalizing the pressures on the masonry walls. However, in a coastal zone where wave run-out and waves can begin impacting the foundation walls long before surge inundation fills the enclosed area, these extreme forces can result in wall failure and structure loss. The NFIP does not allow the use of solid perimeter wall foundations for elevating structures in wave impact coastal zones (V-zone). Figure 26 shows a structure raised on a solid wall foundation. This type of foundation can be used in areas where inundation only would occur and then only when sufficient, automatic equalization of water pressures can occur. In addition to the problems of unequal wall pressures, enclosed, damp foundations (common during wet weather or following a flood event) can lead to the growth of molds and mildews that can be life-threatening and hard to control without good air circulation and sunlight penetration.

Figure 26. Structure Raised on Solid Wall Foundation

4.5.7.4.7 Foundation materials

A variety of materials can be used in open foundation systems. The selection of appropriate materials is based upon criteria such as cost, availability, durability, corrosion resistance, strength, reliability and maintenance. An assortment of foundation materials ranging from wood and steel to unit masonry (concrete block) and poured concrete are present in the project area. Some of the materials weathered Katrina's wrath quite well, others did not perform as expected by the owners. A selection of the foundation types is shown in Figures 27 through 30. By field observation, treated wood pilings (square and round) that had been driven or drilled to a sufficient depth appeared to survive the fury of inundation and waves and wind forces. In many cases the supported structure had been totally lost but the wooden substructure remained intact.

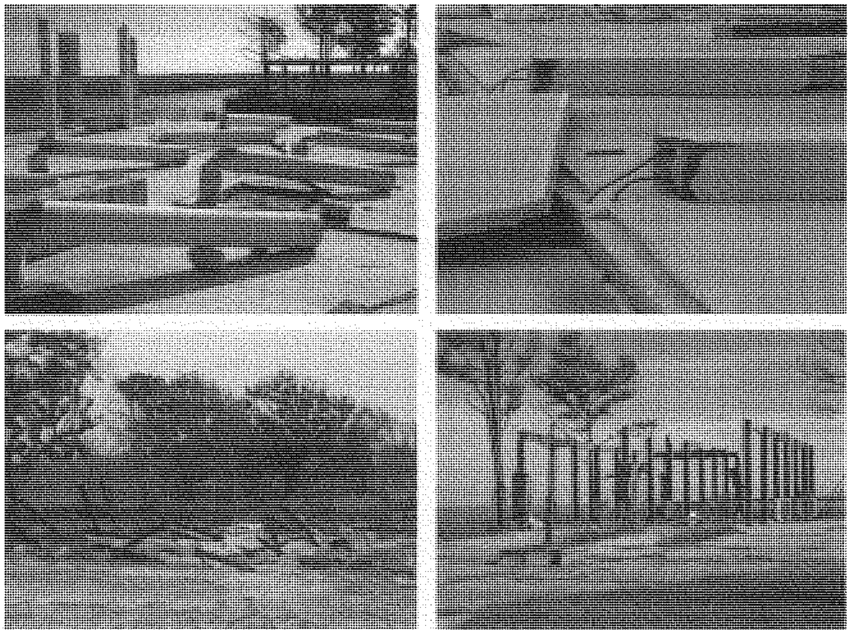
Some of the success of the wood pilings may have been due to inadequate strap connections to the supported structure. Had the strapping been accomplished according to the building codes for hurricane force winds, many more of the piling systems may have failed when the structure was destroyed, but that cannot be confirmed by observations in the project area. Based upon post-Katrina observations and data provided in FEMA technical documents, wood piling driven or drilled to sufficient depth to avoid failure due to scour and adequately braced can be used to elevate structures to the maximum 15 feet height. The nonstructural PDT decided to use driven wood pilings as the basic floodproofing foundation for developing costs for floodproofing. This decision was based upon materials availability, relatively low costs for materials and labor to install and their apparent durability under stress.



Figures 27, 28, 29, and 30. Foundation Materials

In some cases elevated foundations were constructed of steel posts with fabricated steel beams and joists. Several of this type survived the storm event, but in most cases the supported structure was destroyed. Again inadequate strapping between the supporting foundation and structure may have spared the foundation when the structure was destroyed. Other than the high cost of steel posts and fabricated components and their availability in large quantities to support the structures' first floor, steel-based foundations systems would be a feasible alternative.

In a number of cases, reinforced unit masonry (concrete block) columns failed along the coast. Some masonry columns were not reinforced adequately and those failed quickly due to wave impacts. In some instances, reinforced masonry columns failed with the reinforcing steel bars snapped off or bent at ground level where the column met a concrete footing. Figures 31 through 34 show these failed systems. The nonstructural PDT decided not to use standard unit masonry columns (reinforced or not) as supporting foundations for elevated structures due to the number of failures observed in the field. A modified version of the unit masonry column type is described below and will be used to support existing structures that can be raised.



Figures 31, 32, 33, and 34. Failed Supporting Foundations

During investigations of various elevation techniques and materials for the project, the nonstructural PDT became aware of a unique structure lifting system ("segmented piles") that also provided a reliable open-foundation system for raised structures. The system is based upon concrete unit masonry that is stacked around steel rods and driven by a pneumatic jacking system. The segmented piles are positioned at critical load points under the structure (mostly slab foundations) to assure stability of the structure and to avoid differential settlement of the walls and roof systems in the building. Initially the rods and blocks are driven into the soil using the weight of the structure above and the pneumatic jacking system until refusal. Once that solid footing is achieved, the jacking system then begins to elevate the structure as additional blocks and steel rods are added beneath the structure. Figures 35 through 37 show the installation of the segmented piling system and the final result.

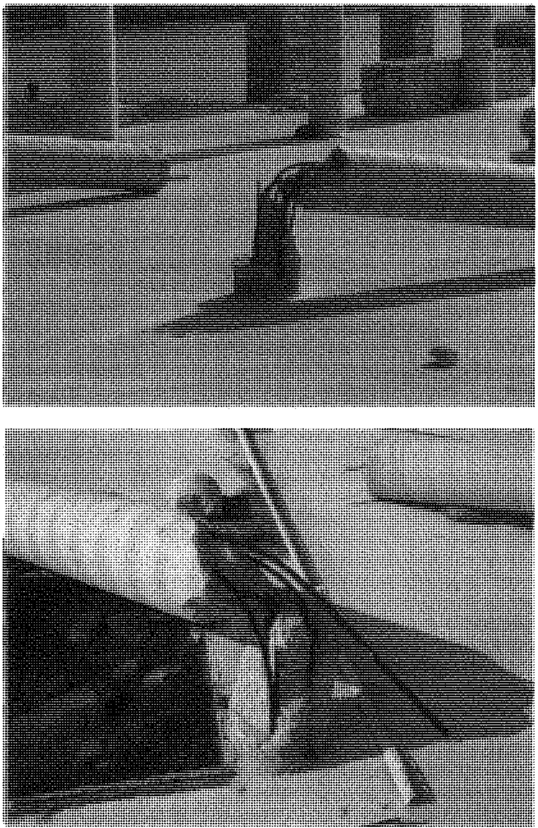
According to the contractors working with the system, this system can provide a safe and durable foundation just using the segmented piles up to four feet of first floor elevation. After four feet of elevation, the contractor reverts the structure elevation to a more standard lifting process using cribbing and steel beam supports. The segmented pilings are then removed to the ground surface and a concrete, grid-shaped footing with steel reinforcing is poured connecting all of the segmented piling footers and reinforced concrete columns are erected beneath the structure with steel beam supports that assure stability and durability of the structure. Elevation up to the limit of 15 feet can be obtained with this system, but due to the increased cost of erecting the reinforced concrete columns after four feet of elevation, this system would only be used in the program up to the four feet of elevation, after which structures would be placed on driven wood piling.

Figures 35, 36, and 37. Segmented Piles Construction Method

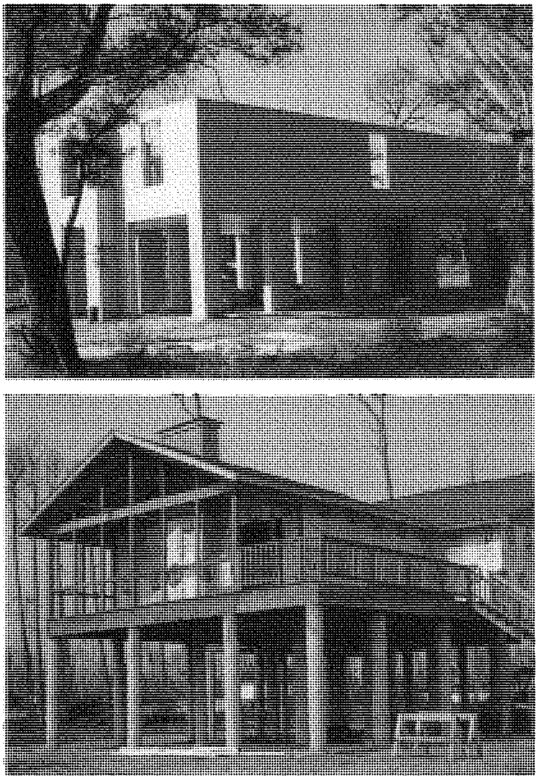
Also prevalent were poured concrete columns (square and cylindrical) with either wood or steel beams supporting joists and tied into the structure floor system. In most cases these materials survived the stresses of water and wind, but at least in one instance this foundation material failed. Figures 38 and 39 show a building location where poured, reinforced concrete columns failed at the base where they were connected to concrete footings. Although the concrete itself performed well, the reinforcing design and connection to the footing may have contributed to the failure. In addition, the supported structure had been destroyed leading perhaps to failure of well-connected foundation members. As all of the columns that failed were oriented in a similar direction, the loss of the structure and columns may have been a combination of wind and wave action on the supported structure. Several new rebuilds along the coast are being supported by poured concrete columns (see Figures 40 and 41).

In addition to the use of wood, poured concrete and steel as vertical support components, these materials can be used as supporting substructure beneath the building. Treated wood beams, fabricated steel beams and cast concrete beams can all be used to support the structure first floor.

Selection of the appropriate material for these supporting elements is based upon cost and design requirements. Using building materials that can withstand the rigors of the saltwater environment, wind-driven rain and stresses is mandatory for elevating structures. All metallic connections and fasteners between extended columns/pilings, supporting beams, lateral bracing and stairways must be able to resist the corrosive forces of saltwater and maintain structural integrity during extreme conditions.



Figures 38 and 39. Reinforced Concrete Columns Failure



Figures 40 and 41. New Concrete Column Construction

4.5.7.4.8 Safety Issues

As in all vertical construction, safety is a paramount concern. Besides the normal safety apparatus and equipment that construction crews may use or wear during the elevation of a structure, there is a constant threat of a catastrophic failure of the temporary supporting members leading to loss of the building and serious injuries or death of crew members. Only qualified, experienced and bonded contractors/builders should be elevating structures. In addition to construction of the supporting foundation, new building construction on elevated foundations places the construction crew as much as 15 feet above the ground surface while working on the new structure. The risks for injury or death due to falls or impacts from falling materials or tools are multiplied during this type of construction. All appropriate OSHA safety standards should be followed during this construction process including the wearing of personal safety gear (helmets and safety shoes) and construction procedures that limit the risks of injuries or death during the elevation of the structure and ensuing construction beneath the raised structure.

4.5.7.5 Floodproofing Design – Residential Construction

4.5.7.5.1 Design Assumptions

In view of the comprehensive nature of this protection plan for the project area and the general lack of information on the characteristics of individual structures, a number of assumptions were made in determining what an appropriate elevation design would be and the approximate costs of elevating residential construction structures based upon that standard elevation design. Those assumptions included:

1. Average footprint size of the first floor of the representative residential structure was 1,600 square feet,
2. Floodproofing of commercial uses within residential-type structures would be elevation in like fashion,
3. Floodproofing of public buildings would be estimated as ringwall construction (see Public Buildings Replacements – Section 4.6) rather than elevation,
4. The maximum elevation of the first floor of any structure is 15 feet above ground level,
5. All structures within the floodproofing area were built upon slab foundations that would have to be adequately braced when lifted onto a new foundation,
6. Foundation type for all existing structures elevated between 0 and 4 feet would be segmented piles,
7. Foundation type for all existing structures elevated between 4 feet and 15 feet would be formed concrete columns.
8. All foundations for elevation where no structure now exists on the property will be driven or drilled wood piling,
9. For the purposes of estimating costs, two categories of raise were considered: 0 to 6 feet of raise and 6 to 15 feet of raise. All eligible structures were categorized into these two groups,
10. Each residential structure has two entrance doors that would require access stairways,
11. A 300 square foot enclosed space would be included under the elevated first floor for storage purposes and utility chase for structures raised at least 7 feet,
12. Repairs or rehabilitation of an existing structure in the elevated position would be minimal and financed by the structure owner or through insurance payments,
13. The structure is DSS in its current condition with adequate sewer, water, HVAC and is structurally sound to elevate,
14. Existing floor joists are of sufficient size and quality to adequately support the structure on the new raised foundation,
15. Floodproofing elevation would require new beams to support the existing sub-floor structural system,
16. All rehabilitation of the structure above the first floor to meet building code standards for hurricane construction will be financed by the landowner or the project sponsor.

17. A separate cost for ADA requirements (access ramp or chairlift) was not included in the basic design package, but costs for step access and the contingency amount should cover these additional requirements.

4.5.7.5.2 Floodproofing/Elevation Design – Residential Construction

For the purposes of this nonstructural plan, floodproofing by elevation is only being implemented in areas devoid of significant wave action. Those areas affected by significant wave action are referred to in this Appendix as "high-hazard zones" and are destined for permanent land acquisition or limitation of development rights under the nonstructural plans. Although the FEMA 550 guidelines do provide information on floodproofing by elevation in the V-zone, the minimum level of protection being presented in the nonstructural plan (an approximation of the anticipated DFIRM BFE elevation plus 2 feet) would not adequately protect an elevated structure in the event of a recurring Katrina-type storm. The impacts of waves on normal residential wood-frame wall construction could result in total failure and loss of the structure and its contents. In addition to the tremendous forces exerted by surge and waves, floating and semi-floating debris from other destroyed structures creates a "battering-ram" effect on standing structures that also quickly leads to structure failure. The visual evidence of damages to standing structures and vegetation (especially trees) from this undulating debris pile was noted throughout the project area. The combination of surge, waves and floating debris resulted in total loss of many elevated structures in Katrina. The following preliminary elevation design and cost estimating information is predicated on raising structures only in areas of surge inundation without significant waves or anticipated debris.

Given the large number of structures in the project area, their diversity of size, type, foundation, use and age, and the limited information available on each structure, the preliminary elevation design and estimated costs were based upon a simplified prototype structure (residential in construction type) and two levels of elevation. A 1,600 square foot structure was selected as the most typical residential structure in the project area. Based upon review of aerial photographs, ground observations and data research, this prototype structure footprint-size was selected as being the most representative of the population of all residential structures.

In view of the preliminary nature of the comprehensive plan and the necessity of further, more detailed technical documentation of floodproofing designs and costs prior to implementation, the heights of elevation were divided into two categories 0-6 feet and 5-15 feet. For existing structures the segmented piling technique was used for cost estimating purposes between zero and four feet of elevation. All foundations for existing structures being elevated greater than four feet were considered to be formed concrete columns. Structures with attached slabs would be elevated with hydraulic jacks and supported by steel beams and timber cribbing. The new foundation would be constructed beneath the raised structure.

Following completion of the new foundation, the structure would be lowered onto the supporting beams and all utilities would be re-connected. In the case where a structure was being raised equal to or greater than 8 feet above the ground surface, a 300 square foot storage space/pipe chase on a concrete slab would be provided in accordance with the FEMA 550 guidelines and local ordinances. New decks and steps for access to the elevated first floor would be installed with pressure-treated wood. Grading around the foundation and lot would smooth any remaining construction scars.

In the case of a property that was considered eligible for elevation (inundation depth less than 13 feet and out of a high-hazard zone), but had no current structure, all elevated foundations would be driven or drilled wood piling. Piling would be 12" in diameter and tapered for driving. Driving depth is estimated to be 40 feet in accordance with the FEMA 550 guidelines. Cross-bracing would be standard practice for all timber piling foundations. In accordance with FEMA 550 guidelines, a 300 square foot storage area/pipe chase was included in the designs and cost estimate for all structures elevated 8 feet or greater.

Although any rehabilitation of the structure above the first floor to meet building code requirements for hurricane protection is to be financed by the landowner or project sponsor, hurricane resistant connections (metal strapping and hardware) between the new raised foundation and the first floor substructure (joists or slab) are part of this preliminary design and are included in the preliminary cost.

Using the stated design assumptions, basic elevation designs for the three primary foundation types (segmented piles, poured concrete columns and wood piling) were prepared. These preliminary elevation designs are shown in Figures 42 and 43, 44 and 45 and 46 and 47. Construction materials will be specified according to accepted engineering and architectural practices for coastal construction and in accordance with the provisions included within the FEMA 550 guidelines for floodproofing structures on the Gulf Coast.

All materials used in the floodproofing work would meet ASTM specifications for construction in coastal areas accounting for the corrosive salt-water environment. Non-corrosive, ferrous connectors, fasteners, steel beams and hardware were used throughout the design and all wooden members used would be pressure-treated materials. All concrete and mortar mixes used in the design would meet ASTM requirements and all utility work (electrical, gas plumbing, HVAC, telephone, and cable) will be installed according to local building codes (minimum IBC 2003).

Prior to implementation of any segment of the identified floodproofing work, more detailed guide plans and specifications would be prepared for each eligible, participating structure with a detailed cost estimate suitable for contract negotiation purposes.

4.5.7.5.3 Floodproofing Cost Estimating – Residential Construction

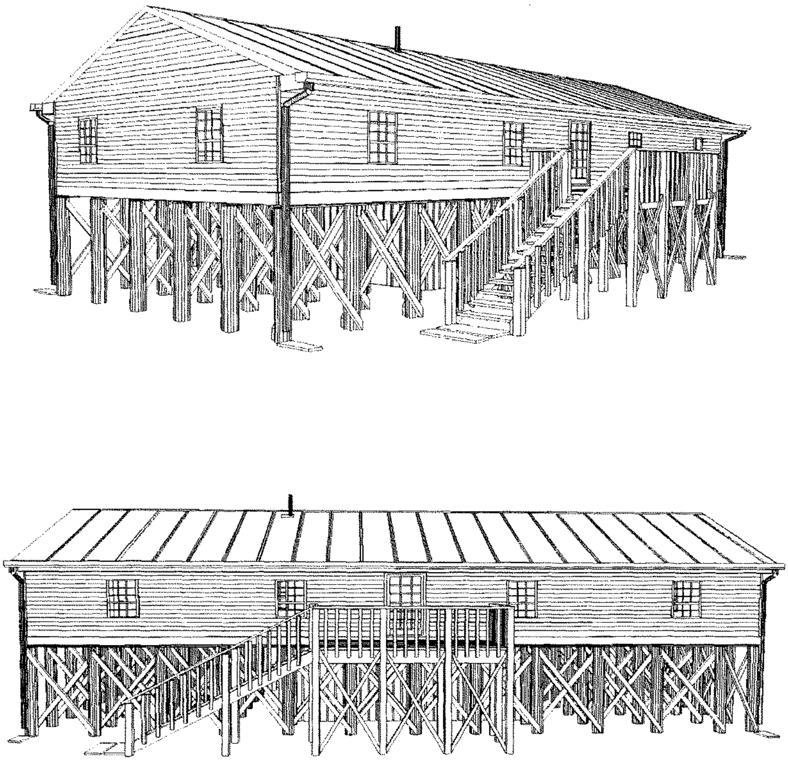
Costs for each of the three primary foundations were based upon the preliminary designs and the assumptions listed above. Since floodproofing contracts are normally negotiated and executed between the structure owner and the contractor (as opposed to a contract between the Government and the contractor), Davis-Bacon wage rates are not required and therefore labor rates in the cost estimate reflect those rates that would be common to the region. Material costs were based upon regional averages for building materials and specialty items. Generally, a 25% contingency was added to all costs unless determined otherwise by the cost engineer. Costs for floodproofing individual prototype structures (structure retrofit and new construction) are shown in the Cost Estimate Appendix.

4.5.7.6 Floodproofing Design – Commercial and Public Buildings

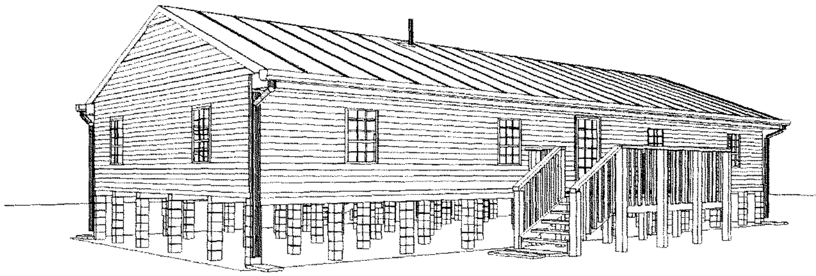
4.5.7.6.1 General

In comparison to floodproofing residential construction through elevation, floodproofing commercial and public buildings is much more complicated due to the need for ground floor access, a much larger footprint size and heavier construction materials (i.e. masonry) in the walls and floors. Commercial and public uses that occupy structures featuring residential-type construction can be elevated according to the techniques, design and costs discussed above. However, commercial sales floors elevated above ground level are not popular with shoppers unless the 2nd floor access is part of a larger raised platform (i.e. elevated mall). For similar reasons, access to most public buildings (significant ADA issues) is preferred at ground level. For this reason floodproofing by elevation for these types/uses of buildings is generally unacceptable to the structure owners and few participate in a voluntary program.

Another major difference is the positioning of the commercial or public building on the lot. Normally residential structures are positioned on the lot with adequate front, side and backyard setbacks (except for the urban residences such as townhouses, etc.) within which construction of various forms of floodproofing can take place. In many cases, commercial retail structures and public buildings are located in more urban settings with minimal setbacks (or no setbacks) from streets, alleys or adjacent buildings. Adequate space for access steps or ramps to an elevated second story is not available on these limited lot sizes.



Figures 42 and 43 – Floodproofing Design – New Structure Wood Piling



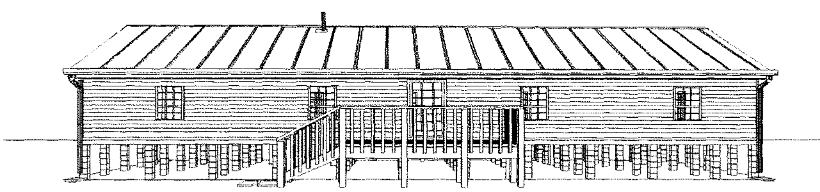
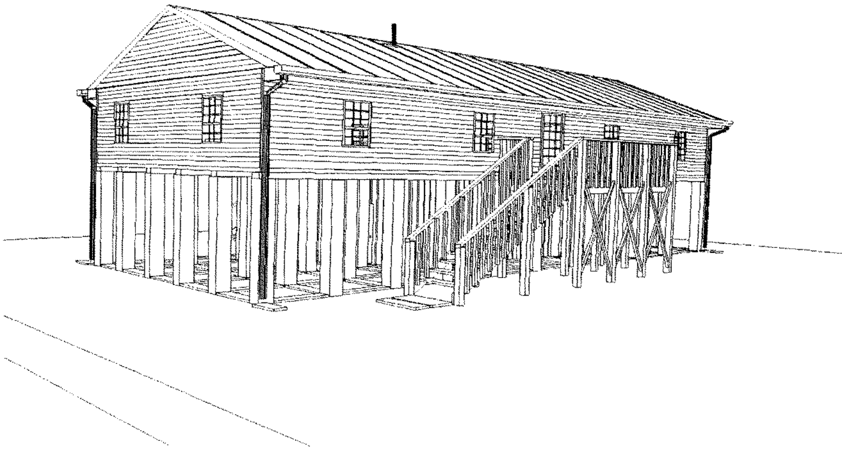
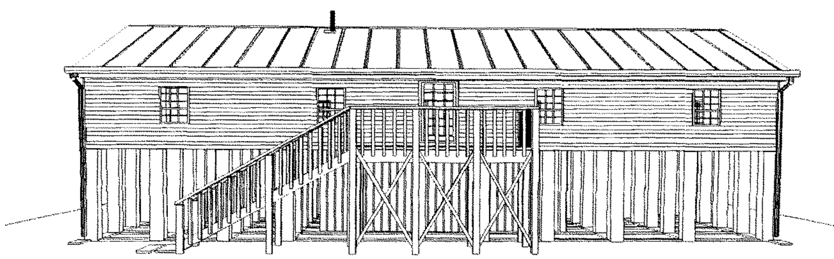


Figure 44 and 45 – Floodproofing Design Segmented Block – Structure Retrofit





Figures 46 and 47 – Floodproofing Design Concrete Column – Structure Retrofit

With these restrictions in mind, other forms of floodproofing such as dry floodproofing must be considered for the commercial and public buildings. Dry floodproofing can take many forms as discussed in Section 4.5.7.2 above. Two of the most popular forms are veneer walls and ringwalls or ring-levees. Veneer walls are constructed as a waterproof layer of dense materials attached directly to the existing structure wall to prevent water-penetration (see more detailed description below). Ringwalls and ring-levees are structural components within nonstructural measures whereby a single structure or complex of allied structures are enclosed with a ringwall or ring-levee structure (see a more detailed description below). In each case, this dry floodproofing technique prevents surge inundation from entering the structure or facility. The primary difference between elevation as a floodproofing technique and this form of protection is the need for closures in the veneer wall or ringwall at structure openings (doors) and the potential need for an interior drainage and pumping system in the ringwall or ring-levee system to remove rainwater due the storm event.

4.5.7.6.2 Design Assumptions

As was the case with residential units, very little specific information has been gathered on the uses, sizes and construction types of the commercial and public buildings within the project area. Generally speaking, they are composed of a mixture of masonry, wood frame and fabricate metal structures. Most of the older public buildings within the urban areas are of masonry construction and are multi-story. Numerous commercial retail and office buildings in Biloxi, Pascagoula and Gulfport are multi-story masonry buildings as well. Newer commercial retail structures located in the sprawl areas and along the major highways (Routes 90 and 29) are generally wood frame construction with masonry surfaces or fabricated metal buildings with various surface finishes. All of the commercial and public buildings appear to be founded on concrete slabs. In view of these observations, the flowing design assumptions were formulated to guide the floodproofing design and cost estimating for these types of structures.

1. The average commercial structure within the project area has a footprint of approximately 8,000 square feet and sits on a concrete slab.
2. Commercial structures can be protected up to 4 feet of water depth by a veneer wall. Costs for that form of protection would be based upon similar installations of veneer walls at commercial structures in LRH.
3. Any flood depths greater than 4 feet at commercial structures would require the use of a ringwall or ring-levee. The costs of that protection method would be capped at the average cost of commercial acquisitions (approximately $2.5 million).
4. Floodproofing of public buildings (schools, fire stations, police stations, city halls, etc.) would be by ringwalls only. Building sizes would be estimated based upon aerial photographs, number of students (square footage) and ground observations. Costs for this form of protection would be estimated based upon indexed values for similar installations at public buildings in LRH. Costs for closures and interior drainage are included in the per linear foot cost.
5. Floodproofing for both commercial structures and public buildings that are of a residential construction type (wood frame on a slab) would be by elevation or ringwall only (wood frame construction cannot support veneer walls).

4.5.7.7 Veneer Walls

One of several methods of dry floodproofing consists of applying a waterproof veneer material immediately against the existing structure wall. In order for landowners to realize the benefits of premium reductions on flood insurance policies, any veneer wall installation must provide at least I foot of protection above the established BFE. The applicability of this method of dry floodproofing depends largely on the structural stability and lateral strength of the receiving wall of the building.

Most residential construction, even masonry brick on concrete block does not have sufficient strength to withstand water pressures above 2 or 3 feet deep. In some cases, heavy industrial or commercial wall construction can withstand greater lateral pressures, but protection above 4 foot depths of water becomes problematic. Un-equalized pressures on un-reinforced masonry walls will soon lead to leaks and possibly catastrophic failures. The waterproof material can range from various sheet polymers, rubber and plastics to concrete. In some cases, constructed veneer walls of high-density, waterproof concrete can be applied directly to the structural walls to provide protection to interior contents. Appropriately sized footers and wall ties provide stability and reliability to the veneer wall structure. Visually pleasing surface treatments can be applied in-situ to poured veneer walls or other surfaces such as brick or stone can be applied to the waterproof concrete structure. Figure 48 shows an example of a veneer wall installation (brick facing) around a restaurant.

In addition to the stability of the structure's walls and waterproofing capability of the material, treatment of closures at existing entrances (doorways, garage doors, windows) into the structure is critical to a successful watertight solution. In veneer wall applications, watertight entrances are affected through casketed, sliding or rolling doors or metal plate inserts in the veneer wall. Although proven designs for these closures are available, none of them are automatic requiring placement by personnel who are on-site immediately prior to or during the flooding event. Annual maintenance of the closure systems is critical to maintaining protection for the structure.

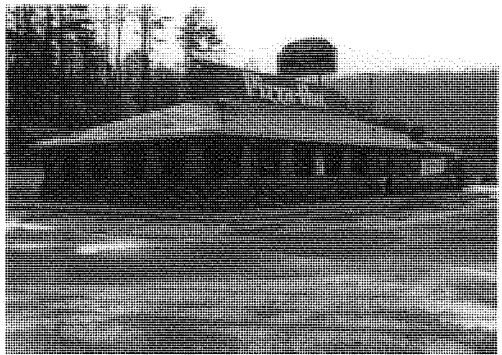


Figure 48. Veneer Wall Installation

Costs for constructing veneer walls on structures varies based upon the perimeter length of the structure, foundation conditions, wall height and number of closures. The NS PDT members have been involved in the design and construction of several veneer walls in nonstructural projects and preliminary costs for this measure can be estimated from those applications. Annual O&M costs for veneer walls relates to inspections of the wall and closures and replacement of gaskets at closures.

Veneer wall costs were based upon information from previous construction of these facilities on LRH nonstructural projects as shown in the above photograph. An average commercial footprint size was determined from aerial photographs and used to estimate approximate costs for commercial floodproofing by this method of protection.

4.5.7.8 Ringwalls/Ring Levees

Another method of dry floodproofing involves the construction of either ringwalls or ring-levees around an individual structure or group of associated structures. Planning and design considerations for ringwalls and ring-levees are similar to any floodwall/levee structure surrounding a community or urban area including risk-based determination of level of protection (wall or levee height), closures at entrances, interior drainage and pumping, geotechnical concerns, foundation design, penetrating utilities, sources of embankment materials and operation and maintenance requirements. Ringwalls can be either of an I-wall design or T-wall design depending upon the soil conditions, footprint restrictions and the height of protection. Normally these ring structures are only applicable to larger commercial, institutional or industrial facilities due to the cost of construction and annual OMRR&R.

Ringwalls can be used to protect schools, medical facilities, and essential emergency facilities. Use of this method of floodproofing is limited on a large scale for residential structures due to restrictions of lot size upon which to align the structure footprint and its cost relative to other options for protection. Generally speaking, these forms of protection are problematic in urban areas where lot sizes are smaller and building setbacks are narrow. Requirements for ongoing OMRR&R and the costs associated with those requirements for these more complex structures also require substantial revenues from the site owner(s).

There would be situations where a ringwall or ring-levee may provide an appropriate level of protection in-place for a critical facility or major employer in the community. On a somewhat larger scale (short of a structural measure), ringwalls and ring-levees may be appropriate for protecting entire neighborhoods of a community or a business or educational complex. In these cases, multiple gate openings in the wall or levee structure require onsite operation just prior to and during a flood emergency and interior drainage and pumping capability can become significant design considerations. Multiple closures and pumping systems require an on-site presence in situations where many surrounding residents may have already evacuated due to the flooding threat. This situation puts operations personnel in great peril should the protection be overtopped.

There are a large number of structures, groups of structures and facilities within the project area that provide critical services to the surrounding neighborhood or community at large. Floodproofing those facilities in-place reduces flood damages and maintains the essential services intact in lieu of acquisition and relocation. Opportunities may arise whereby ringwalls or ring-levees protecting neighborhoods could offer protection for valuable infill redevelopment sites allowing at-risk structures located outside the new line of protection to relocate into protected vacant sites. This floodproofing/infill scenario accomplishes the flood damage reduction objectives while minimizing impacts to the socio-economic and environmental justice components of the project area. For these reasons, dry floodproofing through the use of ringwalls and ring-levees will be carried forward into more detailed formulation of nonstructural plans. Figure 49 shows an example of a ringwall protecting a high school and Figure 50 shows an example of a ringwall protecting a commercial structure.

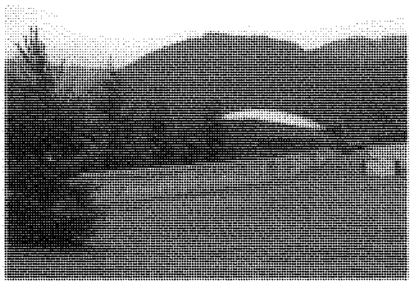


Figure 49. Ringwall Protection for a High School

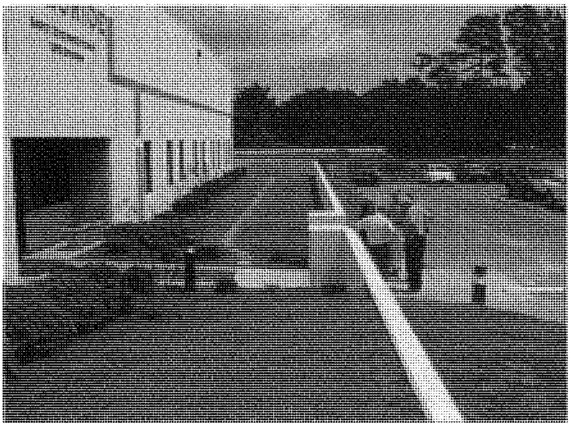


Figure 50. Ringwall Protection for a Commercial Structure

Capital construction costs for ringwalls and ring-levees can be high depending upon the structure's or complex's perimeter length, soil conditions, height of the wall/levee, material sources, hauling distances, number of closures, interior drainage and pumping requirements, alignment limitations, and wall type (I-wall or T-wall). Among all of the nonstructural measures, ringwalls and ring-levees have the highest potential O&M costs due to the complexity of the structural features and the risks involved in failure of individual components of the protection system. In addition, these protection features require on-site personnel to affect access closures and assure that interior drainage systems (pumping systems) are working prior to the event.

The NS PDT members have been involved in ringwall design and construction for schools and businesses from which preliminary costs have been developed for the plan. Based upon indexed costs for a ringwall (heights ranging between 4 and 8 feet) with closures and interior drainage, linear costs of $3,100.00 per linear foot (included E&D and S&A) of ringwall were used to estimate providing this protection for public buildings.

4.5.7.9. Waveland, MS 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 in Waveland, MS 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 that displays the ABFE flood levels in the Waveland area and the extent of the high-hazard zones described in this appendix, the NS PDT identified, in cooperation with the Mobile team, a geographic area within Waveland 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 location of the proposed project is shown in Figure 51.

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. Project construction would take place over a four year period depending upon the flow of funds. Costs for this method of elevation are dependent upon the footprint size of the structure and the height of elevation. It is estimated that the total, fully-funded cost of the project would be approximately $4.6 M. Upon approval of the project concept a more detailed implementation report would be completed showing detailed cost data, floodproofing procedures, contracting procedures and schedules for completion of the project.

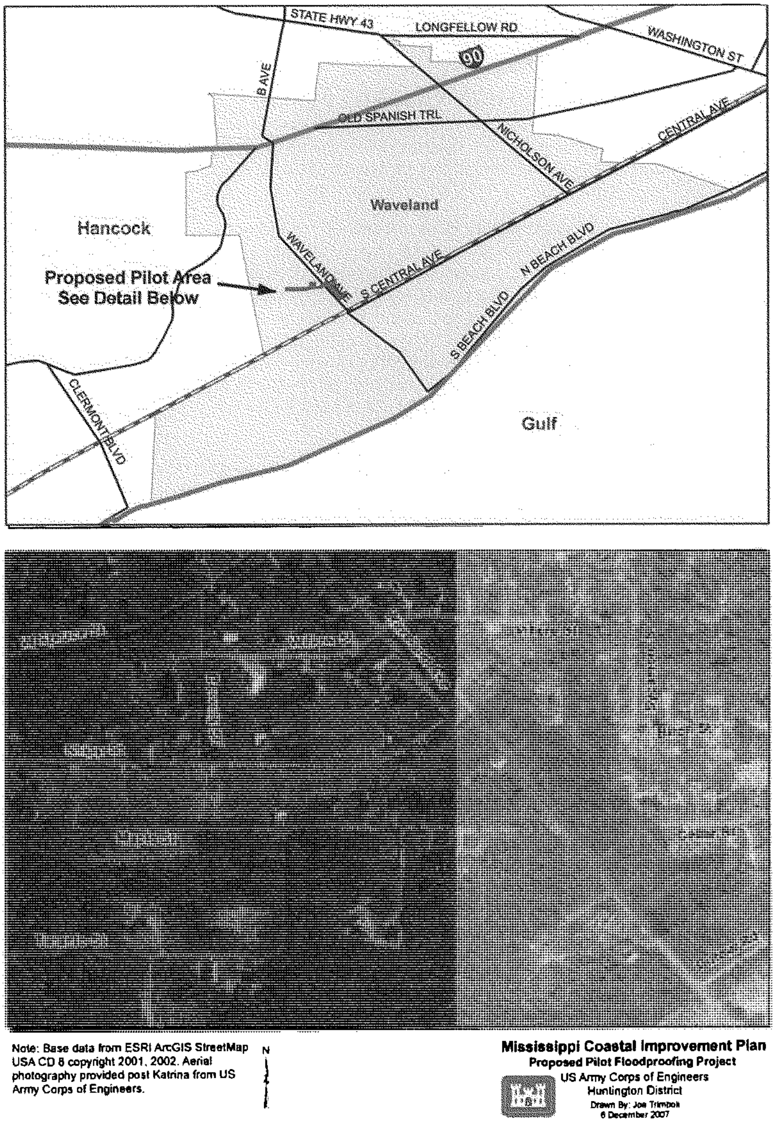


Figure 51. Location of Proposed Waveland, MS Floodproofing Project

4.5.8. Non-Corps Federal Floodproofing Programs

4.5.8.1. General Program Descriptions.

Following the rescue and recovery operations in the project area, both FEMA and HUD entered the damaged Gulf areas and began to implement assistance (grant and loan) programs for elevating structures. Each of the two agencies has been offering floodproofing assistance to eligible landowners so that homes, businesses and public structures could be elevated to reduce future damages.

FEMA, through their Hazard Mitigation Grant Program (HMGP), has been providing elevation grants (through MEMA) to eligible landowners so that either new construction or retrofitted homes could be elevated in accordance with the local floodplain management ordinances. The grant would be in addition to any flood insurance payments that an insured property owner may have received. The grant amount would generally cover the total cost of the structure elevation. The HMGP elevation requirements specify that a new or retrofitted structure be elevated to or above the base flood elevation (BFE) that has been delineated in the new DFIRM whether or not the new DFIRM has been locally adopted or not. FEMA has prohibited elevation of structures within the new V-zone in the HMGP except for structures that must be located within the V-zone due to their water-related usage.

HUD also has an elevation grant program that provides up to $30K to eligible landowners to assist in raising the first floor of either a new home or a retrofitted home to reduce future flood damages. The maximum $30K grant helps to defray the cost of elevating the home and is payable in two installments - $15K when the elevation permit is obtained and $15K when an occupancy permit is obtained. Neither HUD nor MDA are providing agency oversight for the elevation design or construction processes, but are relying on local NFIP and building code inspectors to assure compliance with the local ordinances. Since the program relies solely upon adherence to the local floodplain management ordinances, the HUD program has no restrictions on elevating homes within the V-zone shown on the new DFIRM, but has requirements for meeting building elevation construction standards within the V-zone.

Both of these programs provide monetary assistance to landowners that elevate their homes, but in the case of the HUD grant, the $30K limit may not provide the total amount necessary to cover the entire costs of elevating the structure according to the full requirements of the NFIP or the local building codes (IRC/IBC). When the distance between the ground surface and the BFE is minimal (1-3 feet) and the structure is being newly constructed, the grant may cover the increased costs of the extended foundation, utility lines and additional steps that support, service and access the raised first floor. Normally, the incremental cost of elevating new construction to meet NFIP requirements is less than retrofitting an existing structure.

Where an existing structure must be retrofitted with a new foundation or where a new structure must be raised to a higher level (8-15 feet) above the ground surface, the HUD assistance grant may not cover the homeowner's full cost. Retrofitting normally requires much preparatory work beneath the structure (dependent upon the foundation type; slab, crawl space, basement) followed by raising the first floor of the structure to the new design flood height (BFE) and installing new piling or masonry columns beneath the structure. Retrofitting an existing structure using current design guidelines and increased BFE heights can result in higher construction costs. These high costs may exceed the elevation grant by a significant amount. Significantly elevating a new structure (10-15 feet) can be quite expensive considering the costs of installing deep pilings, bracing the pilings, construction of extended utilities and providing access to the higher first floor. Any special needs of the household members under the American Disabilities Act (ADA) that require wheelchair ramps or chair lifts can add significantly to these costs.

In addition to the differences between elevation construction costs (based upon Corps project cost data) and the grant amount specified in the HUD elevation program – a difference that the landowner will bear, the lack of restrictions on elevating residential construction within the V-zone in the HUD grant program area is a concern. Funding redevelopment and elevation within the V-zone based solely upon local floodplain ordinance requirements would be in conflict with the MsCIP report recommendations. Generally, the BFE to which all new construction or retrofitted construction under the HUD assistance programs must raise the first habitable floor, may be lower than the hurricane surge that would be anticipated (and was experienced during Katrina) from a Category 5 hurricane. Hurricane surge depths in Katrina exceeded 25 feet in portions of the V-zone of the project area.

For instance, at one property parcel in Waveland, MS, a parcel located within the designated V-zone and included in the MsCIP study database, the Katrina surge was approximately 16 feet deep above the ground surface (ground elevation at that parcel approx. 8.9 feet msl). In the MsCIP nonstructural plan, this structure would only be eligible for permanent acquisition since the structure was located in the V-zone. The pre-Katrina BFE elevation at that parcel was 15 feet msl and the BFE from the new DFIRM is 23 feet msl - an 8 foot increase. A new structure elevated to the new BFE elevation (approximately 23 feet msl or a raise of 14.1 feet above the ground surface) could still be subjected to 2 feet of surge inundation from a Katrina-like storm with storm-driven waves possibly impacting the first floor stud-wall construction. The residual damages to that structure could be significant and any occupants taking refuge in the structure who may have decided to "ride-out" the storm would be in extreme peril. Many parcels similar to this example exist within the project area in the V- zone.

The result of this lack of development restriction in the V-zone in the HUD program would be to allow residential structures to be elevated such that the first habitable floor may be subject to the same surge and wave combination that resulted in the loss of thousands of homes and many lives during Katrina. The number of totally destroyed homes in the V-zone that had been elevated in compliance with the pre-Katrina BFE is a testament to the potential for significant residual damages and loss of life that could occur as a result of implementing an elevation grant program in the V-zone.

In addition to the two elevation programs, HUD's compensation program (two phases) provides grants of up to $150K to landowners whose structure was damaged by surge inundation in the Phase 1 program and up to $100K to landowners in the Phase 2 program. The Phase 1 program addressed all those eligible owners whose home was located outside of the 100-year flood zone but still suffered inundation damages from surge flooding. The Phase 2 program addresses all of those whose home was damaged by surge inundation and are located within the 100-year flood zone as shown on the FIRM. The compensation is in a lump sum based upon the estimated percentage of damage of the structure up to the $150K – or $100K limitation and requires no certification of work completed to address the structure damages. Any structure that was damaged more than 50% of the structure's value is required to meet the NFIP requirements for elevating the first floor above the most current BFE and the additional HUD grant in the elevation program (up to $30K) may be used to supplement the compensation grant to raise the structure.

Again as in the case of the HUD grant to elevate structures, the only restrictions placed upon the use of the compensation grant is conformance to the local building codes and NFIP regulations and local floodplain management ordinances. Homeowners choosing to rebuild their homes or repairing a damaged home within the V-zone under the HUD program can do so long as they meet the NFIP requirements and the local floodplain management ordinances. As shown above for the elevation programs, it would be possible for a homeowner to accept the compensation grant in the phase 2 HUD program and reconstruct a new structure in the VE zone that would be highly susceptible to residual damages in a recurring Katrina-like storm.

The MsCIP plan in comparison, although using the storm events of 2005 and especially Katrina as its benchmark for protection and reducing flood damages and loss of life, would substantially reduce residual damages and threats to public safety. Avoiding any new construction or elevation of existing structures in the high-hazard zone virtually eliminates the potential for such surge/wave-related losses in future similar storm events.

In terms of financial assistance, the MsCIP is founded on the premise of government-directed construction activities with associated design, regulatory and contracting controls to assure good quality, legality and accountability. Both the FEMA and HUD programs are essentially grants to landowners with minimal controls for design quality or accountability outside of local government oversight. The MsCIP program costs are founded on the requirements of the Uniform Relocations Act and actual floodproofing/relocations costs while the HUD program has set grant limits regardless of the actual costs of the work required.

4.5.8.2 Coordination with Proposed MsCIP Nonstructural Measures

In their implementation, components of the MsCIP and the FEMA HMGP program may be able to be integrated into a coordinated flood risk reduction program using permanent acquisition, structure elevation and both floodproofing and replacement of public structures. The restrictions in the HMGP limiting reconstruction or elevation in the V-zone are lock-step with the MsCIP recommendations for that high-hazard zone. However, the current HUD assistance and elevation grant programs have no restrictions on elevating structures (new or retrofitted) or new residential construction in the V-zone to match the recommendations in the MsCIP that restrict redevelopment in that high-hazard zone. Sole reliance on the current local ordinance requirements and use of upgraded building standards in the high-hazard zone through the HUD programs may not be sufficient to avoid the potential loss of property and lives during a Category 5 hurricane.

The differences (no matter how slight) between the MsCIP plan recommendations and the HUD grant programs, reinforces the need for a collaboratively developed plan for long-term flood risk reduction that can integrate these programs into one consistent long-range comprehensive strategy for creating disaster-resilient communities. As previously mentioned, the ongoing FEMA HMGP and the MsCIP plan recommendations appear to be very compatible. The best capabilities of the three Federal agencies can be brought to bear on the flooding problems of the project area through collaborative planning.

4.5.9 Permanent Acquisitions (Evacuation)

4.5.9.1 General

Permanent acquisition, (a.k.a. evacuation or buyout), 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 project area (with or without structures) can be purchased at fair market value under the provisions of the Uniform Relocations Assistance and Real Property Acquisition Polices 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.

Under the Uniform Relocations Act, residential occupants are provided the fair market value of their real property and can be assisted in locating suitable DSS (descent, safe and sanitary) replacement housing. Commercial landowners are provided the fair market value of their real property and may be eligible for certain moving and related expenses. Public structures (schools, medical facilities, city halls, county offices, police and fire stations, emergency services, etc.) owned and operated by state or local units of government (municipal and county) can be addressed through the substitute facility doctrine in lieu of permanent acquisition as described in Section 4.6 below. Once the existing structures are demolished (or the structure owner may be permitted to claim salvage rights to the structure and move it at their own cost if they so wish), the vacated land can be turned over to a local project sponsor for future OMRR&R under existing ordinances as may be modified by project agreements. Certain identified lands once purchased can be restored to wetlands from which additional ecosystem benefits can be generated. Post-acquisition use of the land can be dictated through the project partnership agreement (PPA) and could include wetland habitat restoration, recreation or open space uses that would not result in re-establishment of damageable property. Other options can be explored by local communities through local land use zoning for acquired properties.

This nonstructural measure would be applied to a zoning-influenced, land use pattern of residential, commercial, and institutional uses as well as both occupied and interspersed vacant parcels located within identified hazard zones in the project area. Some of the current vacated parcels were occupied prior to the arrival of Katrina and others were vacant prior to that event. In the robust coastal development market that existed prior to Katrina, interspersed vacant parcels were inhibited from development by ownership/title issues, legal liabilities, high prices, or other site constraints that limited their consumption in the marketplace. The PDT determined that these interspersed vacant parcels may not be developed immediately after new regulatory ordinances were adopted and any reinvestment funds were made available to the landowners.

However, parcels now vacated as a result of structure damages from Katrina may be redeveloped within a short period of time when both regulatory and funding issues were resolved. This process is occurring now at an accelerating rate. It was assumed for this report that landowners of parcels currently vacated have found other housing options elsewhere and would not require relocations assistance. Landowners who are now residing in FEMA trailers onsite would be eligible for relocations assistance when the property was acquired. For these reasons, parcels with current structures in place and those parcels previously occupied prior to Katrina (both located in the high-hazard areas described below) could be targeted for early acquisition to forestall redevelopment (i.e.

the Phase I HARP). Other local mechanisms for limiting redevelopment of interspersed vacant properties are discussed in the section discussing TDR and PDR programs.

4.5.9.2 High-Hazard Zone

The nonstructural PDT identified several zones within the project area, where due to extreme forces generated by storms and hurricanes, other measures such as elevation of an existing or rebuilt structure would not be prudent and may endanger the future occupants. Within these zones, successful emergency evacuation during the height of a storm event would be highly improbable and dangerous for the responders, elevated structures may be prone to foundation failures due to waves and surge, elevation by placed fill material is prohibited or infeasible, and non-elevated structures may suffer total or significant losses. Each of these zones was graphically identified using GIS mapping and FEMA database information (see Figures 56 - 60). There are three identified zones where permanent acquisition and evacuation of the property is the preferred nonstructural treatment. Those three zones referred to in this report in a collective sense as the "high-hazard zone" contain approximately 15,000 parcels and are described below:

1) The FEMA-identified V-zone displayed on the National Flood Insurance Rate Maps (FIRM) within the project area. This "Velocity" water zone features extreme energy wave action that was responsible for much of the building damages during the Katrina event and makes elevating structures or otherwise floodproofing structures in-place very dangerous.

2) The FEMA-identified "catastrophic damages zone" which was identified in a "post-Katrina" damage assessment of FEMA insured structures within the project area. This zone included a preponderance of structures that had received damages in excess of 50% of the structure's value. Field observations by the nonstructural PDT confirmed that most of those structures in the zone had been totally destroyed or severely damaged (major structural damages). This area includes the V-zone within its boundaries.

3) A flood damage zone was delineated extending 800 feet back from the beachfront within portions of Jackson County. The aforementioned "catastrophic damage zone" established by FEMA was based upon the Katrina event only and therefore did not account for the area of damages that could be expected along Jackson County were a Katrina-like storm to strike at that location. The 800 feet zone approximated the spatial extent of observed total structure loss and severe structural damages observed within Hancock and Harrison counties located closer to the Katrina landfall. Modifications of this zone's extent from the waterline may be made during more detailed planning to account for intervening topography that would limit the impacts of surge and waves.

4.5.9.3 Non-Floodproofing Zone

The nonstructural PDT also identified one additional zone within the project area where the preferred method of flood damage reduction would be permanent acquisition and evacuation of the property. This zone is located where water depths at the individual structure location occurring during the specified inundation event would exceed the maximum height of elevation prescribed by FEMA's 550 Guidelines for structure elevation. Those guidelines indicate that elevating structures more than 15 feet from the ground surface in hurricane areas would place the elevated structure in high-velocity hurricane force winds resulting in significant damages to the building. Any structure that would be required to be elevated more that 15 feet to place the first habitable or sales floor above the specified inundation level would be acquired. Using GIS software, a zone of inundation deeper than 13 feet (2 feet of freeboard) was identified within the project area where acquisition would be the preferred method of protection. Based upon the tax parcel GIS database information, there are approximately 15,000 parcels in the project area that fall within this non-floodproofing zone.

Additional structure by structure determinations accounting for structurally unsound, dilapidated, non-DSS, or unsafe structures would also result in acquisition of the property and structure. In some cases where the cost to elevate a structure would be greater than the cost to acquire, the owner would be given the option to "buy-up" to the elevation cost or be acquired voluntarily. Another option of rebuilding a new elevated structure on site at a cost less than elevating the old structure would be considered as an alternative to acquisition. As these "transfers" from elevation to acquisition are unknown at this time (determined either during more detailed planning or during implementation), they have not been identified on the GIS mapping as were other zones.

4.5.9.4 Real Estate Acquisitions

Any structure identified for acquisition would be processed according to the provisions and requirements of the Uniform Relocations Assistance and Real Property Acquisition Polices Act of 1970 (P. L. 91-646). In accordance with this Act, the Government will pay the landowner fair market value for the property and structure – a fair market value determined at the time of purchase. In view of the enormous number of potential acquisitions in the nonstructural program and the anemic housing market (post Katrina), application of the full range of relocation benefits under the Uniform Relocations Act may be warranted. Residential structures, because of the potential for social and economic impacts that could occur to families during relocation, are afforded a wider range of opportunities and financial assistance under P. L. 91-646 than are commercial businesses. In addition to the fair market value of the existing property and structure, business owners may be eligible for certain moving and related expenses. Residences are provided much greater benefits to assist with offsetting the hardships of acquiring a new home, relocating contents, and other moving expenses incurred by households. Additional details of the Uniform Relocations Act and its application to acquisitions in the project area can be found in the Real Estate Appendix.

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". The Moss Point municipal facilities discussed in Section 4.6.6 are an example of the application of the substitute facility doctrine referred to as "relocations" in this report.

4.5.9.5 Reuse of Evacuated Floodplain Lands

Since many of the parcels destined for acquisition have existing structures on them, the demolition costs to remove the structures and other site improvements (structural slab, driveways, utilities, building pads, etc.) would be allocated to the nonstructural measures. These demolition costs would only apply to those properties, structures and facilities which the Government acquires as a part of the project. Public streets, utilities and other facilities not within the footprint of the permanent acquisition measure would not be removed with project funds.

A significant amount of the project land area is either occupied by wetlands or had been wetlands before development encroached upon these sensitive habitat areas. It is widely recognized that wetlands and especially those tied hydraulically to the Gulf and its bays are a significant component of the aquatic and terrestrial health of the Gulf aquatic ecosystems. In addition to reuse for ecosystem restoration, evacuated floodplain areas could be used for recreation uses that would be compatible with the inherent flood risk. The locations of these recreation areas and appropriate facility development would be coordinated with the counties and the municipalities in which the evacuated parcels are located. Costs for these recreation developments would be cost-shared with local sponsors at the appropriate rate. Operations and maintenance costs for all post-evacuation recreation development would be the sole responsibility of the local sponsors.

In view of the national and regional benefits associated with expanding wetland habitat along the Gulf and within the project area, those parcels subject to evacuation under the nonstructural program, either located within the high-hazard zone (HARP) or in those areas where floodproofing is not a viable option (inundation depths greater than 13 feet), and that are suitable for wetlands restoration could be set aside for those ecosystem purposes. Using information from ERDC, USFWS and other natural resources agencies, areas suitable for wetlands restoration were mapped in GIS format and prioritized by a joint-agency team. The wetland layers were integrated with tax parcel, structure databases and acquisition layers to determine where permanent acquisitions and wetlands restoration would coincide.

Figure 52 shows the array of potential ecosystem restoration sites across the project area that could be located upon lands acquired in the high-hazard zone (HARP) and the non-floodproofing zone. The potential wetland ecosystem restoration sites (approx. 24 sites) located on evacuated lands are delineated on the map as "Nonstructural risk reduction sites" (orange triangle with #5 inside) to denote that the primary benefit from the action is risk reduction with the wetland ecosystem restoration as a secondary benefit.

4.5.9.6 High Hazard Area Risk Reduction Plan (HARP)

As discussed previously, reconstruction within the project area has been delayed due to uncertainty about the new NFIP regulations for constructing structures and the absence of rebuilding funds due to ongoing insurance claim judicial proceedings. As reconstruction funds become available and the revised NFIP floodplain mapping is adopted, residential and commercial reconstruction may begin at a feverish pace. In view of this anticipated reconstruction boom and the additional costs that would be incurred by the government in purchasing high-hazard zone (HHZ) properties with new, larger, more expensive homes (with greater demolition costs), a proposal for a High Hazard Area Risk Reduction Plan (HARP) has been formulated.

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 initial 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. The total estimated cost for the initial HARP is $408.4 million. More detailed information about the HARP can be found in Exhibit C of the Real Estate Appendix.

Also within the HARP footprint are 4 municipal structures in Moss Point, MS that have been identified as being public facilities that may be eligible for replacement through the Real Estate "substitute facility doctrine" in lieu of acquisition. The costs for the Moss Point replacement of public facilities are included in the total HARP cost. The Moss Point municipal complex is discussed in more detail in Section 4.6.6 below.

The initial 2,000 parcels in the HARP would be extricated from the designated high-hazard zone (HHZ) that extends the entire east-west length of the project area. Within that linear zone are several high-quality wetland ecosystem areas (including emergent tidal marsh) that were (prior to Katrina) occupied by various land uses such as residential and commercial structures and facilities. Figure 52 shows those potential ecosystem restoration areas within the high-hazard zone where acquisition of property through the initial phase of the HARP (2,000 parcels) could provide opportunities for wetland ecosystem restoration following land acquisition and demolition of any remnant facilities (pavements, utilities, foundations, etc.). The orange triangles marked with the number 5 (Nonstructural Risk Reduction Sites) denote potential ecosystem restoration sites that would occur on lands acquired for risk reduction.

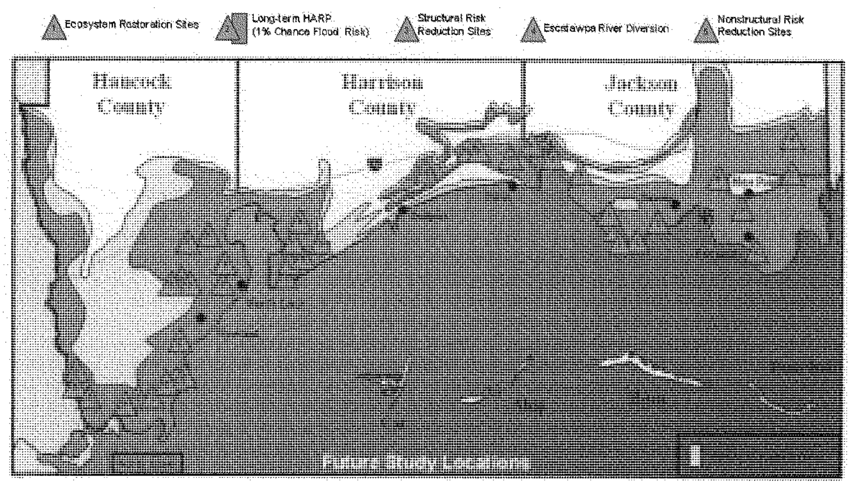


Figure 52 – Post-Evacuation Ecosystem Restoration Areas

4.5.9.7 Permanent Acquisition of At-Risk Properties through Other Federal Programs

Another option for implementing permanent acquisitions within the identified zones would be through the FEMA post or pre-disaster Hazard Mitigation Grant Program (HMGP). Within the overall hazard mitigation program, FEMA has two notable mitigation components that concentrate on acquiring flood-prone properties: the Repetitive Flood Claims Program (RFC) and the Severe Repetitive Loss Program (SRL) that could be used to acquire structures and properties located in these designated high-hazard areas. Generally, all of the FEMA programs target only structures with flood insurance through the NFIP. Annual funds are distributed to participating states through these programs that in turn can provide funds to individual municipal or county jurisdictions to implement their local mitigation plans. Coordination of the proposed acquisitions with the counties' and/or municipalities' All-Hazards Mitigation Plans submitted to FEMA could secure needed real estate acquisition funding and acquisition of the flood-prone properties. Actual implementation of the program would be handled by the state or a local jurisdiction (county or municipal government). Under the provisions of the HMGP program, properties acquired could not be rebuilt upon in the future. Opportunities for merging the FEMA Hazard Mitigation Grant Program and any Corps of Engineers permanent acquisition program within the project area may be possible.

The HUD Homeowners Assistance Program does not acquire property, but merely provides grant funds up to $100K in its Phase 2 program for homeowners living within the 100-year floodplain to compensate for damages from Katrina surge. The targeting of low and moderate income families by the HUD compensation program does raise the potential of the Corps program with greater financial benefits being applied to a wealthier segment of the population. This may be viewed as a somewhat inequitable scenario when viewed from the public's perspective. Other than financially supporting reconstruction or continued habitation in the high hazard zone, the HUD HAP does not conflict in its implementation with the MsCIP plan.

4.5.9.8 Relocation of Acquired Households and Commercial Businesses

4.5.9.8.1 General

The sanctity of the American home and all that it represents to the owner and family are at stake when nonstructural or structural measures are being considered for reducing flood damages. The home represents a unique place full of social interaction, psychological development, self expression and security from the outside world. Our homes may be the largest single investment in our adult lives and the place where families are started and nourished. For those retired, the home may be a place of relaxation and the center for extended family vacations (especially those located on the Gulf). Leaving one's home either by choice, by necessity or by force can be a very traumatic and stressful event. In close association with losing one's home is the loss of one's neighborhood or community due to a relocation project. Numerous studies have shown that although there can be both positive and negative impacts from housing displacement/relocation, the negative impacts can be more long-lasting and mentally stressful. With these considerations in mind, relocation of substantial numbers of households in either structural or nonstructural projects must be accomplished with appreciation for these impacts and stresses on the household members.

Based upon available inundation data for the parcels within the study area and the design limitations on elevating structures (maximum 15 feet in height) there may be a great number of acquisitions and relocated businesses and households in any nonstructural plan featuring floodplain acquisitions for the project area. Needless to say that any major nonstructural program that would feature significant numbers of relocations from the coast would dramatically change the economic and social characteristics of the coastal communities. In addition, the number of public buildings (many regarded as critical facilities) that could be eligible for relocations indicates that some relocation/redevelopment models could produce dire economic and social consequences for the coastal communities. In view of this potential, there are three possible avenues for addressing the relocations of these commercial and residential uses.

In addition to the potentially large numbers of landowners who may be only eligible for the permanent acquisition option due to the hazardous location or ground surface elevation of their property, the personal nature of the nonstructural program further exacerbates the problems of relocating thousands of individual households and commercial establishments within the project area. Left to each landowner's own understanding of the program and expectations of the future, individual decisions to participate in the acquisition program and where to relocate to will be outside the control of the municipality or county governments. An unplanned or uncoordinated dispersion of the coastal population would create many "wicked" problems for municipal managers and public service providers – "wicked" problems being those for which there are no discernable good answers. In view of this potential "scattering" problem, some in-place market systems and options should be explored and considered in planning for such a large movement of the population.

4.5.9.8.2 Market Housing Resources

Although hurricane Katrina demolished or severely damaged an estimated 65,000 residential structures, there are a number of remaining DSS structures that may become available on the market should a Corps buyout program be implemented. These "latent" market resources could be used to address relocations provided that the annual number of relocations from a Corps-sponsored program would not exceed the capability of the existing housing market to allow existing owners of DSS homes to "buy-up" in the market. Some rebuilding of owner-occupied and rental units is already underway in the project area following Katrina (over 1,600 building permits for single-family units in 2006), but the local housing market may not be capable of producing sufficient numbers of DSS replacements to satisfy the entire program-driven need. Should the Corps-sponsored program provide sufficient financial resources through P. L. 91-646 to allow the acquisition or creation of DSS market housing, this option could result in both successful relocations through the acquisition program and a significant housing construction program that would address the expectations of the existing owners and developers.

Regrettably, relying on existing market housing resources to address all of the relocation needs of program participants has a "down-side". Since these available housing resources are now scattered all over the three counties (or to adjacent counties or in other states), these once "neighborhood or community-centered households" would be dispersed all over the region. Besides the obvious impacts of breaking many long-standing social ties within the older, well-established neighborhoods and communities, social problems arise with displaced children, the elderly, physically handicapped, fixed-income, and other interdependent households within the community from displacement. Car-pooling, babysitting, in-home care and other informal social contracts would be broken within the community. In addition to these "social" impacts, dispersal of acquired households could result in impacts to schools, utility districts, public services, and other organizations (churches) that depend upon a stable population for financial resources.

In turn, those communities where displaced landowners would relocate to would be confronted with accommodating the needs (schools, utilities, public services, etc.) of many new neighbors of varying backgrounds and expectations without sufficient financial resources to mitigate the socio-economic impacts. Similar impacts have been realized in "boom-bust" communities associated with energy development and military projects of the past. There are numerous small communities located just north of the I-10 corridor that could be the recipients of this out-migration of relocatees. Table 10 shows a listing of those communities including their land area (in square miles), population, population density and projected population in 2030. The population projections are based upon information from the Gulf Regional Planning Commission's analysis of future traffic generated by zones within Harrison County. It is possible that one or more of these communities would be impacted by an influx of relocatees and many do not have the infrastructure or resources to handle a large number of new residents.

With respect to the commercial relocations, convenient access to one or more of the major existing highways in the area is of paramount importance. Major arterials such as Route 90, Route 49, Route 63, Route 603/43 and Route 110 have captured the majority of the new commercial growth in strip malls and big-box retail complexes. Relocations of at-risk businesses along the coast could follow a similar path given the availability of adequate land along these access roadways. Some flood-safe infill opportunities may exist within established communities, but they are limited due to zoning

Table 10.
Communities Adjacent to the Project Area

Community Name	Population Estimates	Population Density	Community Area	Projected 2030 Population
Escatawpa	3,566	553/sm	6.45 sm	NA
Latimer	4,288	265/sm	16.2 sm	NA
Van Cleave	4,910	113/sm	43.4 sm	NA
Kiln	2,040	153/sm	13.3 sm	NA
Picayune	10,535	918/sm	11.8 sm	NA
Lyman	1,634	135/sm	8.10 sm	4077
Saucier	1,303	186/sm	7.0 sm	NA
Helena	778	385/sm	2.02 sm	NA
Dedeaux	598	NA	NA	3040
Wool Market	3,050	NA	NA	5161
Orange Grove	1,914	NA	NA	3500
New Hope	601	NA	NA	1396
Wortham	NA	NA	NA	NA
Lizana	1,624	NA	NA	2459

sm = square mile(s); NA = data not available
Data source: US Census 2000

restrictions and lot sizes. Other commercial redevelopment opportunities may exist within planned unit developments established with relocated housing initiatives. Certainly for businesses that depend upon a more local clientele, relocation into an existing community structure would better assure their financial success.

4.5.9.8.3 Existing and Planned Redevelopment Sites

In view of the potential impacts that scattered displacement of acquired households could generate in surrounding communities, at least three other redevelopment scenarios should be considered. The first redevelopment scenario is based in part upon a recommendation of the Mississippi Renewal Commission that consideration be given to managed-infill development within existing municipal areas where interspersed vacant property (or property with abandoned buildings that could be demolished) would be available for reconstruction of new housing units. These infill sites should be located at elevations greater than the 500 yr. frequency elevation shown on local FEMA FIRM or where the replacement house could be elevated to avoid first floor damages from a 500 yr. flood event as defined in FEMA mapping or within a line of protection that may be afforded by a Corps structural project (i.e. ring-levee project).

Since existing utilities, streets, public services and other amenities are available at these sites, costs associated with providing these site amenities are significantly reduced. Issues to be resolved in infill projects include land costs, infrastructure capacity, potential HTRW contamination and restrictive zoning regulations. Despite these site issues, infill development helps to increase concentrations of municipal population that can support transit services, recover lost tax revenues, and support social organizations and public services. Any new housing options at infill sites would be subject to local zoning and building codes thus assuring that replacement housing would be DSS and able to withstand hurricane winds.

As was shown in the Mississippi Renewal Design Charrettes, there are many housing and commercial design options available that could provide a visually pleasing urban environment while addressing the flooding risks. Opportunities for mixed use development (residential and commercial) in the more urban areas of the project would abound and strengthen the communities by reinvestment in those damaged economies. Application of New Urbanism concepts for recreating traditional neighborhood areas within existing urban spaces could significantly change the social and economic structure of the communities and reduce the need for vehicular use and parking. See Figure 53 for an example of infill development within the project area in areas where elevation of the new structures may be necessary to meet the program guidelines.

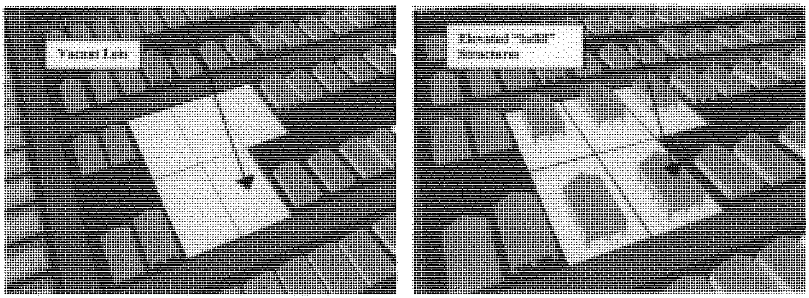


Figure 53. Infill Development

An additional option for redevelopment that could accommodate displaced landowners is the creation of new communities in flood-safe areas. This option can address issues of community cohesion and social impacts that would be raised in circumstances where an existing neighborhood or community has established social or ethnic ties that would resist displacement or where environmental justice issues may arise from acquisition. Sites located above the Probable Maximum Intensity (PMI) hurricane surge inundation elevation (or at a minimum 500 yr. frequency level) or sites that could be physically raised by fill material to be above those elevations, would be platted according to existing subdivision regulations featuring basic residential amenities (utilities, infrastructure, streets, lighting, sidewalks, etc.) and be ready for new housing construction to accommodate displaced landowners. A variety of lot sizes would be platted in the new communities so that a variety of home sizes could be accommodated to meet the replacement housing needs of the displaced owners under the Uniform Relocations Act provisions. These sites could be developed in such a way that many of the urban development concepts recommended by the New Urbanism Congress for Mississippi Renewal could be realized on the ground. These "Housing and Community Development" (a.k.a. H&CD) sites could be located with convenient access to Interstate 10 interchanges and the major arterial roads leading back towards the coastal area. A north-south transit system on those arterials could be initiated to reduce future traffic flows between the relocated communities and the remaining shoreline urban areas.

Should this H&CD option be exercised, relocations of schools and other critical facilities as part of the coastal protection project could be coordinated such that the new communities would be served by those relocated public facilities. Figure 54 shows an example of a new community development with opportunities for residential, commercial and institutional land uses. Development costs for H&CD sites could be as high as $45,000 per lot including land acquisition, site grading and drainage, utilities, streets, lighting and landscaping.

The third redevelopment scenario is based upon the new community concept but the physical location of the existing community does not change. The best example of this option is the community of Pearlington where the current density of development is relatively low and portions of the existing community exhibit higher elevations above the Gulf. The primary component of this redevelopment scenario would be raising areas of the community with locally excavated fill material.

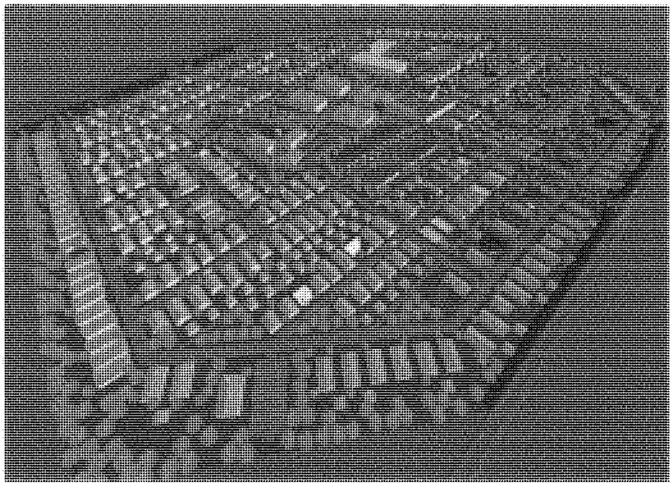


Figure 54. New Housing and Community Development Site

That new site elevation could be adjusted to meet any of the selected levels of protection associated with surge inundation from hurricanes. New residential, institutional and commercial development could be constructed upon the raised site in a more dense development pattern that would be more efficient and safer thus avoiding the social impacts associated with dispersal. New utilities and roadways would complete the community redevelopment.

In the case of Pearlington and the few small residential subdivisions surrounding that community, their current footprint is surrounded by a low-lying landscape that could be converted to wetland habitat as part of the excavation process for fill materials. With careful planning and design the development of a new raised Pearlington community could result in many acres of new wetland habitat adjacent to the Pearl River as a by-product of the borrow operation. Opportunities for a "safe harborage" along the Pearl River could also be explored as a part of the excavation of near-by borrow material to raise the community. Further investigation of this type of on-site redevelopment may indicate other coastal locations for its use and some cost savings above other options for whole community relocations. Certainly the prospect of creating additional high-quality wetland habitat as part of the redevelopment process is noteworthy.

In recognition of current community planning models that emphasize more concentrated development rather than the sprawl pattern of the last four decades, relocations of large numbers of households would need to be better planned and closely coordinated with the municipal and county planning and zoning commissions. New urban development initiatives being promoted by the New Urbanism Congress and "green" neighborhood programs being promoted by LEED (Leadership in Energy and Environmental Design) can be applied to new relocation sites. In an age of higher fuel prices, growing concerns of the effects of greenhouse gases, and conversion of green areas to urban uses, this anticipated redevelopment needs to emphasize walkable communities and reliance on public transit rather than the vehicle-oriented neighborhoods that have become popular along the coast. The more concentrated urban communities within the project area (Biloxi, Gulfport, and Pascagoula) exhibit these more pedestrian-oriented patterns of development. Any new redevelopment options must consider these emerging societal concerns.

4.5.9.8.4 Replacement Housing Options

As important as the location and quality of the relocations sites will be to local governments, the quality and affordability of relocation housing units will be more important to displaced families. The need for affordable DSS housing resources in the project area is well documented. Much of the new replacement housing that has appeared following Katrina has been larger and more expensive than the destroyed units. This trend in replacement housing does not bode well for those families that may be in need of replacement housing but either had limited financial resources or did not have insurance coverage. Housing unit options that can meet a wide range of financial situations will be more successful in such a massive relocation effort.

Housing options such as manufactured units (not mobile homes), panelized units and modular units can provide reasonably priced, well constructed homes for relocated families. Most amenities found in stick-built homes can be incorporated into manufactured homes at the factory. Built in a controlled environment with quality materials, close tolerances and meeting the latest building codes, these units can be produced in large numbers for reasonable prices. A wide variety of styles, sizes and built-in amenities are available from multiple suppliers. All International Building Code requirements can be met with these manufactured housing units. Transported into redevelopment sites and placed on either a concrete slab or crawl space foundation, installation of these units requires days rather than weeks or months and new communities can be established quickly. Coordination with local zoning and code enforcement offices prior to construction and installation of these housing units can reduce any development permitting problems.

4.5.9.8.5 Cemeteries

Among the many personal items that may be encountered during the purchase of private property and relocations of a household or business is a cemetery on the acquired property. The cemetery could be associated with a family or with a church or another commercial enterprise. Cemeteries will not be purchased or relocated as a part of the nonstructural permanent acquisition measure. Under the nonstructural program, cemeteries remaining on the acquired and evacuated land do not result in residual damages and do not further threaten lives. Cemeteries will be left in place unless the landowner chooses to relocate the cemetery with their own resources. The purchase price of the property will take into account the value of the land occupied by the cemetery. Reasonable access to the cemetery for the family or business (or church) will be provided during the structure demolition process. Any additional security, adornment and all maintenance of the cemetery or the plots in the cemetery will be at the discretion and expense of the cemetery owner(s).

The only cemeteries that may be purchased under the nonstructural program would be those located within property purchased for redevelopment sites and then only in cases where the location and size of the cemetery significantly limits the efficient use of the site. All efforts will be made in the site development process to avoid any new or relocated home construction on land previously occupied by known cemeteries. Cemeteries found within the footprint of the contractor's work limits of a structural project (Levee, floodwall, pump station, etc.) will be relocated in accordance with standard Federal relocation procedures.

4.6 Replacement/Relocation of Public Buildings and Facilities

4.6.1 General

Permanent acquisitions within the high-hazard zone (HARP) and the zone where inundation depths would be greater than 13 feet above the ground surface affect a zoning-influenced pattern of residential, commercial and publically-owned institutional land uses. Among those land uses are a scattering of publically-owned and operated buildings and facilities which house the administrative, emergency, security, and management personnel and operational systems that continuously support the project area. As described in Section 4.5.9.4 above, for those facilities and structures that have been identified as having a compensable public interest and cannot be otherwise protected by floodproofing or structural methods or that are located within the high-hazard zone (HARP) would be addressed through the substitute facility doctrine and treated as a relocation item in the project. In these instances, a relocations contract would be executed between the Corps and the public jurisdiction (state, county or municipality) for design and construction of the replacement building/facility. Identification of public facilities that may be eligible for replacement was based in part upon FEMA data and data provided by individual counties and municipalities.

4.6.2 Critical Facilities Database

The database within FEMA's HAZUS (**HAZ**ards **U**nited **S**tates) program identified approximately 75 structures categorized as "critical facilities" within the project area that were damaged by Katrina. Many of those public structures and facilities were confirmed by cross-checking municipal and county databases. Of that total number, approximately 66 could be identified (by name or by use such as schools, fire stations, police stations, city halls, emergency management, or medical facilities) as being publicly-owned or otherwise eligible for the facility replacement under Corps Real Estate regulations. A number of the critical facilities were identified as being privately-owned (faith-based schools, government offices in private office space) and would be purchased through the permanent acquisition program as commercial businesses. Of the 66 structures, 49 could be positively identified with an existing tax parcel in the project database and were determined to be eligible for replacement or floodproofing by some method.

4.6.3 Relocations Planning

Using the GIS hazard zone layers previously developed for commercial and residential structures and the locational data from the tax parcels and HAZUS program, preliminary options for each of the public buildings and facilities were determined. Due to some inaccuracies in the geo-coding of the structures used in the GIS databases, exact determinations of the disposition of each public building cannot be made until each building or facility is field verified in a more detailed study. As with residential and commercial structures, any public buildings/facilities that were located within the three high-hazard zones were determined to be eligible only for replacements to a flood-free site. Public buildings such as schools, city halls, police stations, fire stations, emergency services buildings, and medical facilities located within those hazard zones would be relocated (substitute or replacement structure) through a relocations contract to a suitable flood-free site. Initial analysis of the data indicates that 7 structures/facilities may be eligible for replacement at a new flood-free site. Another 42 public structures were determined to be protected by floodproofing by various methods (assumed to be ringwalls for this appendix).

Prior to any detailed planning for a substitute facility, the Corps would conduct an analysis of each potentially eligible structure or facility for the processing of an Attorney's Opinion of Compensability (one of the necessary steps in determining whether a facility or structure is eligible for replacement). Provided that the Attorney's Opinion of Compensability is affirmative, detailed relocations planning for the facility would commence. The redevelopment site selection, new facility/building design and construction would be fully coordinated with the public facility owner. Relocations planning would determine, in cooperation with the owner and regulating entities whether the existing structure met current regulations regarding size, facilities, and uses. Bona fide upgrades to meet current building/facility standards would be included in designs for relocated structures. Any upgrades that would exceed current standards for that specific building use would be considered "betterments" and would be subject to financing by the owner of the structure or a non-Federal project sponsor.

4.6.4 Replacements Costs

Costs for replacements were based upon estimated square footages for fire and police stations and city halls within the project area. Prices per square foot for standard frame construction were used to estimate new buildings and associated facilities construction. RS Means building construction online calculators (http:www.rsmeans.com/calculator for 2007) were used to determine building costs for each use type based upon a centralized zip code location (Gulfport, MS) within the project area. Square footage estimates for relocated schools were based upon numbers of students (using current online county school board databases) and square footage recommended per student (based upon 2006/2007 school construction in the four state region including MS). Using school construction information from a 2007 Construction Report published by School Planning and Management for a four state region (including MS), costs per square foot of building construction were determined. Per square foot costs were determined by school type (elementary, middle and high school). Land and parking requirements were based upon national standards for the various levels of schools (elementary, middle and high school) and the appropriate contingencies, E&D and S&A costs, overhead and profit were also added to the replacements estimates. Since all of the schools and fire stations in the project area were not specifically identified in the parcel database, an average cost for replacements was calculated for those structures identified in the database and applied to all listed public structures.

For those public structures located outside of the three high-hazard zones and where depths of flooding did not exceed 13 feet, methods for protection in-place would be explored in greater detail. During more detailed nonstructural planning for protecting individual public structures, options for protection in-place such as veneer walls, ringwalls, or ring levees can be considered with respect to the suitability of the property to support certain protection methods as well as building access requirements, utilities, service entrances, ADA requirements and other building use needs that would determine the appropriate type of in-place protection. A more in-depth field investigation of each structure would be necessary prior to implementation of a nonstructural project in these areas.

Approximately 43 public structures may be eligible for floodproofing in some form (elevation, veneer wall, ringwall, ring-levee, etc.). For the purposes of determining a preliminary cost for this nonstructural appendix, it was assumed that each of the structures within the floodproofing area would be protected by a ringwall. Building footprints and perimeter lengths for ringwall length were determined based upon aerial photographs and student numbers for schools. Recent ringwall costs for protecting a high school (portions of I-wall and T-wall construction) were indexed and applied to the wall lengths determined by the methods described above. Appropriate contingencies, E&D and S&A, profit and overhead were added to the estimated per linear foot ringwall costs. The cost estimates assumed that all floodproofing construction would occur on property owned by the municipal or county government so no costs were included for land acquisition.

Estimated costs for floodproofing public structures such as fire stations were based upon a standard building size of 5000 square feet for the project area. Ringwall length was predicated on a 20 footwall setback from the building for interior drainage, closures and vehicle access. Construction costs were estimated according to the procedures listed in Section 4.3.7.8 Ringwalls and Ring Levees.

4.6.5 Replacement Sites

For those critical facilities determined to be public facilities, information on the use, service area, floor space size and special requirements will need to be determined so that an appropriately sized, located and equipped relocated structure can be estimated for construction. That detailed information was not available for each facility to be relocated at this level of planning study. Site selection for these relocated facilities is a critical component of the replacement process given the sensitivities to the service area (police, fire and schools), land area requirements and the need for some emergency services facilities to be protected while remaining relatively close to the event area. In accordance with FEMA guidelines, certain critical facilities should be located above the 500 yr frequency event as defined in the FIRM. A determination of the required or preferred level of protection for each type of publically owned and operated facility or structure will be made during the detailed relocations planning process. Relocations agreements specifying all of the relevant requirements and facilities to be constructed are executed between the governmental unit and the Federal government (USACE) prior to construction.

Replacements of these public buildings, some of which are considered to be critical to the safety, security and administration of communities must be carefully accomplished in concert with other potential relocations of residential and commercial structures and facilities. Re-establishing service areas around relocated facilities that conform to state or national legal and funding requirements will be a challenging task. In some cases, regional facilities could be relocated initially while public facilities with a smaller service area would be moved after substantial numbers of residences and commercial uses have been relocated out of hazard zones. Close coordination with local government units and service providers will be critical to the success of replacing eligible public buildings.

4.6.6 Moss Point Public Buildings Replacement

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 stated previously, public facilities, when determined to be eligible for substitution in lieu of acquisition, (the substitute facility doctrine discussed in Section 4.5.9.4 above) 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.

Coincidently, the NS PDT 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 NS PDT 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, the NS PDT developed 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 55. 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.

Members of the NS PDT provided a preliminary replacement assessment of the required building square footages, parking requirements and land area needed based upon data from the city officials in Moss Point and field measurements. Using this base data, Corps estimators developed a fully-funded total cost for relocating these four structures of approximately $11.4 M which has been incorporated into the total cost of the HARP.

Figure 55 – Moss Point Public Buildings Replacement Location

CHAPTER 5. SUMMARY OF NONSTRUCTURAL MEASURES

As shown above, there are a number of potential nonstructural measures that could be implemented within the project area and would result in significant reductions in flood damages as well as reducing the threats to occupants of the coastal zone. Some of the measures are generally associated with Federal actions that could be implemented through standing or new project authorities and some are purely within the purview of state and local jurisdictions acting through their police powers. Many of the measures have been proven in other locations to be both effective and reliable and some, although theoretical in their construction, if implemented should have dramatic effects on the existing development patterns along the coast that contributed to the high losses from Katrina.

Given the current conditions within the project area with regard to pending insurance settlements and the uncertainties surrounding the anticipated new flood insurance rate mapping, redevelopment along the coast has been relatively minimal. However, when the regulatory and financial components of redevelopment are finally resolved, new construction along the coast is anticipated to proceed at a feverish pace. Opportunities to assure that new development is located in less hazardous areas than in the past and to reduce the future damages associated with large hurricanes and storms are slipping by each day. Some of the measures described above can forestall unwise development along the coast if they are implemented in the near term. Those measures are discussed in the subsequent formulation and evaluation sections of this Nonstructural Appendix.

Although many of the measures are shown to be effective in reducing damages and threats to life, some of them could result in significant social and economic impacts if administered within a short time period to large areas of the coast. Significant numbers of permanent acquisitions and relocations would result in the movement of thousands of families, hundreds of businesses and many facilities regarded to be critical to the functioning of existing communities. Some of the impacts associated with these activities can be mitigated through available programs, but without careful planning and collaboration between Federal, state and local agencies and jurisdictions, the potential exists for significant impacts to the social fabric and economic viability of the coastal communities.

An important feature of the nonstructural measures is the capability to "tier" or layer the measures in different zones over an extended implementation period. Such "tiering" facilitates a constant stream of flood damage reduction benefits through the application of one or more coordinated measures along the coast. As the following formulation process will demonstrate, multiple measures can be implemented simultaneously on a single parcel or across several reaches, each tier providing ever-increasing layers of protection and damage reduction. The tiering approach also eases the social and economic impacts of significant movements of households, businesses and supporting public facilities from high-hazard zones to more flood-safe areas over time.

Collaborative planning among Federal agencies, the state, counties and municipal jurisdictions will be paramount for successful implementation of the nonstructural plans described in the following chapters. Meaningful and continuous public involvement and consensus building will also be key components of a successful nonstructural program. Few other types of flood damage reduction are as personal as are the nonstructural measures and working with homeowners and landowners could be challenging.

CHAPTER 6. NONSTRUCTURAL PLAN FORMULATION

Formulation or "building" alternatives or plans out of identified management measures is a process of creative thought mixed with planning experience and input from various disciplines. Combining various measures into alternative courses of action that address the planning objectives, work within the constraints and that can be implemented by both the Corps of Engineers and other partners in the project is the foundation of the formulation process. Careful manipulation and combinations of proven and reliable tools that reduce flood damages and threats to life and property can result in imaginative solutions to complex problems.

Formulation of successful plans requires a cooperative effort between team members, stakeholders and project partners. Although implementation of certain identified measures within plans may be beyond the limits of the Corps' authority to implement, that does not restrict their inclusion in the formulated plans. Every opportunity to engage the abilities and authorities of our local partners and cooperating agencies in meeting project objectives should be explored. Since nonstructural measures normally include actions that can only be implemented within the statutory scope of local governments, the opportunities for formulating innovative plans abound.

Formulation of plans must consider the intent and direction of the planning objectives. Although the objectives can be revisited and revised during the planning process, the initial or preliminary objectives of the project, based upon the study or project authorization and a careful examination of the stated problems and opportunities, must be satisfied by the formulation process. Failure to meet or exceed the planning objectives calls into question the entire formulation process.

Plan formulation must also consider the temporal aspects of various measures with respect to the size and complexity of the problems to be solved (extended implementation times) and the sequence of applying nonstructural measures to a large population (cumulative social and economic impacts). Since nonstructural measures tend to impact individual properties (residential and commercial) as well as potentially disrupting community systems (education, security and safety, health, and public services), formulation of plans for this project area will consider tiering of measures over an extended period of time. Attempting to relocate large segments of the coastal population as well as commercial resources and critical facilities away from hazardous areas to less flood-prone areas in a relatively short period of time would be an administrative and social nightmare. On a more practical level, the human and financial resources necessary to complete the full suite of nonstructural measures discussed in this appendix in a relatively short period of time are unavailable at this time.

Formulation must consider the various affects or impacts that alternatives or plans may have on the natural and community resources of the project or program area. Each action or activity will generate some differences in the natural, social or economic conditions of the area. Both beneficial and adverse impacts are anticipated from most nonstructural actions, but formulating plans with those potential affects clearly in view can reduce needed mitigation and plan costs. Since communities by definition and function are composed of a mixture of land uses, people and infrastructure systems, each one contributing valuable benefits to the community as a whole, it was determined by the NS PDT that alternatives that targeted one of the individual land uses or components for protection in such a way to totally remove that component from the community structure (i.e. relocation of all residences or just all commercial uses) would not be presented in the nonstructural plan. In cases where a particular structure type (i.e. mobile homes) would be placed in extreme jeopardy through a nonstructural measure (elevation into hurricane-force winds), acquisition of those structure types in lieu of elevation may be warranted. Although it would be possible to envision the separation of community land uses in some future coastal development plan so as to provide greater levels of flood protection and more efficient land use, the social and economic impacts of affecting such a community dispersion in a Federally-funded program would be virtually impossible to describe or justify.

Prior to initiating the nonstructural formulation process, three components of nonstructural measures must be considered: 1) program eligibility of structures and properties, 2) level of protection being provided, and 3) nonstructural measure evaluation criteria. Unlike structural projects where a line of protection or an area of reduced inundation gathers hundreds or thousands of properties, many nonstructural measures (i.e. floodproofing) address individual properties and each must be evaluated with specific criteria for their eligibility in the program options. Each of these three components is discussed below.

6.1 Nonstructural Plan Data Use and Analysis

Formulation of nonstructural measures relied heavily upon many sources of data and information provided by the local counties and municipal areas, as well as from other Federal and state agencies. One of the primary data sources was provided by the three counties (Jackson, Harrison and Hancock) tax assessors offices. Tax parcel databases from the three counties that were geospatially constructed for use with standard Geographic Information Systems (GIS) computer models allowed the NS team to account for the many surge-affected parcels correlate their common site characteristics and display that data graphically for formulation purposes.

As is the case with many county property tax databases, tax parcels may be composed of one or more legally-described tracts of land that are listed under one ownership in the tax system – this is the case for the three county tax parcel databases used in this project formulation. For the purposes of the nonstructural formulation all of those “tracts” were just referred to as “parcels” to avoid confusion. Also, prior to Katrina, a great many interspersed parcels were recorded in the tax database as being vacant without any residential or business structure located on the property. Since these interspersed vacant parcels could be built upon in the future and suffer damages due to hurricane surge inundation those tax parcels located within the permanent acquisition zones were included within the acquisition category of nonstructural measures. An additional number of parcels that had structures located on them prior to Katrina (as determined in the tax base) had been made vacant due to Katrina. Estimates based upon field observations were made in the project database as to that number of newly vacated parcels that would also be eligible for acquisition. It is out of that estimated number of vacated parcels that the proposed initial phase of the High Hazard Area Risk Reduction Plan (HARP - see Section 4.5.9.5) would purchase parcels prior to landowner reconstruction.

For the purposes of nonstructural formulation and the determination of national economic benefits associated with the nonstructural measures, several future-without-project scenarios were developed (see the Economics Appendix). Those alternative scenarios allow comparison of with-project and without-project conditions with regard to inundation damages, potential loss of life and other factors. Each of those 6 scenarios include the assumption that by the year 2012, all of the parcels of land vacated as a result of Katrina would be rebuilt upon with either residential uses or a mixed-use of residential and commercial structures. In keeping with those scenarios of the future-without-project condition, the several plans formulated and evaluated in the pages that follow show a full compliment of developed parcels (existing and new structures in place) within the various inundation zones of the project area. For the same reasons, the costs displayed in the various nonstructural plans (those including the land acquisition measure) represent acquisition of land and structures with associated relocations assistance payments and structure demolition for each parcel within the proposed acquisition footprint.

6.2 Nonstructural Plan Eligibility

In contrast to structural projects where the line and level of protection can actually encompass structures, facilities and lands that were not directly affected by the design flood event, nonstructural measures are directly targeted at structures and facilities which had or would have damages to the first floor and contents from specified inundation events. This difference requires that program eligibility criteria be developed to determine whether the owner of a particular structure or facility can participate (either mandatory or voluntarily) in the program. Usually the ability to participate in a nonstructural program is dependent upon the incidence of damages to the first habitable or sales floor of a structure or facility from a specified flood event. Normally nuisance damages to sub-floor utilities in a crawl space or basement (i.e. ductwork, furnace, hot-water heater, pumps, etc.) do not qualify a structure for program eligibility in nonstructural projects.

Of prime importance in determining program eligibility is the water surface elevation of the flood event that was the genesis of the study or project authorization. The study authorization for the MsCIP specifies *".....to expedite studies of flood and storm damage reduction related to the consequences of hurricanes in the Gulf of Mexico and Atlantic Ocean in 2005,.."* Obviously the largest and most damaging of those hurricanes in 2005 was Katrina. Although both structural and nonstructural measures can be formulated that address a wide range of storm and hurricane events including the theoretical Probable Maximum Intensity (PMI) hurricane, the program eligibility for nonstructural measures must settle on one logical event level.

For this study, the extent and water surface elevation of the Katrina surge inundation was determined to be the limits of nonstructural eligibility. Although the most cost effective project may actually provide a lower level of protection than that necessary to protect structures against a recurrence of a Katrina-intensity event, those structures and facilities that experienced first floor damages from Katrina would be eligible for the nonstructural program at some determined level of protection. It would be possible, depending upon the identification of the most cost effective plan, that structures damaged by Katrina would not receive any program benefits should a lower level of protection than the Katrina inundation level be the basis of the most cost effective plan. This declaration of eligibility for properties damaged by Katrina provides the basis for identifying these landowners as "displaced persons" for the purposes of applying the benefits of the Uniform Act.

6.3 Nonstructural Level of Protection

Determining an appropriate level of protection for nonstructural measures is somewhat unique since most measures apply directly to individual parcels and structures or facilities on those parcels rather than a vast area contained within a structural line of protection. Although many nonstructural measures are unaffected by the concept of level of protection (flood preparedness, land use zoning, etc.), measures such as floodproofing and permanent acquisitions are very sensitive to this parameter. Since a maximum height of elevation in place has been established and since the costs of dry floodproofing are also sensitive to water depth, the level of protection selected can significantly affect which of these measures is applied to individual structures. Increasing or decreasing the level of protection has a corresponding affect on the numbers of structures that can be protected in place rather than relocated by acquisition.

Also unique to nonstructural measures such as floodproofing by elevation is the fact that nationally accepted standards for flood protection upon which the nation's entire flood insurance program is based are already in place within the project area. For formulation purposes, a variety of storm events each having a specific level of inundation that would result in flood damages to structures could be modeled and the benefits of specific applied measures calculated. Somewhere in that array of storms, measures and benefit calculations, the most cost-effective combination of measures and appropriate level of protection could be discerned. Selection of the most cost effective level of protection and array of measures would meet the planning objectives and fulfill the planning process.

However, the National Flood Insurance Program (NFIP) has determined that the Base Flood Elevation (BFE) is the appropriate level of protection with regards to the application of floodproofing (either through wet or dry floodproofing) and other nonstructural measures. The BFE is normally associated with the theoretical 1% annual chance flood event or a level of inundation that corresponds with a storm event of that frequency of occurrence. Since each of the 11 municipal areas and 3 counties continues to be a regular participant in the NFIP, proposing a level of protection less than the BFE in a nonstructural plan for flood damage reduction would not only not be well received by the local population, but would, if implemented, place each of these local units of government potentially in violation of their own ordinances and in jeopardy of being suspended by FEMA from the flood insurance program. For these reasons, the formulation of the nonstructural measures is based upon a minimum level of inundation that approximates the theoretical BFE within the project area. Other higher levels of protection could be formulated for the nonstructural alternatives, but the result of such additional iterations would be merely moving structures from the floodproofing option to the permanent acquisition or replacements (public buildings) option.

For the purposes of this comprehensive plan, the nonstructural formulation appendix bases its development of alternatives and their evaluation on a level of protection approximating the theoretical BFE within the project area. This would be the lowest level of protection that could be provided if floodproofing were a component of the plan. Greater levels of protection would result in fewer structures being protected in place and potentially more structures being acquired and relocated.

6.4 Nonstructural Plan Participation

For the purposes of nonstructural formulation in this appendix, implementation of the identified measures was assumed to be mandatory (thus assuring 100% participation) so that the full range of benefits and costs could be disclosed across the project area and within each reach. Formulation based upon mandatory participation was also necessary so that direct comparisons (costs and benefits) could be made between structural and nonstructural options for protection of particular communities in the project area (i.e. Pearlington, MS). As structural measure protection is in effect mandatory for all those enclosed within or behind a line of protection, nonstructural measures for those same structures and facilities would have to be formulated as a mandatory (100% participation) program for the sake of comparing cost effectiveness of the measures.

Implementation of the floodproofing and replacements of public buildings would be a voluntary action. Other local, regulatory-based nonstructural measures (i.e. land use zoning, building codes, etc.) can be considered mandatory once legally enacted by the municipal or county government. Such measures, implemented by the local governments, are enabled through state legislation and thus carry the authority of the state's legal standing in land use matters. Landowners could seek relief (code variances) from local mandatory measures should the measures be found to be so restrictive as too diminish property values below limits that constitute a taking.

Under the permanent acquisition measure, mandatory acquisition could be enforced since the Federal government would be obtaining an interest in the property as part of the action. Mandatory acquisitions through the use of condemnation proceedings are common for construction of public projects that are found to be in the public's interest and where the Federal government requires fee title to the property to construct permanent public assets. Using mandatory acquisition for coastal zones determined to be high-hazard areas is an option, but the public acceptability of such a program and the political viability of mandatory acquisitions is questionable. Mandatory acquisitions on a large scale generate significant social and economic hardships even in the presence of mitigative actions.

The quantification of project benefits and costs and evaluation/comparison of other non-monetary benefits (reducing loss of life) is more problematic when participation is not mandatory. Landowner participation in a nonstructural program is based upon the owner's perception of the costs and benefits to his own self (rather than the nation's) weighed against the owner's perception (or misperception) of the risks of future flood damages to the property. The severity of the damages to the property as a result of Katrina or a similar type storm may weigh heavily on the owner's decision – loss of life during the same event weighs even heavier. Included within the owner's determination may be years of current land ownership and perhaps past generations of ownership that have been handed down to this time. Family values, traditions, cultural biases and other social factors also influence the owner's decision whether to participate in the program. Added to these factors is the uncertainty of the outcome should the owner choose to participate – any changes in lifestyle can be daunting in the current economic environment, changes with great uncertainty can be paralyzing.

The only certain factor in the nonstructural participation process is that it is full of uncertainty. Who and how many landowners would participate at what time during the project's implementation is at best guesswork at this preliminary level of analysis. Feedback from workshops and meetings and from the media about possible public participation in certain measures is not a reliable yardstick – only when the official agency offer to participate is made and landowners are provided with credible information of their options and benefits does the real participation rate become evident. Past nonstructural projects have experienced participation rates as high as 80-90 percent for permanent acquisitions and floodproofing following major flood events. Participation in certain nonstructural measures has also increased measurably following landowners' observation of pilot or prototype projects showing the benefits of participation. Experience has shown that participation rates in nonstructural projects decrease with each ensuing year following a disaster provided there are no repeat events.

In an attempt to address the problems of nonstructural participation in plan formulation, the various levels of participation for each of the measures can be shown and the effects on costs and benefits can thus be observed. However, since the participation process is largely random (unless specific geographic zones or land use types are selected for sequential implementation in the program) there is no way to determine which properties will be included in the program at which time. In addition, participation rates will vary between NS program component. Participation in permanent acquisitions for those whose structure was only partially damaged may be relatively low, while those landowners who lost their house and have no flood insurance may have a higher participation rate. A large percentage of those landowners eligible for floodproofing may participate in the program when that component of the project is offered since that form of protection is common in the project area and widely accepted. Participation in the replacements options may vary between each municipal and county area depending upon the extent of damages to their public structures and the local population needs. Therefore the stream of costs and benefits will be erratic with varying levels of both costs and benefits as each property enters the acquisition or floodproofing process.

Acquired properties that have the potential for also generating ecosystem restoration benefits will produce more benefits than properties generating only flood damage reduction benefits and obviously more lavish residences or big-box retail commercial will cost more to acquire than a mobile home. Using total permanent acquisition, floodproofing and replacement units and costs to display the ranges of units protected and cost by participation rate provides a general idea of the effect of varying participation rates. Table 11 shows the total units and costs of permanent acquisition, floodproofing and replacements for Plan NSC-1 (see Section 6.6.2.1. and Table 17) displayed by levels of program participation between 10 percent and 100 percent. Although the ensuing graph from that table would generally display positively-sloped, straight lines showing cumulative units protected and costs from the various reaches, the random nature of the participation process would actually produce very erratic, stepped lines during implementation.

In affect, the eligible landowners in the project area are consumers of a service or program for protection of their property and lives. Not unlike purchasing flood insurance, landowners can choose to partake or not of the Corps' nonstructural program as well as any of the other Federal assistance programs discussed in Section 3.5 above. It is the Corps of Engineers intent that each eligible landowner would be afforded sufficient information on the benefits and liabilities of each available program so that his or her selection will be well informed. It is improbable that participants would have the option of selecting more than one Federal assistance program for reducing flood damages without some off-setting reduction in program benefits – a "double-dipping" issue.

In an effort to more precisely determine what levels of participation may surface in a nonstructural project or program, delivery of an OMB–approved survey (randomly-selected or targeted sample) to eligible landowners in the project area during preparation of a more detailed implementation report would begin to better clarify an expected level of participation and therefore expected project costs and benefits. This sample survey process has been used successfully in past nonstructural programs to better determine expected project costs and benefits. Such information is also beneficial in addressing project impacts through NEPA documentation and to project sponsors for budgeting cost-sharing contributions. Using a standard deviation around an expected mean participation rate for each nonstructural measure provides a range of possible costs and benefits that can better inform decision-makers.

Table 11
Effect of Participation Rates on Project Structures and Costs – Plan NSC-1

Participation Rate	Permanent Acquisition Structures - Cost	Floodproofing Units - Costs	Relocations Units - Costs	Plan Total Units - Costs
10%	1,714 - $792,841,130	2,542 – $1,080,530,165	1 - $7,316,697	4,252 - $1,878,492,984
20%	3,429 - $1,585,682,260	5,083 - $2,161,060,331	1 - $7,316,697	8,504 - $3,756, 985,968
30%	5,143 - $2,378,523,390	7,625 - $3,241,590,496	2 - $15,365,065	12,756 - $5,635,478,951
40%	6,858 - $3,171,364,520	10,167 - $4,322,120,662	3 - $20,486,753	17,008 - $7,513,971,935
50%	8,572 - $3,964,205,651	12,709 - $5,402,650,827	4 - $30,730,130	21,260 - $9,392,464,919
60%	10,286 - $4,757,046,781	15,251 - $6,483,180,992	4 - $30,730,130	25,512 - $11,270,957,903
70%	12,000 - $5,549,887,911	17,793 - $7,563,711,158	5 - $35,851,818	29,764 - $13,149,450,887
80%	13,715 - $6,342,729,041	20,335 - $8,644,241,323	6 - $46,095,195	34,016 - $15,027,943,870
90%	15,430 - $7,135,570,171	22,877 - $9,724,771,489	6 - $46,095,195	38,268 - $16,906,436,854
100%	17,144 - $7,928,411,301	25,419 - $10,805,301.654	7 - $51,216,883	42,520 - $18,784,929,838

For the sake of an example showing the effects of varying participation rates on the plan units and costs, the safe harborages included in Plan NSC-1 were not included in this table illustration (only 3 proposed). The costs by measure are based upon the average for each option times the units under each percentage rate of participation. Actual plan costs could be any number of combinations of participation rates (and costs) between the three components of the plan.

6.5 Nonstructural Criteria/Design Parameters

All structures and facilities located within the eligibility footprint (Katrina surge limits) that can be addressed by the nonstructural flood damage reduction program as defined herein will be subject to on-site evaluation based upon the criteria listed below. Separation into one of the nonstructural measures identified in Section 4.0 above will be based in part upon the results of that on-site evaluation. The nonstructural criteria are listed below:

6.5.1 Location with Respect to High-Hazard, Moderate Hazard and Limited Hazard Zones

High-hazard zones are defined as those comprised of the FEMA-identified V-zone, the FEMA-identified "catastrophic damage zone", and a 800 feet wide zone bordering the coast within Jackson County identified by the nonstructural PDT as a high-hazard area based upon observed damages. Moderate hazard areas are those areas where the depth of flooding at the structure exceeds 13 feet at the specified inundation level. Limited hazard zones are those areas where the depth of water at the structure was at or less than 13 feet at the specified inundation level.

6.5.2 Depth of Flooding at the Structure

As described above, the determining inundation depth at the structure that separates structures that can be safely elevated from those that can only be voluntarily acquired is 13 feet at the specified inundation level. This depth is measured from the lowest ground elevation along the perimeter of the structure first floor.

6.5.3 Post-Floodproofing Occupancy Requirements and DSS Status

The proposed floodproofing/elevation program would be implemented in accordance with the requirements of the NFIP as a minimum standard. The goal of elevating or otherwise floodproofing a residential structure is to provide a dwelling unit whose first floor elevation has been raised in accordance with the most current local floodplain management ordinance and for which an occupancy permit can be obtained (should one be required). All floodproofing work would be accomplished in accordance with existing building codes for the purposes of obtaining an occupancy permit from the local jurisdiction following elevation. Any existing structure for which an occupancy permit could not be secured (due to structural instability or other reasons) would be subject to acquisition under P. L. 91-646, considered for an on-site elevated rebuild or regarded as a non-participant in the program.

For existing structures that were not considered DSS prior to or as a result of Katrina damages, no project floodproofing funds would be used to bring the structure up to current DSS standards. Either private or other Federal or State funds may be used to attain any DSS requirements. Such additional, privately-funded construction could be accomplished during the floodproofing work by the contractor provided that such work would be described in a separate contract and paid for with non-Corps funds.

6.5.4 Structural Stability

Residential, commercial or institutional buildings that are determined by a qualified engineer or architect to be structurally unsound are not eligible to be elevated as a means of protecting the first floor form inundation. Any structures determined to be structurally unsound would only be eligible for either acquisition or an on-site, elevated rebuild.

6.5.5 Structure Use and Type

Feasible nonstructural options for structures are determined in part based upon the use and type of the structure or facility. Access requirements vary between residential, commercial and institutional uses considering ADA codes, service areas, parking needs, utility needs, lot size, zoning issues, and other characteristics of the building type and use. A critical facility may have stringent service area restrictions that severely limit options to move the structure from its local population. The ability to either protect a structure or facility in place or acquire or relocate the building is partially dependent upon its use or structure type.

6.6 Applicable Nonstructural Measures

6.6.1 General

Section 4.0 of this Appendix identifies and describes in detail the various types of nonstructural measures that could be applied to the project area for the purpose of reducing loss of life and flood damages as a result of storms and hurricanes along the coast. That section also makes a preliminary determination as the applicability of those individual measures to all or portions of the project area based upon the existing conditions, expected effectiveness of the measure itself in reducing damages and protecting lives and potential social, economic and environmental impacts. Based upon that determination, Table 12 provides an overview of the potential nonstructural measures that could be formulated into several plans either as single measures or as combinations of measures.

Table 12.
Applicable Nonstructural Measures

Measure Acronym	Measure Name
FWEE	Hurricane/Storm Flood Warning and Emergency Evacuation
FM&Z	Floodplain Management and Zoning (NFIP)
LLUR&Z	Local Land Use Regulation and Zoning
BC&E	Building Codes and Enforcement
FP	Floodproofing by Elevation and Other Means
PRM ACQ	Permanent Acquisition
DIF	Development Impact Fees
TDR & PDR	Transfer of Development Rights & Purchase of Development Rights
RELO	Replacements of Public Buildings

As this table shows there are a number of nonstructural measures that have been determined to be potentially effective in reducing damages and preventing loss of life in the project area. These nonstructural measures include three measures that could be primarily applied by Federal agencies (i.e. US Army Corps of Engineers (USACE) and Federal Emergency Management Agency (FEMA) using federal funds and locally supplied matching funds. Those measures are floodproofing (FP) by structure elevation or other means, permanent acquisition (ACQ) and replacements (RELO) of public buildings and facilities.

Prior to the process of formulating alternatives or plans using the above discussed measures, at least three steps must be taken to characterize the measures so that formulated plans do not contain conflicting measures or incomplete measures or that formulated plans have not correctly sized the measure. These three characterizations included scaling, dependency and combinability.

6.6.2 Scaling

Scaling addresses the appropriate sizing of each measure with respect to spatial coverage, timing of the measure application over the period of analysis, number and type of component processes, and size of the measure (number of units or parcels affected in nonstructural terms). In short, formulating 5 different acquisition programs consisting of differing numbers of units acquired would not constitute separate plans, just different scales of the same measure. Likewise formulating 4 alternatives/plans for floodproofing structures that would take place sequentially over 10 years would not constitute 4 separate plans, but one plan implemented over an extended period. Also, raising the level of protection offered by the nonstructural measures from a minimum BFE (approximately the 1% annual chance event) that meets local floodplain ordinances to several inundation depths (i.e. 20 ,30, or 40 feet of depth) would also be scaling the basic plan (i.e. Tables 25 through 29 for Plan NSC-6).

Finally, formulating plans composed of modified zoning or building codes for all 11 municipal areas would not constitute 11 separate plans but one plan applied in 11 separate areas – a scaling exercise. The appropriate scales for each of the nonstructural measures being considered will depend upon the wishes of the potential project sponsors (and the extent of their legal boundaries for those measures being implemented by local jurisdictions) and issues of combinability. In actual implementation, nonstructural measures can be applied to a single parcel of land or many thousands of parcels as funds and resources allow. The ability to have an infinite number of plan scales is one of nonstructural measures primary strengths.

6.6.3 Dependency

It is possible to have nonstructural measures that are dependent upon one another for their effectiveness. Obviously building codes are best applied when the structure has not been acquired from the lot and altering property taxes to discourage development works best when the property is in the ownership of a private individual rather than the county or municipal government (post acquisition OMRR&R). Many measures are not effective in the absence or presence of a structure on the particular tract of land. Independent measures should be grouped together as a single measure or at least depicted as working in concert to meet planning objectives.

6.6.4 Combinability

The concept of combinability addresses whether measures may or may not be mutually exclusive of one another. This character trait can be further divided into combinability with respect to location, function or overlap. Obviously in the nonstructural arena, one cannot both purchase and demolish a structure and then elevate that same structure as a floodproofed structure on the same lot. Once acquired and demolished, no structure is left on the site to elevate. In the same way, application of building codes on property where structures are acquired in the program and reserved for ecosystem restoration is impractical. Some nonstructural measures can negate the benefits of others: modification of the flood insurance program to suspend the program cannot co-exist with a measure to apply new structure design guidelines through the same suspended program. These issues of combinability can usually be addressed through a "pair-wise" matrix evaluation in which the measures are evaluated against one another to determine where conflicts or compatible measures may exist. The pair-wise comparison matrix for the above described measures is shown in Table 13.

Most notable in the table is the combinability and potential juxtaposition of improved components of the storm warning and emergency evacuation system, local land use controls, floodplain management, permanent acquisition, and various types of floodproofing across the project area. Since some of the measures require direct action to be taken on a property (acquisition and demolition, floodproofing or replacements) and others are primarily regulatory or administrative in nature, some of the measures are very combinable and reinforce each other in their application. Combining the flood warning system and emergency evacuation system improvements, upgraded building codes and floodplain management and zoning modifications with floodproofing by elevation on a single parcel (with an existing structure) accomplishes several of the planning objectives at minimal construction and annual O&M costs.

Being more than 80 miles in extent and addressing more than 70,000 individual parcels, the project area provides many opportunities for application of a variety of nonstructural measures that are usually applied on a lot-by-lot basis. In practice, adjacent structures can have different nonstructural measures applied to accomplish project objectives. These measures can be applied as a suite of components that would most effectively reduce damages and threats to loss of life. In some areas of the coast, careful application of these measures could approximate the "100%" solution to flood damages and loss of life with minimal OMRR&R costs while providing ecosystem restoration benefits as well.

Of particular note in the table is the combinability of some of the measures that work in a symbiotic relationship. Such a relationship exists between the flood warning and emergency evacuation measures and floodproofing by elevation or other means. Considering the uncertainty and risks associated with habitation of an elevated structure during a hurricane surge/wave event that may surround the structure, the NS PDT would not recommend that anyone seek shelter within an elevated structure. Therefore, the flood warning and emergency evacuation system is a necessity for a nonstructural program featuring so many potentially elevated structures. Likewise having a reliable and timely warning system enables the safe use of structure elevation to maintain community structure. Likewise, although many structures may be relocated from their present high-hazard location, upgraded building codes can be applied to reconstruction of new housing to resist hurricane force winds.

Nonstructural measures can be divided into two groups for the purposes of combinability. Those measures that concern modification of private and public structures and associated facilities or the ownership of the land upon which they are located and those measures that concern regulation, taxation, fees and assessments and enforcement of regulations and codes that apply to the land. By Congressional action the Corps can be authorized to implement certain nonstructural measures that result in modification of buildings and facilities through contractual arrangements with the landowners to reduce damages and loss of life. However, as certain private and public rights and responsibilities have been conferred to the states by the Federal government and then subsequently passed down to local governments as police powers, the Corps is unable to implement or administer certain nonstructural measures described in Section 4.0. These 'local measures" can be just as effective in reducing damages although the benefit stream may be more difficult to identify for formulation processes. It is possible to combine both measures implemented by the Corps and measures implemented by local jurisdictions on one parcel of land and realize the full benefit potential of their combination.

Table 13.
Pair-wise Comparison of Nonstructural Measures

Measures	FWEE	FM&Z	LLUR&Z	BC&E	FP	PRM ACQ	DIF	TDR or PDR	RELO
FWEE		Compatible	Compatible	Compatible	Compatible and required	Compatible for new housing wind damages	Compatible	Not Compatible	Not Compatible
FM&Z	Compatible		Compatible	Compatible	Compatible	Not Compatible	Compatible	Not Compatible	Not Compatible
LLUR&Z	Compatible	Compatible		Compatible	Compatible	Not Compatible	Compatible	Compatible	Compatible
BC&E	Compatible	Compatible	Compatible		Compatible	Not Compatible	Compatible	Not Compatible	Compatible
FP	Compatible and required	Compatible	Compatible	Compatible		Not Compatible	Compatible	Not Compatible	Not compatible unless relocated structure is FP
PRM ACQ	Compatible for new housing (wind damages)	Not Compatible	Not Compatible	Not Compatible	Not Compatible		Not Compatible	Not compatible, but vacated land may be in PDR/TDR	Not Compatible
DIF	Compatible	Compatible	Compatible	Compatible	Compatible	Not Compatible		Not Compatible	Not Compatible
TDR or PDR	Compatible, wind related	Not Compatible	Not Compatible	Not Compatible	Not Compatible	Not compatible, but vacated land may be in TDR/PDR	Not Compatible		Not Compatible
RELO	Compatible, wind related	Not Compatible	Compatible	Compatible	Not compatible unless relocated structure is FP	Not Compatible	Not Compatible	Not Compatible	

FWEE = Hurricane/Storm Flood Warning and Emergency Evacuation
LLUR&Z = Land Use Regulation and Zoning
FP = Floodproofing by Elevation and other Means
DIF = Development Impact Fees
FM&Z = Floodplain Management and Zoning (NFIP)
BC&E = Building Codes and Enforcement
PRM ACQ = Permanent Acquisition (a.k.a. HARP)
TDR & PDR = Transfer and Purchase of Development Rights
RELO = Replacements of Public Buildings

Table 14 shows a listing of the various nonstructural measures identified above and whether the Corps of Engineers or another Federal agency (FEMA) or State or local governments would be the appropriate entity to implement the measure. This table also indicates by this division of responsibility the various combinations of measures that could be instituted as a joint effort by the Federal government and the State and local governments in the project area. Of particular interest is the measure "Hurricane Warning and Emergency Evacuation" which has components that can be implemented by both the Federal and non-Federal partners. In addition, although permanent acquisition and floodproofing would normally be Federal roles, local entities could implement these components either through FEMA's HMGP or as local initiatives financed through state resources.

Table 14.
Nonstructural Measures by Responsible Entity.

Responsible Entity	Federal Government	State and Local Governments
Measures		
Hurricane Warning and Emergency Evacuation	X	X
Floodplain Management and Zoning (NFIP)		X
Local Land Use Regulation and Zoning		X
Building Codes and Enforcement		X
Floodproofing	X	
Permanent Acquisition	X	
Development Impact Fees		X
Transfer or Purchase of Development Rights		X
Replacement of Public Buildings	X	

As these tables show, there are numerous individual measures that could be applied across the project area that would be effective to a certain degree in reducing damages and saving lives. As effective as some single nonstructural measures can be (i.e. just permanent acquisition or just floodproofing or just zoning) in reducing damages and loss of life, they would be applied on the notion of "one size fits all" and could fail to address longer term problems or result in unintended impacts. On the other hand, combinations of these measures have the potential for addressing not only damages that could be expected to occur in the short term (existing development) but long term potential damages that would occur due to different levels and types of future development. Combinations of measures can also be more "tailored" to the specific conditions at each neighborhood or community thus reducing anticipated socio-economic impacts.

The formulation process will address both single-measure plans and combined measures plans to determine the full range of possible nonstructural protection scenarios. As is the case with structural measures, differing levels of protection can be addressed by nonstructural measures by adjusting the measure's response to inundation depths (i.e. floodproofing versus acquisition) or modifying the spatial coverage by each measure.

Since this appendix is accompanying a "Comprehensive Plan" that addresses the entire project area, nonstructural plans that could be tailored to a single community (i.e. Pascagoula) or a single planning unit (i.e. Harrison County) are not included in this formulation as they are scaled-down, more detailed plans of the more comprehensive alternatives described below. More detailed planning documents or implementation plans, formulated in collaboration with local jurisdictions would be needed address specific communities should construction authorization be provided.

6.7 Nonstructural Plans

6.7.1 *Single-Measure Nonstructural Plans*

Of the identified measures, eight measures could be applied singularly to meet one or a number of the planning objectives. The principals among those singular measures are:

- Permanent acquisition – High Hazard Area Risk Reduction Plan (HARP)
- Floodproofing by elevation or other methods (dry and wet)
- Replacements of Public Buildings
- Floodplain zoning and ordinance enforcement
- Upgrading and enforcement of existing building codes
- Land use regulations and zoning
- Flood Preparedness and Public Education
- PDR and TDR

Each of these measures implemented as a singular measure across the project area is able to reduce the incidence of flood damages and reduce the threats to life from storms and hurricanes. However, many of them, implemented as a single measure are unable to reduce all of the potential for future flood damages or loss of life along the coast. The closest single solution would be permanent acquisition of all structures damaged by Katrina or a specific subset of that population, but without significant changes to State laws and the economic base of the area, permanent acquisition cannot address all of the damages or threats to life either as described below. In addition, the social and economic impacts of a compete buyout of the project area are unacceptable to the population.

For the purposes of inter-agency and public recognition, the single-measure nonstructural plans have been designated with a two-letter prefix "NS" and all combined measure plans are designated with the prefix "NSC" (**N**on **S**tructural **C**ombined). The suffixes "HHZ" and "PA100" used for the single measure plans refer to "**H**igh **H**azard **Z**one" and "**P**ermanent **A**cquisition in the **100**-year flood zone" (a delineated zone in the flood insurance rate maps). Both numbers and letters (letters are used to designate scales of surge inundation in plans NSC-1 and NSC-6) are used to further differentiate the plans with the prefix NSC.

6.7.1.1 *Permanent Acquisition – Katrina Level of Protection*

A single-measure plan, featuring the permanent acquisition of all structures and facilities found to be eligible for the nonstructural program literally removes every structure and facility within the proscribed level of inundation across the entire coast. This measure could be implemented by the Federal government as a flood damage reduction program component. Application of a very high level of protection (i.e. Katrina level) would be very effective in reducing flood damages and threats to life from surge and waves generated by storms and hurricanes. In all, approximately 74,000 parcels of land would be purchased at an approximate cost of $17.0 billion (using an average cost per structure based upon RE estimates of nonstructural acquisitions). Although effective, acquisition of all eligible properties across the project area would be expensive when compared to other effective alternatives and would result in catastrophic consequences for the socio-economic fabric of the three counties and 11 municipal areas. Also, it has been determined that certain structures and facilities closely associated with the Gulf (ship-building, power plants, energy resource exploration and production) or locked to a location by State law (casinos) cannot be moved from their high-hazard location. For these reasons, a singular plan featuring permanent acquisition at a high level of protection (Katrina inundation or higher) should not be carried forward. However, permanent acquisition as a single measure for more modest levels of protection (1% annual chance event) or for specific high-hazard zones may be acceptable and cost effective (see Plans below).

Obviously, both of the following permanent acquisition plans would have to be closely coordinated with FEMA and HUD disaster-assistance programs currently being administered in the project area. Opportunities for landowners to "double-dip" into Federal funds would be carefully scrutinized by the agencies through sharing of databases on program participants. Initial coordination of the various programs between USACE, FEMA and HUD was undertaken prior to completion of this appendix.

6.7.1.1.1 Plan NS-PAHHZ - Permanent Acquisition of the High-Hazard Zone

Permanent acquisition of structures and property within the high-hazard zones identified in this appendix would significantly reduce damages and potential loss of life in this hazardous area. Approximately 14,900 parcels of land (including approximately 7,500 structures) are located in the high-hazard zones that could be acquired through the Uniform Relocations Act. Field observations indicated a substantial number of properties without structures (vacated parcels) in the high-hazard zones following Katrina. The proposed initial phase of the HARP may be able, if authorized and funded, to acquire a substantial number of the vacated parcels before new structures are rebuilt at an overall cost savings to the program. However, this alternative does not contemplate that many properties would be vacated when this plan is implemented. In view of the future-without-project condition predictions of redevelopment along the coast, this alternative assumes that a substantial number if not all properties would be rebuilt upon by the time the normal project implementation process begins to acquire parcels. The costs of this plan (acquisition, relocations assistance and demolitions) therefore are based upon structures being present on the parcels when the plan is implemented.

Approximately 57,000 acres of land could be acquired in the high-hazard zone were there to be 100 percent participation in the acquisition program. The vacated property could be used for ecosystem restoration of wetland habitat, passive recreation uses that are consistent with the identified flood hazard or just maintained as open space for passive public uses. Of the total acres that could be purchased in this zone, approximately 4,000 acres of land have been determined to be suitable for ecosystem restoration as wetlands.

Sufficient financial resources would be made available through the Uniform Relocations Act so that suitable replacement DSS housing could be secured for eligible households in this area. The estimated cost for real estate acquisition, relocations assistance and structure demolition for this alternative is $5.9B. This plan is identified as Plan NS–PAHHZ. The numbers of parcels to be acquired by reach and the costs are shown in Table 15. The high-hazard acquisition areas are displayed on Figures 56 through 60.

In addition to the cost of the real estate acquisition, relocations assistance and structure demolition associated with this alternative, the large number of displaced households may trigger the need for replacement DSS housing over and above what normal market resources could provide. Based upon current housing construction capacity in the project area, as much as 40 percent of the need may be unmet by the market area (based upon current levels of housing construction permits). In view of this anticipated shortage of suitable DSS housing, the plan would include several redevelopment sites (at least one in each county) that would hold approximately 3,000 residential lots. Lot sizes would vary within the redevelopment sites but would be no less than quarter-acre in size. At an average cost of $45,000 per lot for site acquisition, site development, infrastructure and site amenities, the total cost of these redevelopment sites would be approximately $135.0M

This alternative could be supplemented by the addition of either the TDR or PDR program to address redevelopment of interspersed property that was vacant prior to the destruction wrought by

Katrina. As this interspersed vacant property within the high-hazard zone was probably encumbered in some way so as to hinder development, either the TDR or PDR program could be applied to restrict any future development that would be subject to inundation damages. Development right values would be established through comparison of tax assessments for the "with" and "without" development scenarios. Either of the two programs would be administered as a joint effort by the counties and municipalities with an estimated start-up cost of $1.5M. Annual costs for the TDR program would be local and minimal administrative expenditures while the PDR annual costs could be supplied by the state and local jurisdictions and would reflect a percentage of the total assessed value of those properties.

The High Hazard Area Risk Reduction Plan (HARP) could be an initial component of this alternative whereby the highest-risk properties that were vacated (structures demolished) by Katrina and not as yet rebuilt upon could be acquired at a fraction of the cost that would be required once a new structure is rebuilt. Avoiding the costs of acquiring a new structure, relocations assistance (for relocating a household to a DSS replacement house) and demolition of the existing home would significantly reduce the overall program cost and assure that families would not be re-entering a high-hazard area. The estimated cost of the initial HARP program is $397.0 M and would affect approximately 2,000 parcels. Those 2,000 initial acquisitions would be extracted from the designated high-hazard zone (approximately 7,400 total vacated parcels in the HHZ) extending the east-west length of the project area. Figure 52 shows areas with potential for restoration of high quality wetland ecosystems that are within that acquisition footprint.

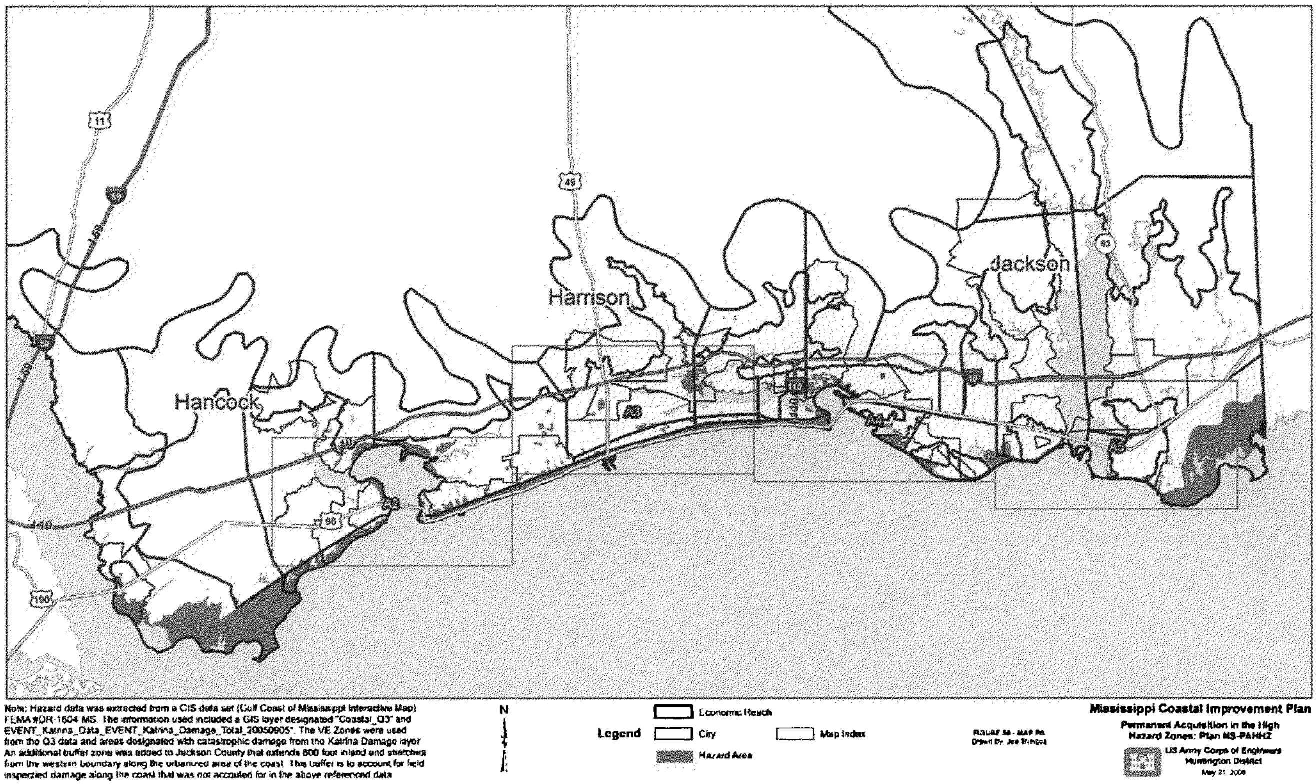
Table 15 – Plan NS-PAHHZ
Permanent Acquisition in the High-Hazard Zones

Economic Reach	County	Parcels for Acquisition	Cost
1	Hancock	0	0
2	Hancock	1056	$459,548,812
3	Hancock	2099	$851,631,850
4	Hancock	823	$202,919,893
5	Hancock	971	$107,653,678
6	Hancock	210	$114,862,969
7	Hancock	125	$9,562,216
8	Harrison	1565	$431,782,512
9	Harrison	5	$6,652,740
10	Harrison	1695	$736,216,496
11	Harrison	0	0
12	Harrison	450	$138,318,777
13	Harrison	595	$821,785,431
14	Harrison	0	0
15	Harrison	66	$88,566,796
16	Harrison	36	$14,594,008
17	Harrison	0	0
18	Harrison	285	$608,152,730
19	Harrison	12	$17,246,403
20	Harrison	1150	$316,031,090
21	Jackson	2082	$695,355,710
22	Jackson	62	$39,368,916
23	Jackson	0	0
24	Jackson	138	$45,373,108
25	Jackson	0	0
26	Jackson	31	$11,221,913
27	Jackson	37	$5,996,209
28	Jackson	583	$10,167,976

Economic Reach	County	Parcels for Acquisition	Cost
29	Jackson	132	$14,287,454
30	Jackson	81	$24,818,841
31	Jackson	37	$9,281,900
32	Jackson	0	0
33	Jackson	0	0
34	Jackson	0	0
35	Jackson	0	0
36	Hancock	0	0
37	Hancock	0	0
38	Hancock	0	0
39	Harrison	0	0
40	Harrison	0	0
41	Jackson	0	0
42	Jackson	0	0
43	Jackson	0	0
44	Jackson	0	0
45	Jackson	0	0
46	Jackson	0	0
47	Harrison	0	0
48	Harrison	0	0
49	Harrison	0	0
50	Harrison	96	$24,190,783
51	Jackson	0	0
52	Jackson	275	$68,789,089
53	Jackson	300	$46,723,811
54	Jackson	0	0
Subtotals		14,997	$5,921,102,106
H&CD sites	Jackson, Harrison, Hancock	3,000 constructed lots	$135,000,000
Total cost			**$6,056,102,106**

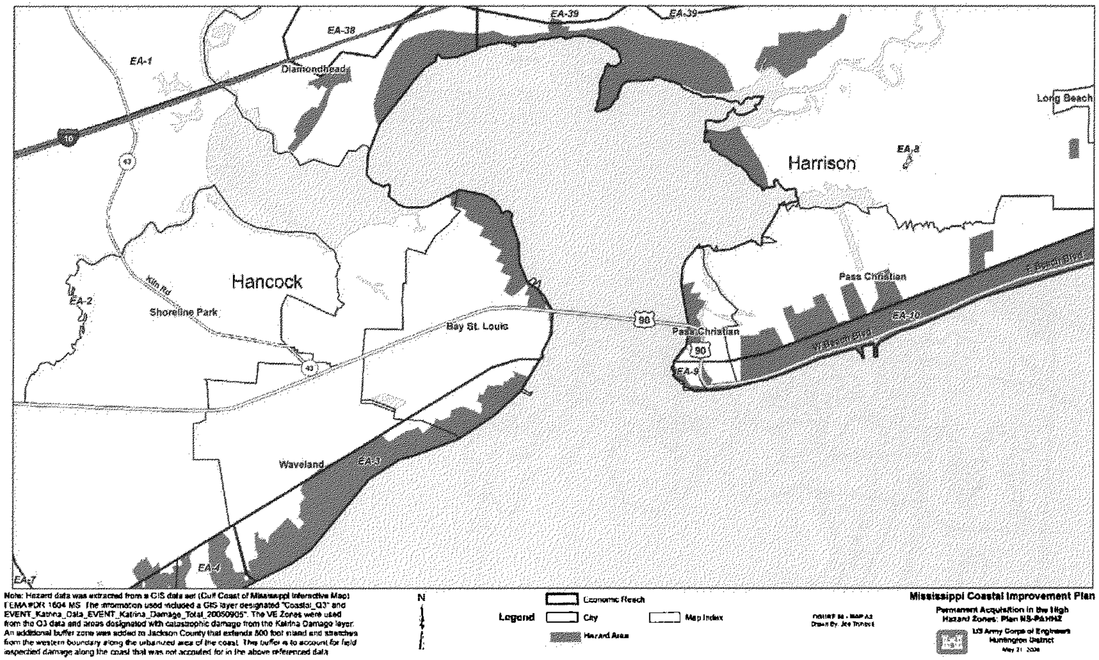
Based upon the county assessors data and the future without project conditions scenarios, there could be as many as 14,997 structures located on the HHZ parcels by 2012. Costs for acquisition, relocations assistance and structure demolitions are included in the total cost.

Figure 56– Plan NS- PAHHZ – Permanent Acquisition in HHZ (A1)



Note: Hazard data was extracted from a GIS data set (Gulf Coast of Mississippi Interactive Map) FEMA #DR-1604 MS. The information used included a GIS layer designated "Coastal_Q3" and EVENT_Katrina_Data_EVENT_Katrina_Damage_Total_20050905". The VE Zones were used from the Q3 data and areas designated with catastrophic damage from the Katrina Damage layer. An additional buffer zone was added to Jackson County that extends 800 foot inland and stretches from the western boundary along the urbanized area of the coast. This buffer is to account for field inspected damage along the coast that was not accounted for in the above referenced data.

Figure 57 – Plan NS- PAHHZ Permanent Acquisition in HHZ (A2)



Note: Hazard data was extracted from a GIS data set (Gulf Coast of Mississippi Interactive Map) FEMA#DR 1604 MS. The information used included a GIS layer designated "Coastal_Q3" and EVENT_Katrina_Data_EVENT_Katrina_Damage_Total_20050905". The VE Zones were used from the Q3 data and areas designated with catastrophic damage from the Katrina Damage layer. An additional buffer zone was added to Jackson County that extends 800 foot inland and stretches from the western boundary along the urbanized area of the coast. This buffer is to account for field inspected damage along the coast that was not accounted for in the above referenced data

Figure 58 – Plan NS – PAHHZ Permanent Acquisition in HHZ (A3)

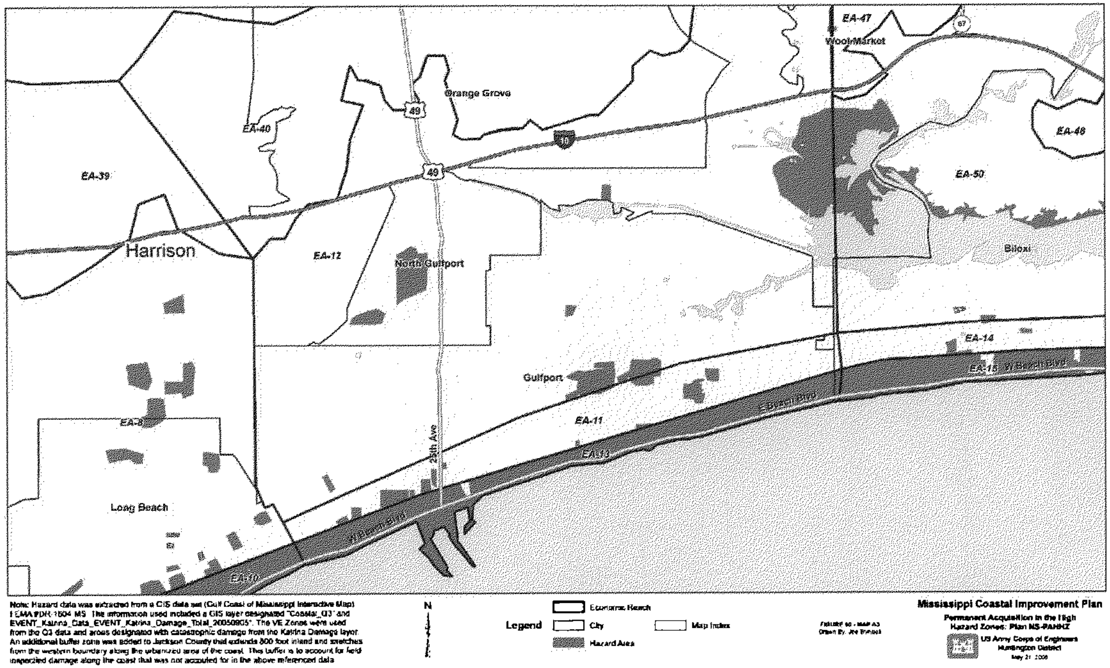


Figure 59 – Plan NS- PAHHZ Permanent Acquisition in HHZ (A4)

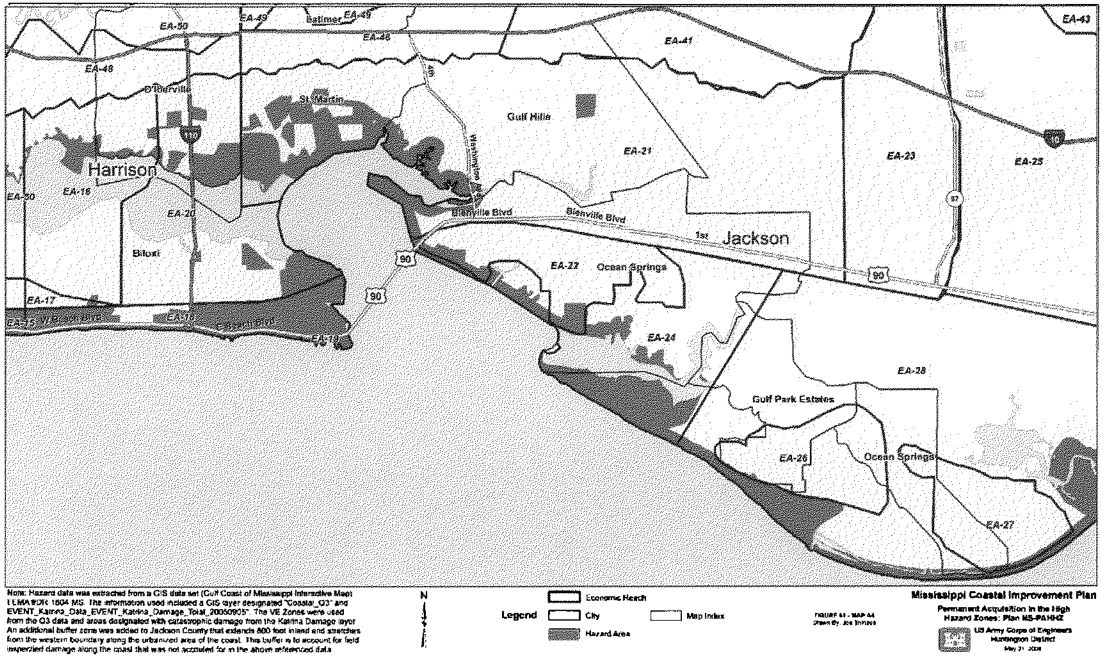
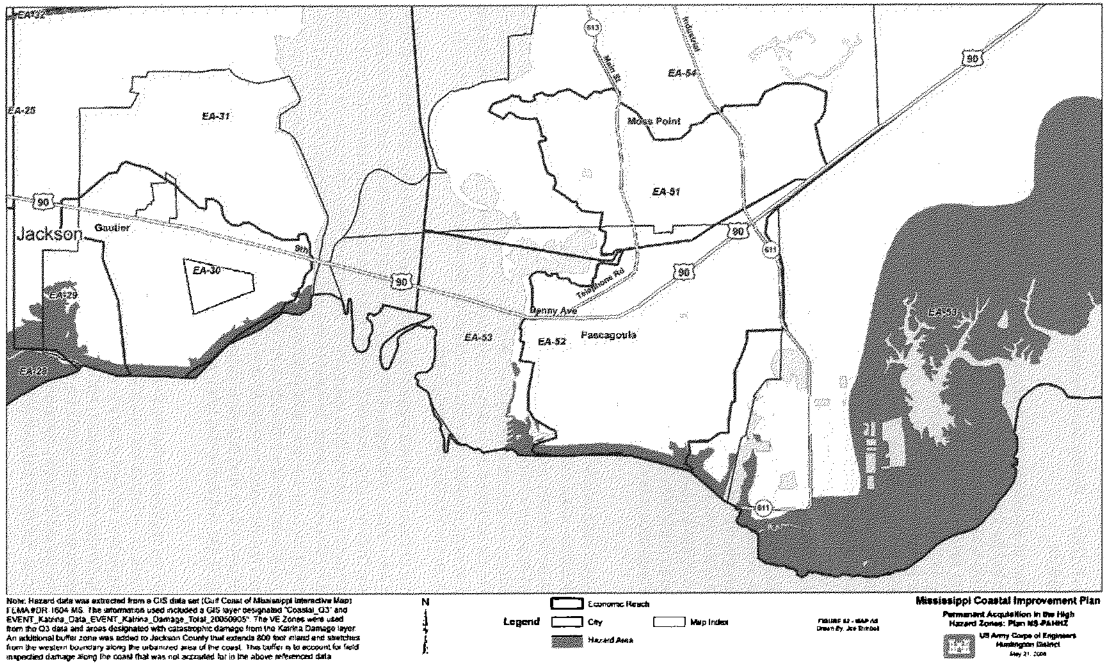


Figure 60 – Plan NS- PAHHZ Permanent Acquisition in HHZ (A5)



6.7.1.1.2 Plan NS-PA100 - Permanent Acquisition within the One Percent Annual Chance Floodplain

Permanent acquisition of structures and property within the FEMA-designated 1% annual chance floodplain (as amended by the adoption of the ABFE's by the communities) that are located within the high-hazard zones and in areas where water depths exceeded 13 feet would significantly reduce future flood damages and threats to life by storms and hurricanes. Approximately 33,200 parcels of land (approximately 17,100 structures) are located within these two areas that could be purchased through the Uniform Relocation Act (P. L. 91-646). Field observations indicated a large number of vacated parcels within the high-hazard zone. This plan contemplates that most if not all of the interspersed parcels originally made vacant by Katrina would be redeveloped by the time this acquisition option was implemented as described in the future without-project condition. Therefore the cost of the plan (acquisition, relocations assistance and demolitions) reflects structures and families in place when the plan would be implemented.

Approximately 57,000 acres could be purchased in the high-hazard zones were there to be 100 percent participation in the acquisitions program. Of that total, approximately 4,000 acres have been determined to be suitable for ecosystem restoration of wetlands. An additional 37,000 acres of land could be purchased within the area where water depths exceeded 13 feet were there to be 100 percent participation in the acquisitions program in that zone. Of that total acres approximately 5,200 acres of land has been determined to be suitable for ecosystem restoration as wetlands. In total over 9,000 acres of wetlands could be restored as a result of the purchase and restoration of these hazard zones.

Sufficient financial resources would be provided through the Uniform Relocations Act so that suitable replacement DSS housing could be secured for each household in this buyout area. The vacated property could be used for ecosystem restoration of wetland habitat, passive recreation consistent with the flood hazard or just maintained as open space for public uses. The estimated cost of land and structure acquisition for this alternative is $7.9B. This plan is identified as Plan NS-PA100. The numbers of parcels to be acquired by reach and the costs are shown in Table 16. The acquisition areas within the 1% annual chance area (as amended by the adoption of the ABFE by the communities) are shown in Figures 61 through 65.

In addition to the cost of the real estate acquisition, relocations assistance and structure demolition associated with this alternative, the large number of displaced households would probably trigger the need for replacement DSS housing over and above what normal market resources could provide. Based upon current housing construction capacity in the project area, as much as 40 percent of the need may be unmet by the market area. In view of this anticipated shortage of suitable DSS housing, the plan would include several redevelopment sites (at least one in each county) that would hold approximately 6,000 residential lots. Lot sizes would vary within the redevelopment sites but would be no less than quarter-acre in size. At an average cost of $45,000 per lot for site acquisition, site development, infrastructure and site amenities, the total cost of these redevelopment sites would be approximately $270.0M. Added to the total land acquisition figure above, the total plan cost would be $8.2B.

This alternative could be supplemented by the addition of either the TDR or PDR program to address redevelopment of interspersed property that was vacant prior to the destruction wrought by Katrina. As this interspersed vacant property within the high-hazard zone was probably encumbered in some way so as to hinder development, either the TDR or PDR program could be applied to restrict any future development that would be subject to inundation damages. Development right values would be established through comparison of tax assessments for the "with" and "without" development scenarios. Either of the two programs would be administered as a joint effort by the counties and municipalities with an estimated start-up cost of $1.5M. Annual costs for the TDR program would be local and minimal administrative expenditures while the PDR annual costs could be supplied by the state and local jurisdictions and would reflect a percentage of the total assessed value of those properties.

The High Hazard Area Risk Reduction Plan (HARP) could be an initial component of this alternative whereby the highest-risk properties that were vacated (structures demolished) by Katrina and not as yet rebuilt upon could be acquired at a fraction of the cost that would be required once a new structure is rebuilt. Avoiding the costs of acquiring a new structure, relocations assistance (for relocating a household to a DSS replacement house) and demolition of the existing home would significantly reduce the overall program cost and assure that families would not be re-entering a high-hazard area. The estimated cost of the initial HARP program is $397.0 M and would affect approximately 2,000 parcels. Those initial 2,000 parcels would be extracted out of the high hazard zone footprint that extends the entire east-west length of the project area. Figure 52 shows the potential high-quality wetland ecosystem restoration areas where the HARP acquisitions may occur.

Table 16 – Plan NA-PA100
Permanent Acquisition within the 1% Annual Chance Zone (ABFE-2 feet)

Economic Reach	County	Parcels for Acquisition	Cost
1	Hancock	997	$194,118,218
2	Hancock	9911	$2,990,789,131
3	Hancock	2202	$668,691,437
4	Hancock	922	$120,307,916
5	Hancock	2714	$238,362,794
6	Hancock	567	$107,292,775
7	Hancock	450	$33,210,174
8	Harrison	3623	$476,088,333
9	Harrison	44	$16,132,783
10	Harrison	1945	$432,581,234
11	Harrison	0	$0
12	Harrison	1047	$179,614,825
13	Harrison	650	$583,121,543
14	Harrison	0	$0
15	Harrison	85	$44,354,843
16	Harrison	78	$16,399,728
17	Harrison	0	$0
18	Harrison	1502	$409,411,532
19	Harrison	46	$292,728,063
20	Harrison	1397	$238,433,082
21	Jackson	2108	$301,798,272
22	Jackson	61	$26,330,663
23	Jackson	0	$0
24	Jackson	220	$65,229,820
25	Jackson	0	$0
26	Jackson	37	$9,210,336
27	Jackson	53	$12,880,944
28	Jackson	961	$90,294,697
29	Jackson	147	$23,394,829
30	Jackson	90	$29,459,003

Economic Reach	County	Parcels for Acquisition	Cost
31	Jackson	51	$14,946,829
32	Jackson	1	$216,228
33	Jackson	0	$0
34	Jackson	0	$0
35	Jackson	12	$682,228
36	Hancock	32	$3,834,485
37	Hancock	0	$0
38	Hancock	50	$21,424,866
39	Harrison	0	$0
40	Harrison	0	$0
41	Jackson	0	$0
42	Jackson	0	$0
43	Jackson	0	$0
44	Jackson	0	$0
45	Jackson	0	$0
46	Jackson	0	$0
47	Harrison	0	$0
48	Harrison	0	$0
49	Harrison	0	$0
50	Harrison	495	$89,247,661
51	Jackson	0	$0
52	Harrison	285	$102,951,211
53	Harrison	399	$113,015,335
54	Jackson	9	$1,114,862
Subtotals		33,191*	$7,947,670,680
H&CD Sites	Jackson, Harrison, Hancock	6,000 constructed lots	$270,000,000
Total Cost			**$8,217,670,680**

*This parcel total (33,191) includes 17,144 structures anticipated to be redeveloped by 2012 in the future-without-project condition - this anticipated condition is reflected in the total cost.

Figure 61 – Plan NS - PA100 Permanent Acquisition in 1% Annual Chance Flood Zone (A1)

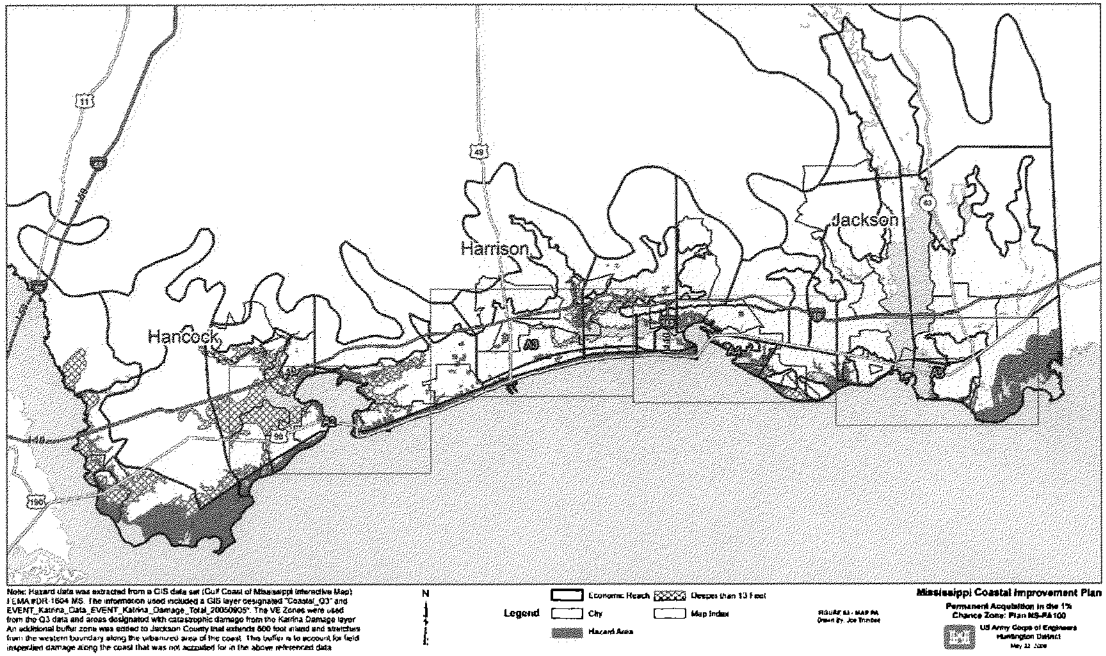
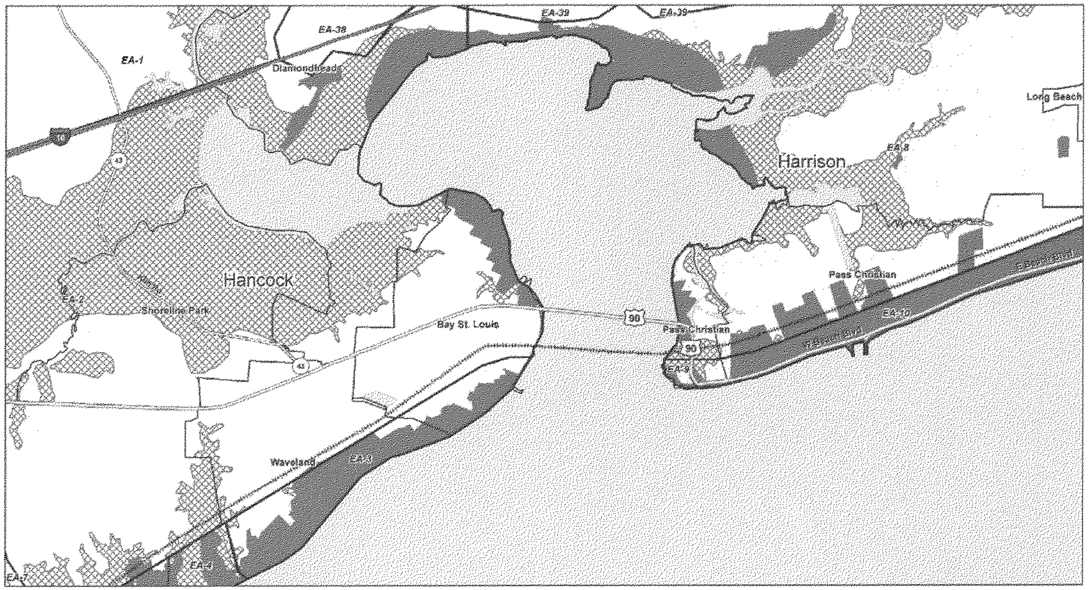


Figure 62 – Plan NS- PA100 Permanent Acquisition in 1% Annual Chance Flood Zone (A2)



Note: Hazard data was extracted from a GIS data set (Gulf Coast of Mississippi Interactive Map) FEMA #DR-1604 MS. The information used included a GIS layer designated "Coastal_Q3" and EVENT_Katrina_Data_EVENT_Katrina_Damage_Total_20050905". The VE Zones were used from the Q3 data and areas designated with catastrophic damage from the Katrina Damage layer. An additional buffer zone was added to Jackson County that extends 800 feet inland and stretches from the western boundary along the urbanized area of the coast. This buffer is to account for field inspected damage along the coast that was not accounted for in the above referenced data.

Figure 63 – Plan NS – PA100 Permanent Acquisition in 1% Annual Chance Flood Zone (A3)

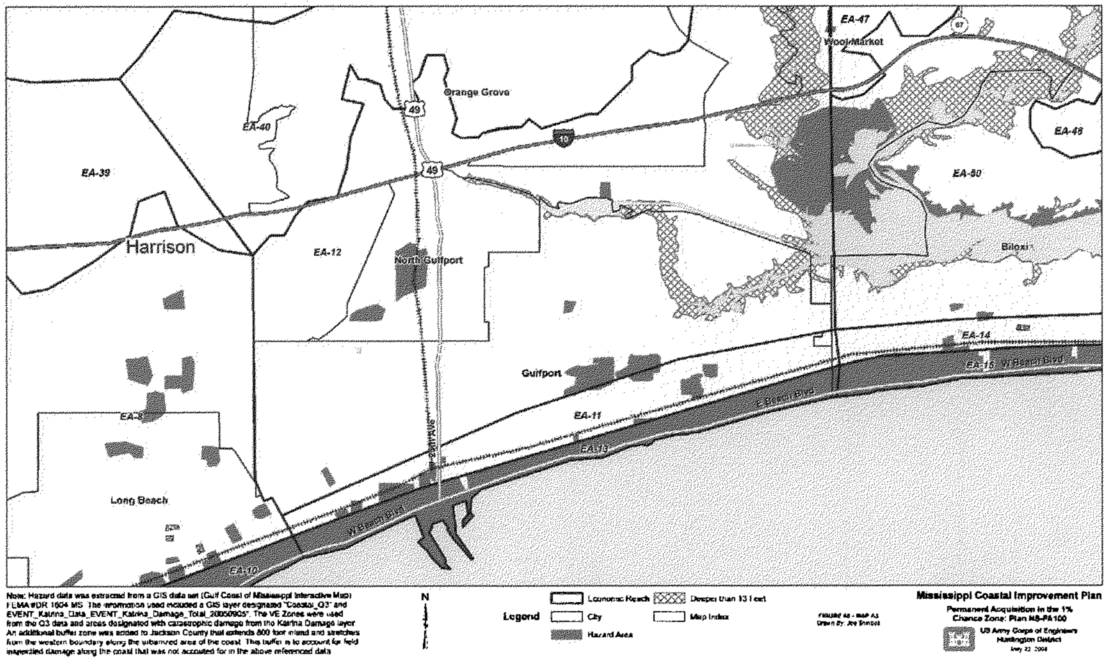
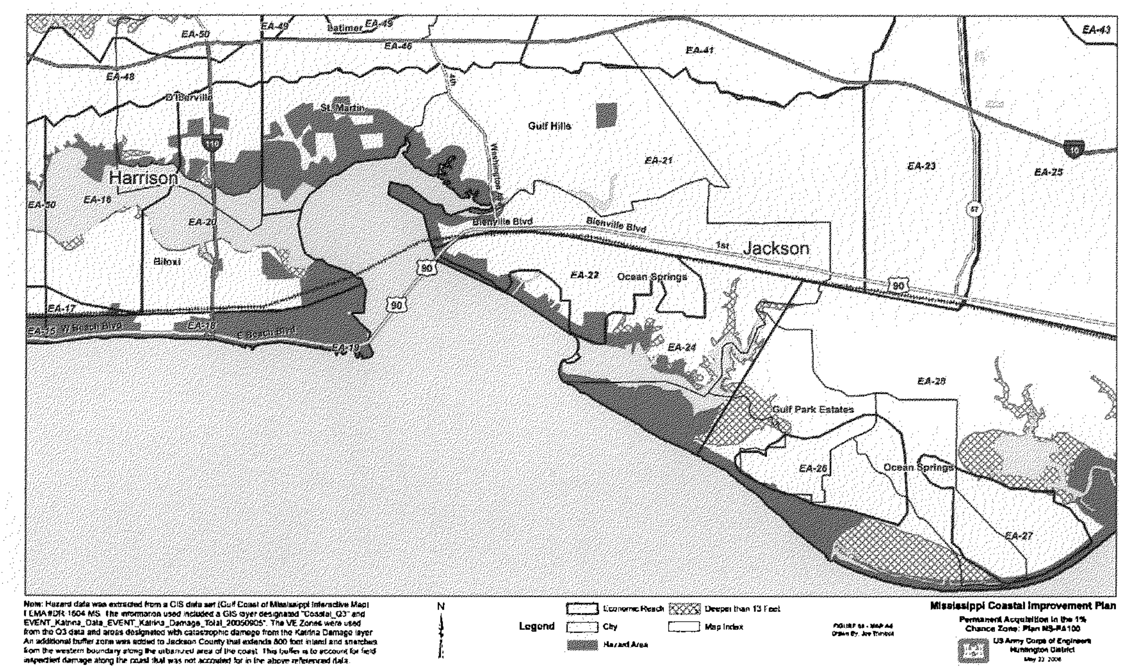
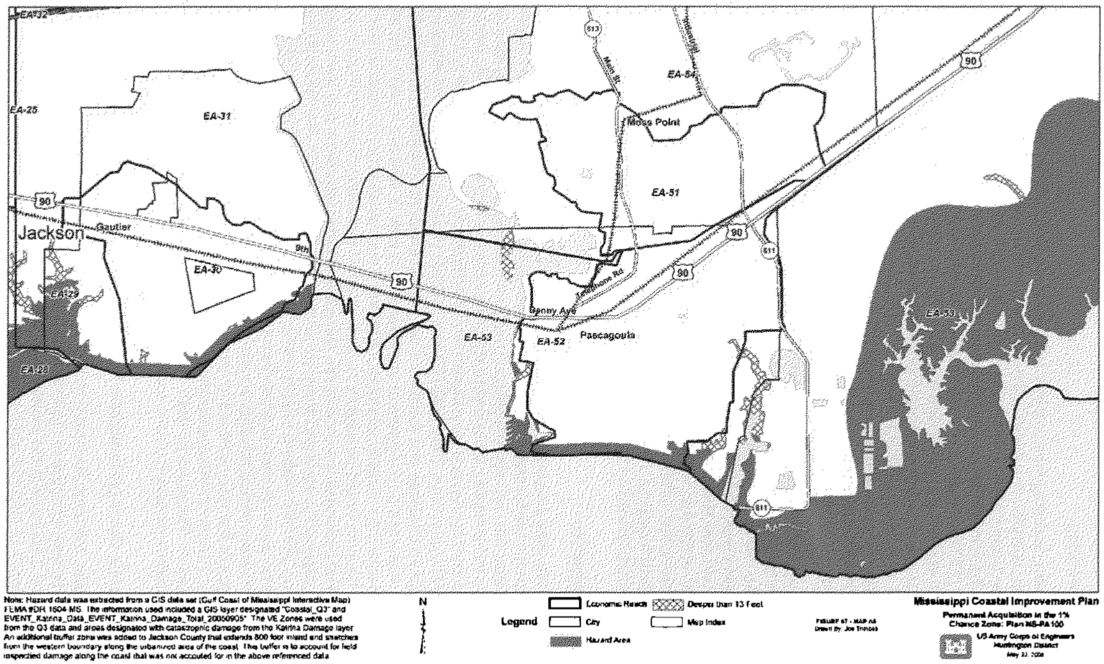


Figure 64 – Plan NS-PA100 Permanent Acquisition in 1% Annual Chance Flood Zone (A4)



Note: Hazard data was extracted from a GIS data set (Gulf Coast of Mississippi Interactive Map) FEMA #DR-1604 MS. The information used included a GIS layer designated "Coastal_Q3" and EVENT_Katrina_Data_EVENT_Katrina_Damage_Total_20050905". The VE Zones were used from the Q3 data and areas designated with catastrophic damage from the Katrina Damage layer. An additional buffer zone was added to Jackson County that extends 800 foot inland and stretches from the western boundary along the urbanized area of the coast. This buffer is to account for field inspected damage along the coast that was not accounted for in the above referenced data.

Figure 65 – Plan NS- PA100 Permanent Acquisition in 1% Annual Chance Flood Zone (A5)



6.7.1.2 Floodproofing

A single-measure plan, featuring floodproofing activities and using both dry and wet floodproofing techniques including ringwalls, ring-levees, elevation and veneer walls would significantly reduce flood damages in the project area. This measure could be implemented by the Federal government as a component of the flood damage reduction program. Unfortunately, because of the restrictions of height for elevation (15 feet maximum height of raise), excessive depths of inundation where veneer walls are impractical and unsafe and limited space for constructing ringwalls and ring-levees on small urban lots, a single measure featuring floodproofing would not address many of the structures and facilities at risk. In addition, although there are many parcels located within the project area where the combination of surge and waves would not be a limiting factor, many thousands of parcels are located in high-hazard surge and wave zones where floodproofing in any manner for certain types of structures would be dangerous.

Also, implementing a single-measure floodproofing plan without adding improvements to the existing flood warning and emergency evacuation system could result in many structure owners deciding to "ride-out" a hurricane that could seriously endanger not only their lives but the lives of rescue personnel. This single measure plan would address approximately 25,400 parcels of land in the project area and would cost approximately $10.8B. Based upon the limitations of floodproofing due to inundation depths, surge and wave dangers, and spatial constraints and the necessity of adding all proposed upgrades to the existing flood warning and emergency evacuation plan, a single measure plan featuring floodproofing should not be carried forward. Floodproofing has been included as an effective measure in some of the combined-measure plans described below.

6.7.1.3 Replacements

A single-measure plan, featuring the replacement of public buildings would be effective in protection of many of the critical facilities located in the project area. Since these structures and the services they provide (i.e. police, fire, city administration, emergency management, education, etc.) are considered critical to the everyday life and security of the communities that they serve, protection of them by either floodproofing in-place (see above) or replacement to a flood-safe site is a significant component of any protection plan. Data from FEMA's HAZUS program and local tax assessments indicates that at least 75 buildings and facilities in the project area are considered to be "critical facilities". Of those, many are publicly-owned and operated. A total of 49 were found to be attached to identified-parcels within the project database. Of those, 7 may be eligible for replacement in lieu of acquisition and the balance would be eligible for some form of protection (floodproofing) in place. Based upon preliminary information on the types and uses of those structures and their approximate locations, the cost of replacing the 7 structures would be approximately $51.3M. Although this measure would be an effective method of addressing damages to these important facilities, replacement/relocation accomplished in accordance with Corps Real Estate regulations does not address the other privately-owned facilities considered also to be critical (privately owned schools, medical facilities, etc.) or the vast numbers of residential and commercial structures that are also at risk from inundation. Therefore, replacement/relocation of public facilities as a single measure plan would not be an effective alternative by itself. Replacement or relocation of public structures as a means of reducing damages is included in some of the combined plans described below.

6.7.1.4 Floodplain Zoning/Floodplain Management Ordinances

A single-measure plan, featuring floodplain zoning and floodplain management ordinance enforcement could be very effective in many locations within the project area. Implemented by the 11 municipalities and 3 counties in the project area, these measures would affect approximately 74,000 separate parcels of land (exceptions being military bases and installations). This measure would be implemented solely by the local governments with technical input from FEMA. Estimated cost for applying this measure across all parcels is approximately $280,000. Although the combination of these two activities seldom is effective in reducing damages to existing structures and reducing threats to life because of the existence of "grandfathered" development, the number of empty lots across the project area that would be subject to more stringent zoning and ordinances that dictate development makes this singular measure palatable and effective. Current floodplain zoning based upon previous ordinances could be replaced with more stringent ordinance requirements and floodplain mapping based upon updated Digital Flood Insurance Rate Maps (DFIRM's) being prepared by FEMA. As the municipalities and counties adopt and enforce more stringent regulations based upon updated mapping, potential damages and losses of life from future storms and hurricanes to new development would be lessened significantly.

Ironically, a significant number of structures and facilities did survive Katrina's onslaught with rather minor damages; damages that would not trigger all of the new requirements for elevating structures above the modified BFE or result in any significant improvements in the structure to resist storm damages. However, of the many modifications to the NFIP that could be instituted, instituting cumulative storm-related damages over a period of years (that period to be determined locally) as the trigger for requiring compliance with NFIP regulations and local floodplain management ordinances is worthy of consideration. In fact the City of Pascagoula already has instituted this procedure as a part of their local floodplain ordinance administration. Outside of the ordinance requirements under the NFIP there are few incentives to retrofit existing structures or adhere to upgraded building codes if new requirements are not strictly enforced locally. For this reason, floodplain zoning and floodplain management ordinance enforcement as a single measure plan should not be carried forward. However, both of these measures (upgraded zoning and ordinance enforcement) are used in combined plans described below.

6.7.1.5 Building Codes

A single-measure plan, featuring updated building codes based upon new versions of the IBC and the FEMA 550 guidelines could substantially reduce storm damages to new construction in those areas where units were totally destroyed by Katrina. Implemented by the 11 municipalities and 3 counties these codes would affect over 74,000 parcels and existing or new structures. Other buildings (residential. commercial and institutional) damaged less severely by Katrina would be subject to these updated codes for repairs resulting in some reduction of future damages. Costs for upgrading and applying the buildings codes is negligible since the administration and enforcement of the building codes is supported by building construction permit fees.

However, as in the case of floodplain zoning and floodplain management ordinance enforcement, there are many structures and facilities that were only minimally damaged by Katrina and they would be largely unaffected by the new building codes and therefore still susceptible to flood damages. Although the institution of updated building codes and the FEMA 550 guidelines would reduce future damages to new construction and those structures requiring substantial repairs as a result of Katrina, as a single measure building codes do not address a sufficient number of the planning objectives to be carried forward. Instituting upgrades to the existing building codes and conducting educational seminars for those people in the design, construction, inspection, real estate and mortgaging professions who would be using the codes are included in some of the combined plans described below.

6.7.1.6 Land Use Regulation and Zoning

A single-measure plan, featuring modification and enforcement of new land use zoning by the local governments on areas inundated by Katrina (or any lesser area of inundation) could significantly reduce damages and threats to life by inundation from storms and hurricanes. As described in Section 4.3.4, land use zoning applied through the police powers of counties and municipalities can direct the types and densities of development that occur in each regulated area. Owing to that fact that so many structures were totally destroyed by Katrina and that redevelopment of those areas has been largely delayed due to lack of rebuilding capital and updated floodplain mapping, it would be possible to modify existing zoning ordinances such that either redevelopment of high-hazard areas was severely restricted (restrictions that may trigger a taking and therefore be more like the permanent acquisition measure) or that redevelopment of high-hazard areas was permitted for only those uses that could afford to invest sufficient funds to provide the high levels of protection needed in that area.

Implementation of these zoning changes to the approximately 7,500 parcels contained within the high-hazard zones could dramatically reduce future damages during redevelopment. Rezoning all of the project area where the most severe damages occurred (total destruction of buildings and facilities) to open space or recreation park land (devoid of damageable structures) may result in a determination that such a diminution of property value and use by private owners would constitute a taking and require full compensation of its market value. In effect, that result would be much like the single measure of permanent acquisition described above.

On the other hand, rezoning of those same areas that would permit mixed-use development featuring high-density commercial (casinos and malls) and high-density residential (condominiums) in structures elevated above pre-determined inundation levels could provide numerous local benefits and meet several of the planning objectives. Such mixed-use high density zoning along the beachfront area could encourage high-end developers to invest the required resources needed to create multi-story structures perched upon layers of parking garages that would be able to withstand the rigors of future storms and hurricanes. An example of this type of zoning is the present location of the Beau Rivage casino and hotel complex at Biloxi, MS. That sturdily-constructed complex weathered the Katrina storm with relatively minor damages compared to other beachfront structures.

This rezoning concept would confer great value on beachfront property that in a post-Katrina market has far less value in the hands of single-family homeowners, would potentially create additional jobs and tax revenues through construction and operation of the mixed use development, could generate additional tourism along the coast, and could create a wave and wind shadow effect for redevelopment located farther inland from the beach area. Large, well-designed and constructed mixed use buildings with first floors appropriately elevated on parking garages to reduce flood damages would provide many benefits to the local economy as well as addressing the reduction of damages and through improved emergency evacuation procedures reduce loss of life along the coast. In effect, current landowners along the beachfront would have the option to sell their land to potential developers at an inflated price above that now available and with appropriate application of floodplain zoning ordinance requirements and building codes, investors could make the best use of this prime beachfront property.

Careful rezoning of the lands subject to inundation by storms and hurricanes could attain one or more of the planning objectives, but accomplishing the rezoning would fall into the hands of the local municipal and county governments. The Federal government is not able to direct or otherwise coerce local governments to rezone private property as a plan alternative. Similar to the concept of allowing local floodplain zoning and ordinance administration to control new development on vacated property (in lieu of offering federal funds to elevate new structures on interspersed vacant land) and thereby accomplish planning objectives with no cost to the project, allowing rezoning of high-hazard areas such that permitted uses would be substantially protected from future damages would lead to the same benefits at no Federal cost. The estimated cost of modifying the existing zoning along the coast is approximately $500,000 including modification of or amendments to local comprehensive plans that support local zoning ordinances. This single measure is not carried forward as a separate plan into the formulation process since it primarily reduces damages on future development and would have little effect on existing structures, but this measure is included in some of the combined plans described below.

6.7.1.7 Flood Preparedness and Public Education

A single-measure plan, featuring flood preparedness and public education would be effective in meeting portions of the planning objectives. Implementing various components of an improved storm warning system and emergency evacuation plan across the project area could significantly reduce the threats to life from storms and hurricanes and possibly reduce damages to structure contents that could be moved out of the inundation zone prior to the arrival of the storm event. In all, approximately 74,000 parcels of land, the structures on them and the families and individuals living within them would be provided an increased level of protection for structure contents and loss of life.

A sustained program of public education regarding the potential threats posed by storms and hurricanes applied to all sectors of the resident and itinerant population in the project area could significantly increase the population's awareness of the dangers and options for reducing the threat. A good public education program could save lives in the event of another large hurricane. The estimated cost of applying this measure across the project area is $2.9M. Unfortunately, without the application of other nonstructural measures, structures and facilities left behind by fleeing residents or business owners would still be subject to inundation damages. Some improvements to structures and facilities as a part of the flood preparedness measures could be undertaken to reduce building damages, but without other measures (i.e. floodproofing, acquisition, building codes, etc.) structure and facility damages would still occur. Therefore, as a singular measure plan, flood preparedness and public education was not carried forward. Flood preparedness and public education was included in some of the combined plans as described below.

6.7.1.8 Transfer of Development Rights and Purchase of Development Rights

A single-measure plan consisting of transfer of development rights and/or purchase of development rights could be effective in addressing interspersed properties within hazard zones that were vacant prior to Katrina or were vacated as a result of Katrina. If these programs were instituted by the three counties in cooperation with the municipal areas, future development of interspersed vacant private property in hazard zones that are entered into either of the two programs could be thwarted (mitigated by cash payments from receiving property owners) thus reducing future flood damages. Likewise, receiving areas designated under a TDR program would be given the opportunity to develop flood-free property at higher densities that could provide housing for displaced landowners within the hazard areas. Under the PDR option, owners of interspersed vacant properties in hazardous zones would sign over their rights to further develop their property for a lump sum of cash provided by the implementing local entity. According to RE data, over 33,000 interspersed vacant parcels exist within the project area, many of which are located within the high-hazard zones.

Purchasing or transferring the development rights of these interspersed vacant parcels would limit future development of damageable property. The estimated cost to establish the TDR/PDR programs is approximately $1.5M ($500,000 per planning unit) with annual sums of state and/or local capital with which to purchase the development rights. However, neither of these programs can accomplish flood damage reduction objectives for existing structures that survived Katrina because neither of the programs modify or remove an existing structure from the property to avoid future damages but only thwart future additional development of the site from the day of the agreement or purchase of the rights to further develop the property. Although effective in reducing further damages from new development on interspersed vacant property, these programs do little to reduce damages to existing structures and facilities in hazard areas. For this reason, TDR and PDR are not effective as a single measure plan, but could be combined with other measures (such as permanent acquisition) that would address damages to existing and future development.

6.7.1.9 Development Impact Fees

Development impact fees can be used as a financial disincentive to steer development away from hazardous locations and allow jurisdictions to recover the external development costs for emergency services and post-storm recovery activities. Normally the fees are paid by the developer as a one-time lump sum on a per-lot basis rather than a continuing repetitive payment on developed lots that may be located in a hazardous zone. The estimated cost to enact development impact fees across the project area is $370,000. The total number of undeveloped acreage that may be converted to residential or commercial use in the project area is unknown at this time, but the institution of impact fees may limit development on those acres located in flood-prone areas. Although the use of such fees has proven to be effective in modifying the behaviors of developers in high-growth areas, the fees by themselves do not reduce flood damages to existing development nor do they absolutely prohibit such development from occurring. Since the project objectives emphasize reduction of flood damages to existing development, development impacts fees would not be an effective single-measure plan. However, given their ability to redirect growth away from hazardous or environmentally sensitive areas and to recover external costs, development impact fees would be effective when combined with other measures as described below.

6.7.2 Combined Measures Nonstructural Plans

As shown in Section 6.5.1., none of the nonstructural measures in and of themselves (except for lower levels of protection or single measures concentrated on very specific coastal areas such as permanent acquisition) fully meets the planning objectives of the study. Closest to the mark is permanent acquisition of all property damaged by Katrina and yet within that seemingly complete solution are holes bored by legal restrictions and economic imperatives such that it too is unable to fully address the objectives. Two alternatives featuring permanent acquisition as the only measure (described above as NS-PAHHZ and NS-PA100) are effective in reducing damages, but neither of them fully meets the planning objectives stated in the report.

In view of the inability of single-measure alternatives to address a majority of the planning objectives, combinations of measures, each with its unique ability to address portions of the objectives must be considered. Combining the best attributes of measures that can be implemented by Federal agencies and both state and local governments can provide substantial benefits. Using the results of the pair-wise evaluation in Table 13, combinations of measures were developed that can cost-effectively reduce damages, while providing for ecosystem restoration of wetlands and minimizing long-term social, economic and cultural impacts.

Two of the nonstructural measures already functioning in the study area can be components of any combined plan since they involve administrative and regulatory activities that would remain effective in any nonstructural plan. As shown in the pair-wise analysis, these two measures combine favorably under any future development scenarios. Flood Preparedness composed of Hurricane & Storm Warnings and Emergency Evacuation and Floodplain Management and Zoning both operate at the Federal, State and local levels of government to reduce losses of life and property damages. Only in the permanent acquisition measure, with a high degree of participation, does either of these two measures lose their effectiveness (very limited damageable property would remain in place), but with remnants of development (casinos and associated development) remaining even under that acquisition scenario, these two measures would remain in effect and be necessary for those facilities to safely maintain their location on the coast. For this reason the existing components of both Flood Preparedness and Floodplain Management and Zoning are incorporated into each combined plan although in Plan NS-PAHHZ and Plan NS-PA100 (described above) they are assumed to function only at their present level of operation without the improvements recommended in Plan NSC-1.

As stated above with respect to the two single-measure plans for permanent acquisition, all of the combined measures plans described below would have to be closely coordinated with current FEMA and HUD disaster-assistance programs before implementation so that opportunities for "double-dipping" could be eliminated and so that eligible landowners would be provided with the optimal solution for their individual structure or facility.

The combined nonstructural plans are described below:

6.7.2.1 Plan NSC-1 Federal Agencies Plan

This plan alternative would consist primarily of four measures that could be implemented by Federal agencies in cooperation with state and local agencies. This plan would provide protection for structures determined to be eligible for the program as a result of suffering inundation damages from Katrina. Although the level of protection for this plan was based upon the ABFE minus 2 feet, if approved and implemented, the Base Flood Elevation established by the anticipated revised DFIRM's from FEMA would be the minimum level of protection afforded by this plan in accordance with the local ordinances. Those four plan measures include 1) permanent acquisition of approximately 33,200 parcels (approximately 17,100 structures) located in the three high-hazard zones and areas where water depths exceed 13 feet, 2) floodproofing by elevation and other means for approximately 25,400 parcels, 3) construction of three safe harborages within three separate inlets, and 4) replacement of 7 public buildings. Figures 66 through 70 show the coverage of the different nonstructural measures applied to the project area. Table 17 shows the costs of these various components. The estimated total cost of this plan would be $19.1B.

Structures and facilities located within the three high-hazard zones as identified in this plan would be subject to acquisition with full application of relocations assistance under the Uniform Relocations Act. Where required to resolve title issues or market value, condemnation under the eminent domain provisions of the Uniform Act could be exercised by the project sponsor (or Federal government). Relocations assistance payments would be provided to displaced landowners for the purpose of re-establishing businesses and households.

A variance in this permanent acquisition plan component would be for FEMA through their Hazard Mitigation Grant Program (HMGP) to acquire all insured (insured through the National Flood Insurance Program – NFIP) structures (with the exceptions listed in 3.3.2) within the identified V-zone. The Corps of Engineers would purchase all uninsured structures, through the provisions of P. L. 91-646, that are located within the V-zone, the "catastrophic damages zone" and within the 800 foot buffer in Jackson County as well as structures where water depths at the structure exceed 13 feet. Land acquisition costs would be similar to the all-Corps plan for acquisitions in these identified zones ($7.9 billion in Plan NS-PAHHZ), but relocations assistance payments may be less through the FEMA HMGP program.

Implementation of the HARP would enable the Corps to acquire many parcels made vacant by Katrina before landowners could re-establish their residence. This early action would reduce acquisition costs and demolition costs and make the program more palatable to landowners. Once a new residence was constructed, landowners would be less willing to accept an offer to purchase the property and new home even with relocations assistance.

All structures and pavements on acquired property will be either demolished or salvaged by the owner or disposed of by auction and removed from the site. Demolished construction materials will be disposed of in approved landfills or accumulated in designated staging areas for submerged habitat purposes. Utilities that are no longer necessary for service could be removed by the utility companies and unnecessary roadways could be demolished and abandoned by MDOT.

It is estimated that approximately 57,000 acres of land could be acquired in the high-hazard zones (were there to be 100 percent participation in the program). Of that total acreage, approximately 4,000 acres have been identified as suitable for ecosystem restoration as wetland areas. Those acres could be restored by numerous methods as described in the Environmental Appendix. In addition, there are approximately 37,000 acres of land that could be acquired in those areas where water depths at the AFBE-2 feet exceeded 13 feet (no floodproofing by elevation). Of that total acreage, approximately 5,200 acres have been identified as suitable for ecosystem restoration as wetland areas. Those acres as well could be restored by numerous methods as described in the Environmental Appendix. Additional acquisitions could occur in the areas designated for floodproofing by elevation or other means should specific structures be determined unsuitable for floodproofing during more detailed investigations or where elevation costs exceed acquisition costs. Lands acquired within the designated floodproofing areas that could be restored for ecosystem benefits would be investigated by the environmental team for their use as future wetlands.

Total estimated costs for all permanent acquisitions would be approximately $7.9B. Table 17 shows the approximate numbers of units and acquisition costs by economic reach. Figures 66 through 70 show the extent of the permanent acquisition area [shown in red and dark green] in the project area.

In an effort to reduce the overall project costs and forestall the re-establishment of many households in the high-hazard zones, implementation of the High Hazard Area Risk Reduction Plan (HARP) would concentrate on properties in the high-hazard zones that were made vacant by Katrina (structures demolished by the storm). This initial acquisition program described in Section 4.3.8.5 of this Appendix could significantly reduce the overall program cost by purchasing vacated property that has a high likelihood of redevelopment. Foregoing the high costs of purchasing new, larger residences, paying household relocation assistance and demolishing buildings and disposing of the debris, the HARP could save more than $270.0M in the permanent acquisition program and significantly reduce the threats to loss of life for those who would be re-establishing residences in high-hazard zone. The initial HARP program cost is estimated to be $397.0M and would affect approximately 2,000 parcels of property. Figure 52 shows those areas of the project where high-quality wetland ecosystem restoration opportunities correlate with the proposed acquisition in the HARP. Acquisition of interspersed vacant property (no structures) would require relatively minimal restoration to achieve ecosystem benefits.

Depending upon the type of redevelopment/resettlement options that are agreed upon by the local communities and the availability of existing DSS market housing for displaced landowners, one or more redevelopment sites may be developed in association with the permanent acquisition component of this nonstructural plan. These redevelopment sites would be constructed by the Federal government on lands acquired by the non-Federal sponsor (or the Federal Government by sub-agreement). All site improvements and community amenities would be installed prior to new housing or commercial building construction. To handle the anticipated number of displaced households a total of at least three redevelopment sites would be needed, one in each county (planning unit). Total estimated costs for three redevelopment sites (total of 6,000 lots) based upon an average developed cost per lot of $45,000 would be $270.0M.

Floodproofing of selected residential, commercial and institutional structures by elevation or other means would be implemented by Federal agencies with cooperation from state and local agencies. The floodproofing component would be on a voluntary basis only. During implementation of the floodproofing component of the plan each structure would be carefully evaluated to determine the appropriate method of protection. The most cost effective solution would be offered to the landowner. The existing structure could be either elevated in-place, purchased voluntarily and demolished or demolished and a new structure rebuilt on-site in an elevated condition. Guide plans and specifications based upon the engineering standards proscribed in the FEMA 550 guidelines would be prepared for each structure to be elevated. Specific plans and specifications for floodproofing measures at larger commercial or institutional buildings would be completed for each structure. The estimated cost for floodproofing 25,419 structures is $10.8B. Table 17 shows the floodproofing costs by economic reach. A total of 43 public buildings are included in the total number of structures eligible to be floodproofed. Figures 66 through 70 show the extent of the area where floodproofing by elevation would be practical and safe (shown in green).

In order to demonstrate the effectiveness of floodproofing by elevation to the general populace within the project area, this plan would request authorization to proceed with floodproofing construction by elevation in selected communities where elevation could be accomplished safely and at a much lower cost than any other measure (structural or nonstructural) heretofore identified. A neighborhood within Waveland, MS has been identified where elevation of residential structures using the FEMA 550 guidelines for floodproofing in the Gulf Coast would be within the program guidelines. An early-action floodproofing program would provide an opportunity to evaluate the FEMA 550 guidelines, demonstrate to potential program participants the appearance of structure elevation according to the guidelines and provide valuable information to the Mobile District on anticipated floodproofing and administrative costs for the remainder of the project area. Approximately 25 residential structures would be included in this project. The total, fully-funded project cost is estimated to be $4.6 M with a project duration of four years depending upon the flow of project funds. A Detailed Project Report (DPR) or Project Implementation Report (PIR) would be prepared for approval by Corps Division offices prior to implementation of this program.

To address the emergency evacuation requirements of the many fishing and pleasure vessels in the project area, three safe harborages would be constructed within the three major inlets in the project area. Safe harborages would be constructed on the Bay St. Louis embayment, Biloxi embayment and Pascagoula River embayment. An alternate harborage location would be at the Pearlington site on the Pearl River should the Pearlington redevelopment site be constructed. Material from the excavated safe harborage could be used as a portion of the fill for raising the Pearlington community. Construction at these sites would entail excavation of the harbor areas, dredging (if deemed necessary) of channels between the Gulf and the safe harbor area, a berthing area(s) of sufficient size to accommodate fishing vessels, security fencing, lighting and a gravel parking area. The total estimated cost for these three safe harborages is approximately $23.1M. This amount reflects the cost-shared (non-Federal 10%) project cost with a maximum Federal cost per project of $7.0M (Federal project limit revised in WRDA 2007).

Public buildings that cannot be safely protected in place by floodproofing or that were located in the high-hazard zone could be replaced at a flood-safe location in lieu of acquisition in accordance with Corps regulations (ER405-1-12).. A detailed engineering assessment of each public structure or facility would be made by USACE personnel to determine what a suitable replacement structure would require in terms of floor space, facilities, access, equipment, and maintenance. Building design would be based upon current-day standards for the particular facility (school, police station, fire station, city hall, etc.) being relocated. Replacement costs would account for land acquisition of a new flood-free site, building/facility design costs, construction costs and demolition costs of the old building. The existing flood-prone public property would be turned over to a non-Federal local sponsor for future OMRR&R. The 7 identified public buildings for replacement include schools and fire stations. Based upon available information for the affected public buildings, the estimated replacement costs would be approximately $51.2M. Table17 shows the numbers of public structures that would be subject to replacement or a floodproofing option and associated costs by economic reach. Figures 66 through 70 show the approximate locations of these existing structures within their economic reach.

The aforementioned Moss Point public buildings replacement could be implemented to demonstrate the effectiveness of facility replacement in reducing flood damages. The four public structures within the municipality that compose the city administrative offices and community recreation facility could be replaced at less flood-prone locations within Moss Point to demonstrate to other communities in the project area the usefulness of this nonstructural technique. The total, fully-funded estimated cost of this replacement project is $11.4 M with a project duration of four years.

As stated above, flood preparedness and floodplain management zoning and ordinance enforcement as well as building code enforcement would continue as well as the NFIP program in the project area. There wouldn't be any significant improvements to these three local systems beyond what is currently in-place following Katrina. Costs for these in-place, ongoing local processes are purely non-federal costs and are not captured in this alternative plan.

Other scales of Plan NSC-1 include providing the same suite of protection measures for several levels of inundation (each greater in magnitude than the minimum ABFE) including 20 foot, 30 foot and 40 foot storm surge inundation levels within the project area. The primary differences in this sub-set of Plan NSC-1 are the total number of parcels being protected and the division of the parcels between the floodproofing and either permanent acquisition or replacement (public buildings) measures within the plan. As the level of storm surge increases (ABFE-2 to 20 feet, 30 feet, and 40 feet), the total parcels treated by the measures would be steadily increased and more parcels (and attendant structures if not vacant) would be acquired (water depths greater than 13 feet) than floodproofed.

The only category of parcels whose total number would remain constant across the scaled versions of NCS-1 would be those in the high-hazard zones that are not affected by water depth, but by their proximity to the shoreline. In view of study time constraints and the limitations of the databases to accurately capture public buildings at these higher levels of inundation, municipal buildings listed in the tax assessor's database were considered as commercial structures to determine acquisitions and floodproofing costs at the 20, 30 and 40 foot levels of inundation. Total units and costs for each measure for the three, scaled versions of Plan NSC-1 (NSC-1a, NSC-1b, and NSC-1c) are shown in Tables 18, 19 and 20 by economic reach.

As shown in Tables 18, 19 and 20, the numbers of parcels increases dramatically with each increase in inundation depth between the ABFE and the 40 foot depth of inundation. Also evident is the movement of parcels eligible for floodproofing to the permanent acquisition category based upon depth of water at the structure. In addition, because of the dramatic increases in the numbers of parcels eligible for permanent acquisition, the numbers of potential H&CD lots required to handle the anticipated displaced landowners increases dramatically (as well as the costs and acres of land that would be required to accommodate the displaced households). This close relationship between inundation depth and numbers of permanent acquisitions (as well as needed lots for displaced landowners) remains fairly constant throughout the continuum of inundation depths.

From a total plan cost standpoint, greater levels of surge inundation do result in costs actually decreasing slightly because of the slightly lower cost for permanent acquisition as opposed to floodproofing used in this analysis. As more structures are added to the eligible list (deeper surge depth covers greater land area and more parcels), the overall cost of the plan does not rise at the same rate of increase through each increment of surge depth. Although somewhat counterintuitive, the difference in measure cost and the movement of structures from one category to another (floodproofing to permanent acquisition) drives this slight reduction in cost. As discussed in Section 6.3 – Nonstructural Program Participation, participation in the program at higher levels of surge protection may drop as landowners who would have been willing to have their homes elevated (at a lower level of protection) may decline to have their homes purchased at the higher level of protection. Although a change in the participation rate would further decrease the plan cost, its effectiveness in reducing damages from surge inundation would also be reduced.

Table 17.
Plan NSC-1 – Federal Agencies Plan (ABFE)

Economic Reaches	Permanent Acquisition Parcels	Cost	Floodproofing Structures	Cost	Public Buildings Relocations	Cost	Safe Harborages	Cost
1	997	$194,118,218	394	$124,162,500	0	0		
2	9911	$2,992,128,131	3294	$1,940,527,762	0	0		
3	2202	$668,691,437	376	$333,327,500	0	0		
4	922	$120,307,917	16	$30,715,000	0	0		
5	2714	$238,388,794	119	$79,272,500	0	0		
6	567	$107,292,775	590	$332,629,236	1	$8,536,147		
7	450	$33,303,080	232	$186,928,125	0	0		
8	3623	$476,153,333	1730	$696,585,161	4	$25,608,442		
9	44	$16,145,783	16	$16,552,500	0	0		
10	1945	$432,607,234	62	$24,201,250	0	0		
11	0	0	8	$2,105,000	0	0		
12	1047	$179,783,825	1136	$443,587,036	0	0		
13	650	$583,121,543	0	0	0	0		
15	85	$44,354,843	9	$28,406,250	0	0		
16	78	$16,399,728	121	$38,542,500	0	0		
18	1502	$409,463,532	5	$1,396,250	0	0		
19	46	$292,728,063	0	0	0	0		
20	1397	$238,563,082	2050	$876,852,680	1	$8,536,147		
21	2108	$301,824,272	419	$193,663,144	0	0		
22	61	$26,330,663	92	$44,933,750	0	0		
23	0	0	44	$24,735,000	0	0		
24	220	$65,229,821	178	$58,153,750	0	0		
26	37	$9,210,336	952	$331,648,993	0	0		
27	53	$12,880,944	1029	$275,385,243	0	0		
28	961	$90,294,697	122	$59,837,500	0	0		
29	147	$23,394,829	168	$63,560,625	0	0		
30	90	$29,459,003	467	$197,030,000	0	0		
31	51	$14,959,829	447	$209,015,000	0	0		
32	0	0	208	$64,368,750	0	0		
35	12	$682,228	1406	$431,113,125	0	0		
36	32	$3,834,485	2	$6,312,500	0	0		
38	50	$21,424,866	78	$19,440,625	0	0		
39	0	0	6	$1,204,375	0	0		
43	0	0	1	$206,250	0	0		
48	0	0	2	$445,000	0	0		
50	495	$89,312,661	848	$263,763,750	0	0		
51	0	0	786	$329,689,637	0	0		
52	285	$103,016,211	6838	$2,412,346,817	1	$8,536,147		
53	399	$113,054,873	360	$256,581,875	0	0		
54	9	$1,114,862	808	$406,074,697	0	0		
Subtotals	**33,191**	**$7,928,411,301**	**419**	**$10,805,301,654**	**7**	**$51,216,883**	**3**	**$23,100,000**
H&CD Sites		Hancock, Harrison and Jackson Counties			3 Sites – 3,000 total lots			$135,000,000
Total Cost								$18,943,029,838

Table 18
Plan NSC-1a – 20 Feet of Inundation

Economic Reach	Acquisition Parcels	Acquisition Cost	Floodproofing Parcels	Floodproofing Cost	Subtotal NS Cost by Reach
1	795	$242,760,352.63	1068	$111,644,220	$354,404,572.63
2	6119	$1,982,505,118.75	12206	$2,270,306,077	$4,252,811,195.75
3	2029	$869,599,919.38	502	$261,603,614	$1,131,203,533.38
4	769	$137,140,841.63	55	$41,048,722	$178,189,563.63
5	1907	$221,978,091.88	680	$93,803,252	$315,781,343.88
6	753	$84,228,949.38	167	$67,872,872	$152,101,821.38
7	343	$28,183,289.75	1092	$123,833,026	$152,016,315.75
8	6585	$721,036,617.25	2761	$268,481,369	$989,517,986.25
9	23	$10,006,258.75	15	$4,155,724	$14,161,982.75
10	3052	$687,523,634.50	36	$9,985,596	$697,509,230.50
11	45	$13,955,967.50	882	$131,996,005	$145,951,972.50
12	1617	$398,388,336.75	2184	$925,803,107	$1,324,191,443.75
13	2284	$1,059,037,972.50	1	$275,000	$1,059,312,972.50
14	10	$3,531,145.00	3	$0	$3,531,145.00
15	407	$321,467,398.75	5	$195,994	$321,663,392.75
16	178	$45,986,843.00	420	$89,816,180	$135,803,023.00
17	0	$0.00	0	$0	$0.00
18	1650	$531,842,684.50	29	$7,968,172	$539,810,856.50
19	15	$238,143,653.50	0	$0	$238,143,653.50
20	1046	$197,002,707.50	1756	$491,997,409	$689,000,116.50
21	2142	$698,779,207.38	1688	$518,126,016	$1,216,905,223.38
22	314	$142,425,847.38	1921	$475,539,586	$617,965,433.38
23	59	$18,831,864.50	104	$23,208,676	$42,040,540.50
24	301	$134,113,558.00	854	$131,106,828	$265,220,386.00
25	0	$0.00	27	$3,700,964	$3,700,964.00
26	1117	$143,629,375.25	1094	$150,558,498	$294,187,873.25
27	203	$21,004,404.13	2725	$269,721,562	$290,725,966.13
28	1318	$162,484,163.75	444	$40,032,082	$202,516,245.75
29	491	$115,704,667.88	1081	$180,905,804	$296,610,471.88
30	612	$183,628,802.88	2158	$599,471,114	$783,099,916.88
31	472	$150,421,617.50	810	$206,865,030	$357,286,647.50
32	236	$44,686,667.38	461	$71,960,724	$116,647,391.38
33	0	$0.00	0	$0	$0.00
34	0	$0.00	0	$0	$0.00
35	630	$92,739,948.25	1277	$453,335,528	$546,075,476.25
36	0	$0.00	29	$0	$0.00
37	0	$0.00	5	$0	$0.00
38	33	$23,256,254.25	304	$16,587,864	$39,844,118.25
39	8	$1,627,170.00	287	$16,374,482	$18,001,652.00
40	1	$100,211.25	4	$0	$100,211.25
41	0	$0.00	0	$0	$0.00
42	0	$0.00	0	$0	$0.00
43	0	$0.00	4	$366,298	$366,298.00
44	0	$0.00	0	$0	$0.00
45	0	$0.00	0	$0	$0.00
46	0	$0.00	3	$114,092	$114,092.00
47	0	$0.00	5	$587,982	$587,982.00
48	1	$1,457,777.50	5	$587,982	$2,045,759.50
49	0	$0.00	63	$2,318,648	$2,318,648.00

Economic Reach	Acquisition Parcels	Acquisition Cost	Floodproofing Parcels	Floodproofing Cost	Subtotal NS Cost by Reach
50	574	$204,376,584.50	1915	$363,408,582	$567,785,166.50
51	1005	$220,389,345.63	883	$241,849,268	$462,238,613.63
52	1840	$535,059,176.25	7305	$4,108,479,076	$4,643,538,252.25
53	646	$134,435,107.63	613	$207,158,892	$341,593,999.63
54	1100	$276,596,580.13	655	$219,619,572	$496,216,152.13
Subtotal	**42730**	**$11,100,068,114**	**50586**	**$13,202,771,489**	**$24,302,839,603**
H&CD Sites	Hancock, Harrison & Jackson		Approx. 15,000 lots at $45,000/lot		$ 675,000,000
Total Cost					**$ 24,977,839,603**

Table 19
Plan NSC-1b – 30 Feet of Inundation

Economic Reach	Acquisition Parcels	Acquisition Cost	Floodproofing Parcels	Floodproofing Cost	Subtotal NS Cost by Reach
1	1591	$470,268,503.50	511	$80,353,606	$550,622,109.50
2	15864	$3,364,937,903.75	6331	$2,006,692,184	$5,371,630,087.75
3	2565	$1,036,199,788.88	557	$239,155,950	$1,275,355,738.88
4	823	$143,859,191.50	1	$195,994	$144,055,185.50
5	2545	$514,085,341.38	42	$8,818,078	$522,903,419.38
6	920	$108,477,101.25	0	$0	$108,477,101.25
7	1222	$127,404,692.38	267	$18,389,310	$145,794,002.38
8	8591	$913,966,937.50	755	$201,679,104	$1,115,646,041.50
9	38	$12,583,953.75	0	$0	$12,583,953.75
10	3088	$696,444,472.00	0	$0	$696,444,472.00
11	79	$17,236,421.25	848	$315,371,358	$332,607,779.25
12	3801	$1,250,095,756.75	0	$0	$1,250,095,756.75
13	2284	$1,059,037,972.50	1	$2,525,000	$1,061,562,972.50
14	10	$3,531,145.00	3	$0	$3,531,145.00
15	412	$326,617,775.00	0	$0	$326,617,775.00
16	598	$173,917,626.75	0	$0	$173,917,626.75
17	0	$0.00	0	$0	$0.00
18	1655	$533,199,240.00	24	$11,739,556	$544,938,796.00
19	15	$238,143,653.50	0	$0	$238,143,653.50
20	2144	$416,967,996.50	1802	$861,061,816	$1,278,029,812.50
21	3830	$1,483,891,217.50	0	$0	$1,483,891,217.50
22	2235	$872,740,336.25	0	$0	$872,740,336.25
23	163	$57,221,763.88	0	$0	$57,221,763.88
24	539	$264,338,265.75	616	$110,725,374	$375,063,639.75
25	27	$11,661,813.00	0	$0	$11,661,813.00
26	2211	$438,492,100.00	0	$0	$438,492,100.00
27	2928	$453,066,871.38	0	$0	$453,066,871.38
28	1687	$241,776,845.63	1742	$249,531,974	$491,308,819.63
29	1572	$359,722,100.25	0	$0	$359,722,100.25
30	2770	$942,794,462.50	0	$0	$942,794,462.50
31	1282	$415,121,092.13	0	40	$415,121,092.13
32	697	$173,934,340.75	0	$0	$173,934,340.75
33	0	$0.00	0	$0	$0.00
34	0	$0.00	0	$0	$0.00
35	1907	$416,542,564.88	0	$0	$416,542,564.88
36	15	$2,306,708.13	36	$0	$2,306,708.13
37	1	$340,434.38	4	$0	$340,434.38
38	198	$59,672,860.88	452	$74,116,316	$133,789,176.88
39	295	$34,977,357.00	0	$0	$34,977,357.00
40	5	$417,288.75	0	$0	$417,288.75
41	0	$0.00	0	$0	$0.00
42	0	$0.00	0	$0	$0.00
43	4	$1,269,975.00	0	$0	$1,269,975.00
44	0	$0.00	0	$0	$0.00
45	0	$0.00	0	$0	$0.00
46	3	$322,862.50	0	$0	$322,862.50
47	5	$1,720,815.00	0	$0	$1,720,815.00
48	6	$5,485,907.50	0	$0	$5,485,907.50
49	63	$8,814,550.50	0	$0	$8,814,550.50

Economic Reach	Acquisition Parcels	Acquisition Cost	Floodproofing Parcels	Floodproofing Cost	Subtotal NS Cost by Reach
50	1652	$665,887,180.75	837	$176,952,378	$842,839,558.75
51	1888	$447,319,912.38	0	$0	$447,319,912.38
52	9145	$3,199,336,671.63	0	$0	$3,199,336,671.63
53	1234	$464,412,757.75	49	$26,056,898	$490,469,655.75
54	1755	$541,259,959.00	0	$0	$541,259,959.00
Subtotal	**86362**	**$22,971,824,488**	**14878**	**4,383,364,896**	**$27,355,189,384**
H&CD Sites	Hancock, Harrison & Jackson		Approx. 30,000 lots at $45,000/lot		$ 1,350,000,000
Total Cost					**$ 28,705,189,384**

Table 20
Plan NSC-1c – 40 Feet of Inundation

Economic Reach	Acquisition Parcels	Acquisition Cost	Floodproofing Parcels	Floodproofing Cost	Subtotal NS Cost by Reach
1	2102	$632,549,786.38	0	0	$632,549,786.38
2	22195	$5,686,835,321.25	0	0	$5,686,835,321.25
3	3122	$1,266,472,734.00	0	0	$1,266,472,734.00
4	824	$144,644,086.50	0	0	$144,644,086.50
5	2587	$519,349,802.25	0	0	$519,349,802.25
6	920	$108,477,101.25	0	0	$108,477,101.25
7	1489	$159,349,868.63	0	0	$159,349,868.63
8	9346	$1,119,589,307.50	0	0	$1,119,589,307.50
9	38	$12,583,953.75	0	0	$12,583,953.75
10	3088	$696,444,472.00	0	0	$696,444,472.00
11	927	$238,310,263.50	0	0	$238,310,263.50
12	3801	$1,250,095,756.75	0	0	$1,250,095,756.75
13	2285	$1,059,287,941.25	0	0	$1,059,287,941.25
14	13	$5,321,020.00	0	0	$5,321,020.00
15	412	$326,617,775.00	0	0	$326,617,775.00
16	598	$173,917,626.75	0	0	$173,917,626.75
17	0	$0.00	0	0	$0.00
18	1679	$542,567,877.25	0	0	$542,567,877.25
19	15	$238,143,653.50	0	0	$238,143,653.50
20	3946	$829,880,446.50	0	0	$829,880,446.50
21	3830	$1,483,891,217.50	0	0	$1,483,891,217.50
22	2235	$872,740,336.25	0	0	$872,740,336.25
23	163	$57,221,763.88	0	0	$57,221,763.88
24	1155	$598,237,712.00	0	0	$598,237,712.00
25	27	$11,661,813.00	0	0	$11,661,813.00
26	2211	$438,492,100.00	0	0	$438,492,100.00
27	2928	$453,066,871.38	0	0	$453,066,871.38
28	3429	$714,783,499.38	0	0	$714,783,499.38
29	1572	$359,722,100.25	0	0	$359,722,100.25
30	2770	$942,794,462.50	0	0	$942,794,462.50
31	1282	$415,121,092.13	0	0	$415,121,092.13
32	697	$173,934,340.75	0	0	$173,934,340.75
33	0	$0.00	0	0	$0.00
34	0	$0.00	0	0	$0.00
35	1907	$416,542,564.88	0	0	$416,542,564.88
36	51	$6,438,158.75	0	0	$6,438,158.75
37	5	$1,911,196.25	0	0	$1,911,196.25
38	650	$214,970,390.38	0	0	$214,970,390.38
39	295	$34,977,357.00	0	0	$34,977,357.00
40	5	$417,288.75	0	0	$417,288.75
41	0	$0.00	0	0	$0.00
42	0	$0.00	0	0	$0.00
43	4	$1,269,975.00	0	0	$1,269,975.00
44	0	$0.00	0	0	$0.00
45	0	$0.00	0	0	$0.00
46	3	$322,862.50	0	0	$322,862.50
47	5	$1,720,815.00	0	0	$1,720,815.00
48	6	$5,485,907.50	0	0	$5,485,907.50
49	63	$8,814,550.50	0	0	$8,814,550.50

Economic Reach	Acquisition Parcels	Acquisition Cost	Floodproofing Parcels	Floodproofing Cost	Subtotal NS Cost by Reach
50	2489	$1,063,036,000.75	0	0	$1,063,036,000.75
51	1888	$447,319,912.38	0	0	$447,319,912.38
52	9145	$3,199,336,671.63	0	0	$3,199,336,671.63
53	1283	$496,107,037.25	0	0	$496,107,037.25
54	1755	$541,259,959.00	0	0	$541,259,959.00
Subtotal	**101240**	**$27,972,036,750**	**0**	**0**	**$27,972,036,750**
H&CD Sites	Hancock, Harrison & Jackson		Approx. 35,400 lots at $45,000/per		$1,593,000,000
Total Cost					**$29,565,036,750**

Figure 66 – Plan NSC-1 Permanent Acquisitions and Floodproofing (A1)

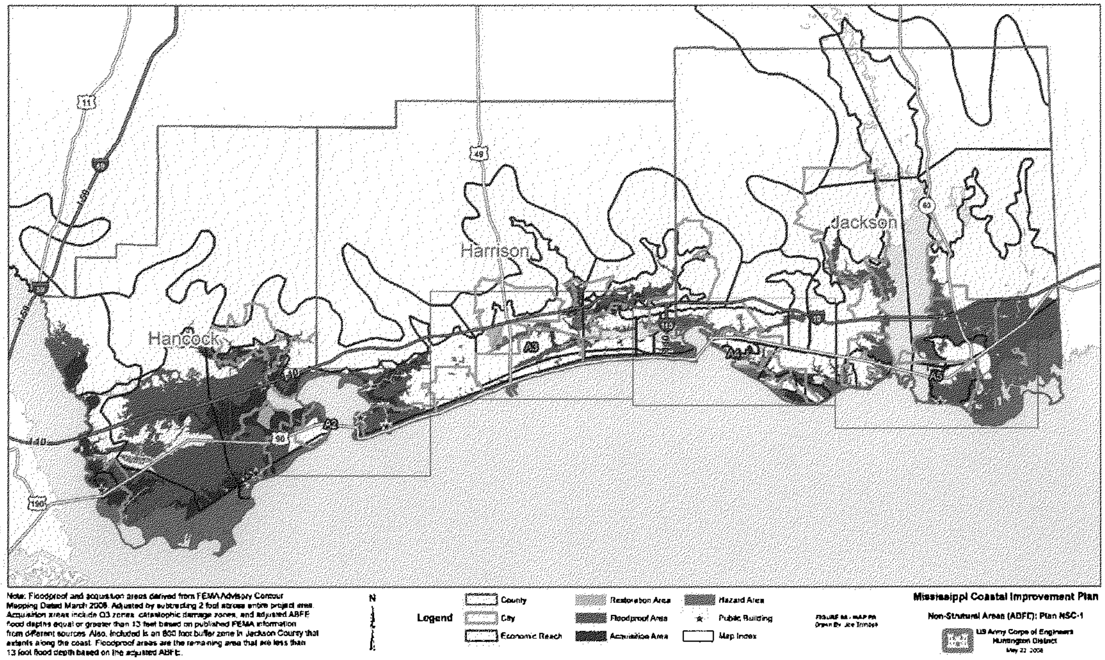


Figure 67 – Plan NSC-1 Permanent Acquisitions and Floodproofing (A2)

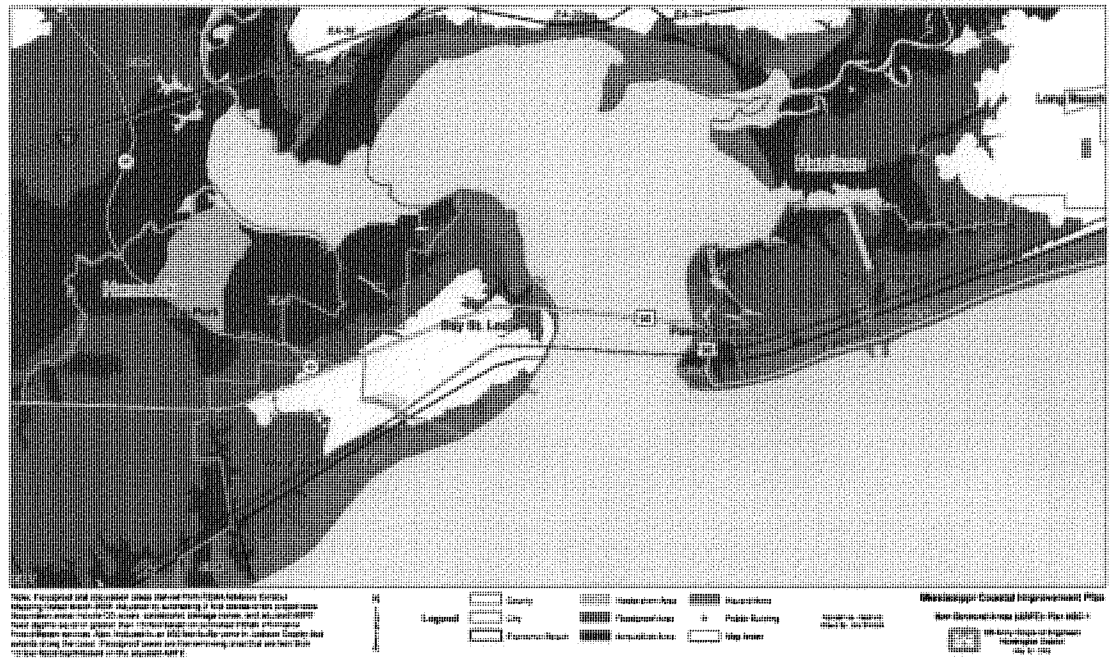


Figure 68 – Plan NSC-1 Permanent Acquisitions and Floodproofing (A3)

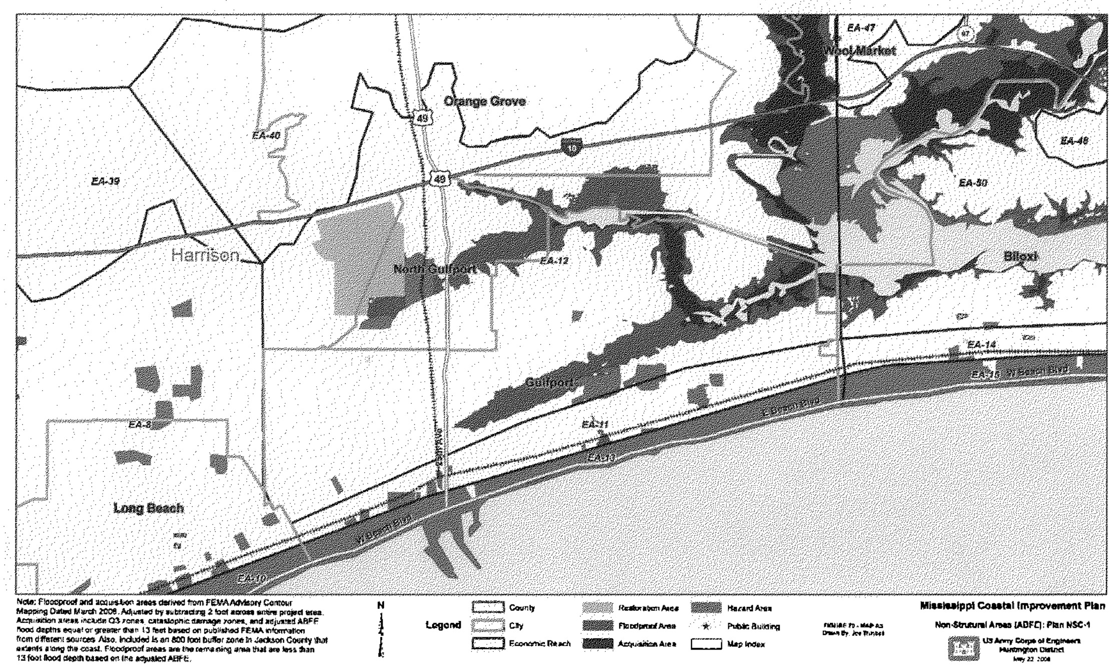


Figure 69 – Plan NSC-1 Permanent Acquisitions and Floodproofing (A4)

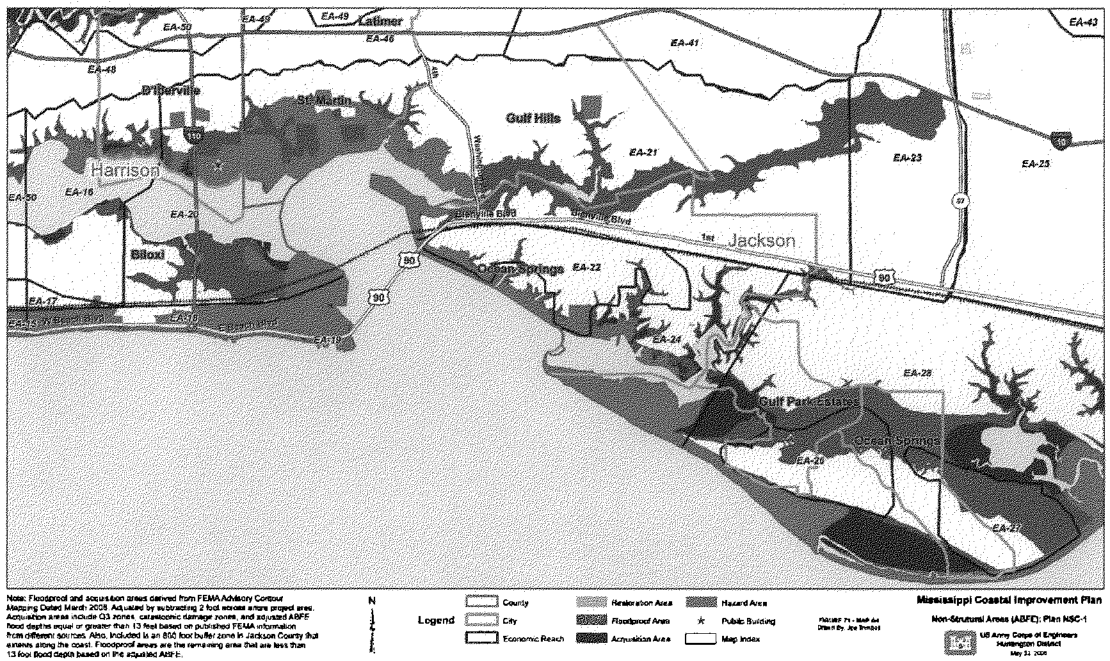
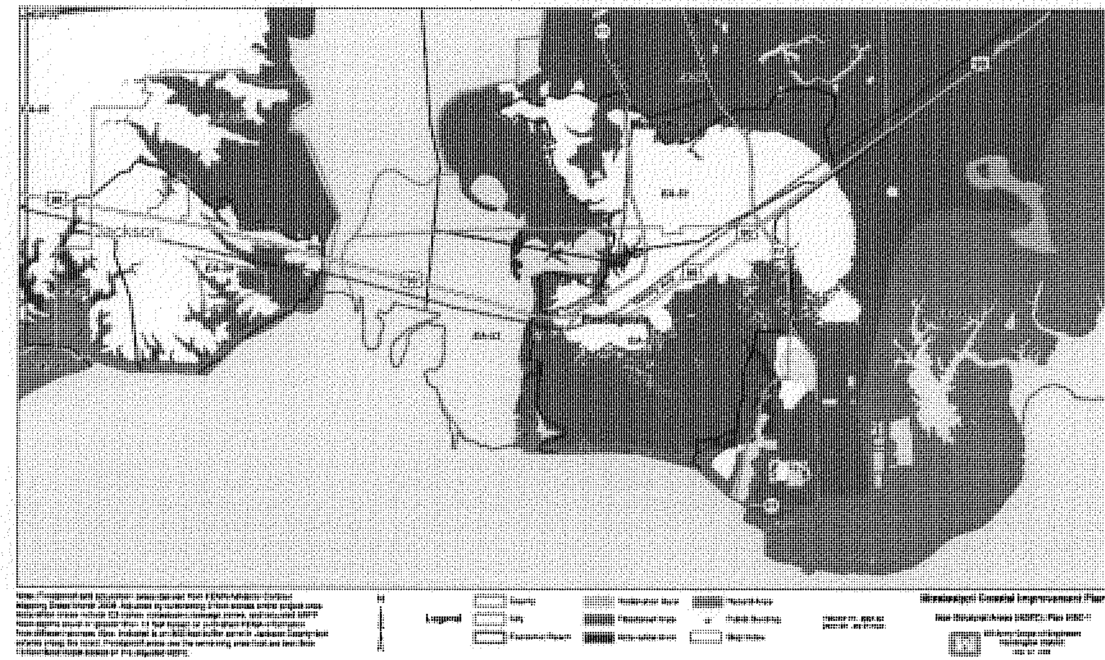


Figure 70 – Plan NSC-1 Permanent Acquisitions and Floodproofing (A5)



6.7.2.2. Plan NSC-2 – Dry and Wet Floodproofing Plan w/FWEE Upgrades

This plan is comprised of two primary measures: 1) dry and wet floodproofing of structures located outside of the high-hazard zones and in locations where water depths would not exceed 13 feet at the ABFE-2 feet flood event, and 2) upgrades to the flood warning and emergency evacuation system. As shown in the pair-wise comparison (Table 13 on page 124), these two measures need to be implemented in concert so that the occupants of elevated or otherwise floodproofed structures would have credible warnings of approaching storms provided in adequate time to prevent their being trapped inside the protected structure. Due to the H&H uncertainties surrounding the determinations of the final elevation of raised first floors and the many risks associated with "riding-out" a hurricane in an elevated structure, all occupants of floodproofed structures would be strongly encouraged (in some areas this could be a mandatory evacuation by local officials) to vacate their homes during hurricane events.

The two methods of floodproofing (dry and wet) would be applied to various structure types and uses including veneer walls, ringwalls and ring-levees (dry floodproofing) for larger commercial or institutional structures or complexes (industry, educational, medical/health facilities, military) and elevation of habitable or sales floors of residential, commercial or institutional structures (wet floodproofing) to protect the structure and its contents. Due to the ADA requirements of most public structures and the confined urban lots on which many of them are located, elevation of institutional structures has limited application. In any case, floodproofing would not be used as a method of protecting occupants of these structures, therefore emergency evacuation of people from floodproofed structures would be the norm.

The flood warning and emergency evacuation (FWEE) system upgrades would include installation of additional reporting buoys in the Gulf (coordinated with NOAA), modifications to existing warning times for category 4 and 5 hurricanes (to assure adequate evacuation time), installation of hurricane evacuation route signs throughout the project area (coordinated with MDOT), installation of messaging boards on primary north/south evacuation routes, installation of warning sirens and dissemination of weather hazard radios, various (but currently undefined) improvements to evacuation routes and intersections (signalization and lanes), and an ongoing public education and emergency evacuation training program. These upgrades to the existing FWEE system would increase public awareness (residents and tourists) of the risks posed by tropical storms and hurricanes, increase the credibility of advanced storm warnings, increase the safety and efficiency of large-scale evacuations in the face of large hurricanes and provide ongoing training and assistance to emergency response teams. In addition, this program would provide technical assistance and appropriate financial assistance to those facilities (casinos, industries, utilities) that are dependent upon their geographic location at the water's edge so that future damages can be reduced and both visitors and employees can be safely evacuated.

The total cost of Plan NSC-2 is estimated to be $10.8B. Of that total, the majority of the funds would be used to floodproof (dry and wet methods) 25,419 structures. Approximately $2.9M would be used for the FWEE upgrades for approximately 95,000 at-risk parcels within the project area. Table 21 shows the numbers of units affected by each component and the estimated costs by reach. Figures 71 through 75 show the extent of the floodproofing areas under this plan.

Table 21
Plan NSC-3 Wet and Dry Floodproofing with FWEE Upgrades

Economic Reaches	Floodproofing	Cost*	Flood Warning and Emergency Evacuations	Cost
1	394	$124,162,500	2062	$62,540
2	3294	$1,910,805,000	19363	$587,280
3	376	$333,327,500	2673	$81,072
4	16	$30,715,000	901	$27,327
5	119	$79,272,500	3109	$94,296
6	590	$311,335,000	1123	$34,061
7	232	$186,928,125	1574	$47,739
8	1730	$691,816,250	8716	$264,356
9	16	$16,552,500	52	$1,577
10	62	$24,201,250	1727	$52,380
11	8	$2,105,000	44	$1,335
12	1136	$438,818,125	2777	$84,226
13	0	0	500	$15,165
14	0	0	788	$23,900
15	9	$28,406,250	76	$2,305
16	121	$38,542,500	209	$6,339
17	0	0	6	$182
18	5	$1,396,250	1223	$3,7094
19	0	0	22	$667
20	2050	$853,008,125	3064	$92,931
21	419	$174,587,500	1867	$56,626
22	92	$44,933,750	157	$4,762
23	44	$24,735,000	65	$1,971
24	178	$58,153,750	524	$15,893
25	0	0	327	$9,918
26	952	$321,001,875	1279	$38,792
27	1029	$264,738,125	2145	$65,058
28	122	$59,837,500	1718	$52,107
29	168	$63,560,625	546	$16,560
30	467	$197,030,000	626	$18,987
31	447	$209,015,000	708	$21,474
32	208	$64,368,750	398	$12,071
33	0	0	77	$2,335
34	0	0	600	$18,198
35	1406	$431,113,125	1599	$48,498
36	2	$6,312,500	62	$1,880
37	0	0	540	$16,378
38	78	$19,440,625	1	$11,040
39	6	$1,204,375	364	$758
40	0	0	7824	$237,302
41	0	0	536	$16,257
42	0	0	667	$20,230

Economic Reaches	Floodproofing	Cost*	Flood Warning and Emergency Evacuations	Cost
43	1	$206,250	25	$61
44	0	0	2587	$78,464
45	0	0	2267	$68,758
46	0	0	3331	$101,029
47	0	0	1303	$39,520
48	2	$445,000	1	$61
49	0	0	338	$10,252
50	848	$263,763,750	1594	$48,346
51	786	$299,966,875	1089	$33,029
52	6838	$2,300,775,000	7628	$231,357
53	360	$256,581,875	1557	$38,125
54	808	$396,536,875	1548	$46,951
Totals	**25,419**	**$10,803,744,154**	**95,931**	**$2,899,820**

* Costs by reach include contingencies.

Figure 71 – Plan NSC-2 Dry and Wet Floodproofing w/FWEE Upgrades (A1)

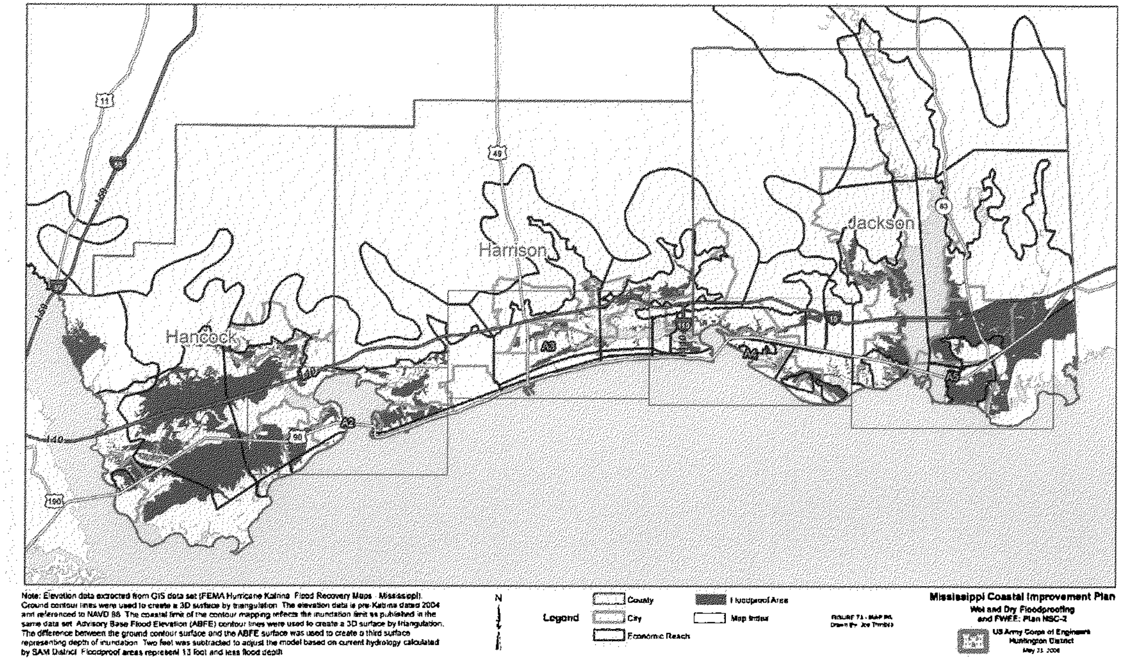


Figure 72 – Plan NSC-2 Dry and Wet Floodproofing w/FWEE Upgrades (A2)

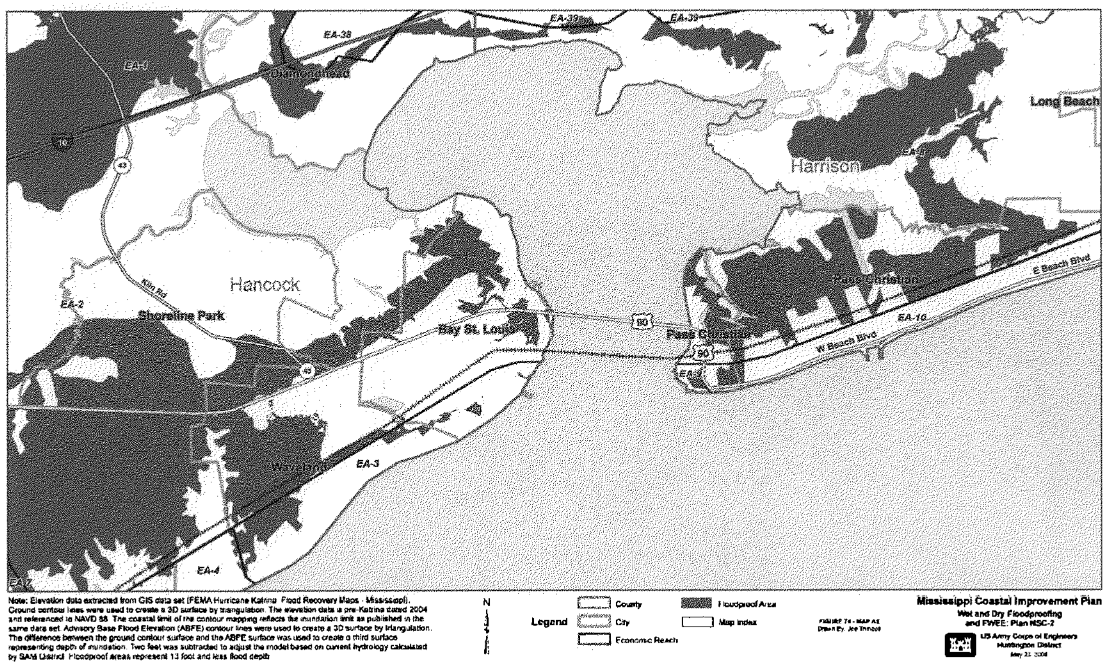


Figure 73 – Plan NSC-2 Dry and Wet Floodproofing w/FWEE Upgrades (A3)

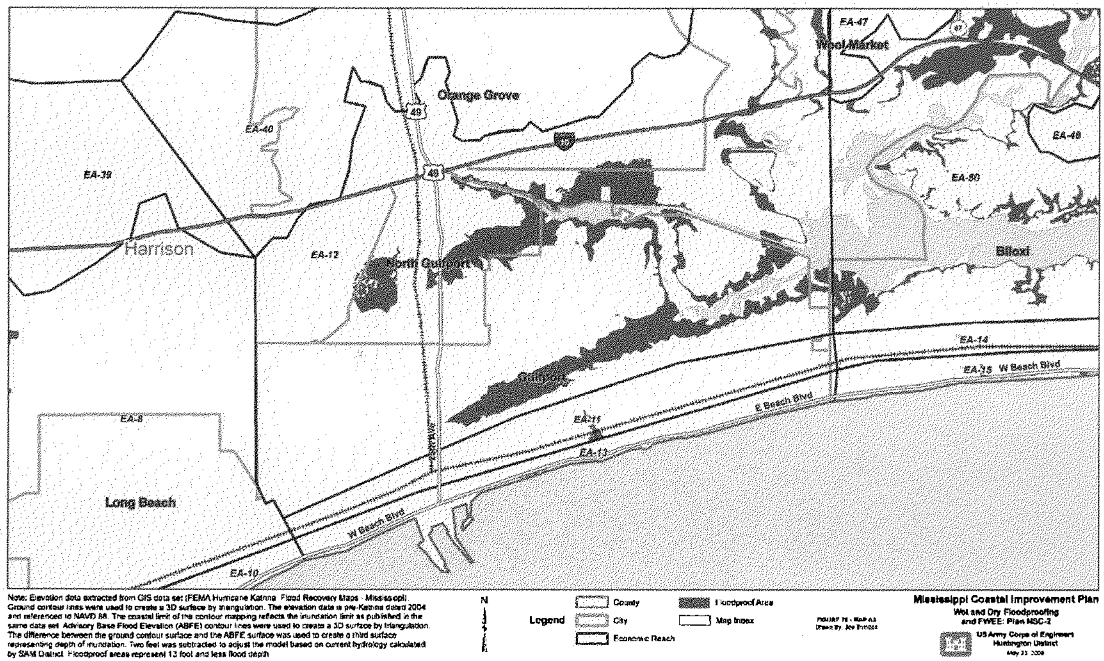


Figure 74 – Plan NSC-2 Dry and Wet Floodproofing w/FWEE Upgrades (A4)

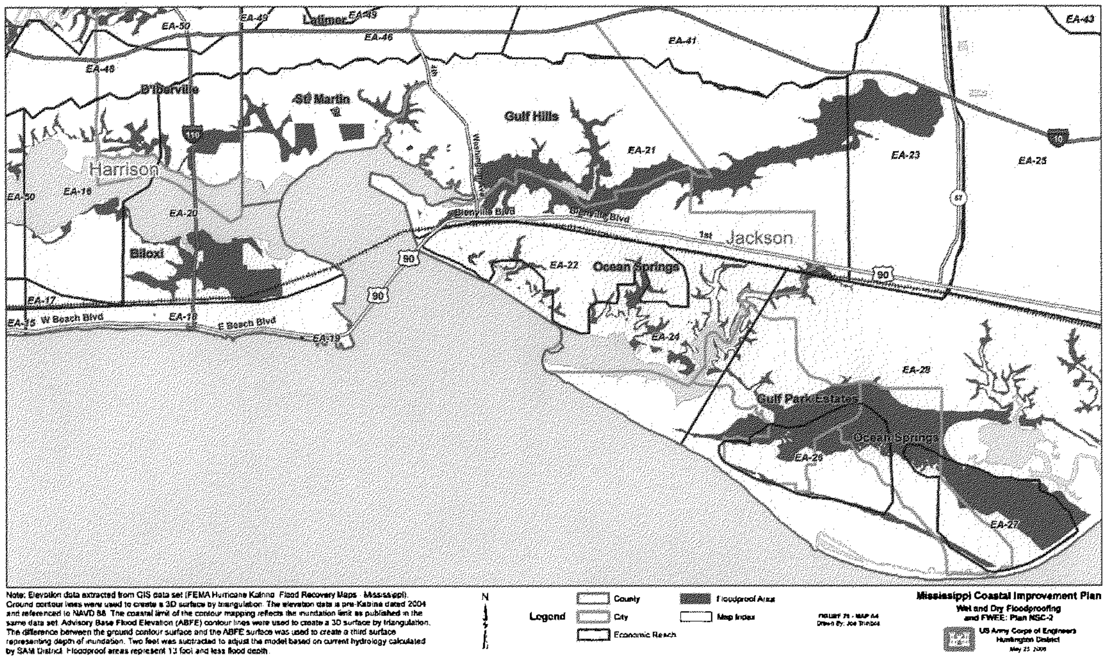
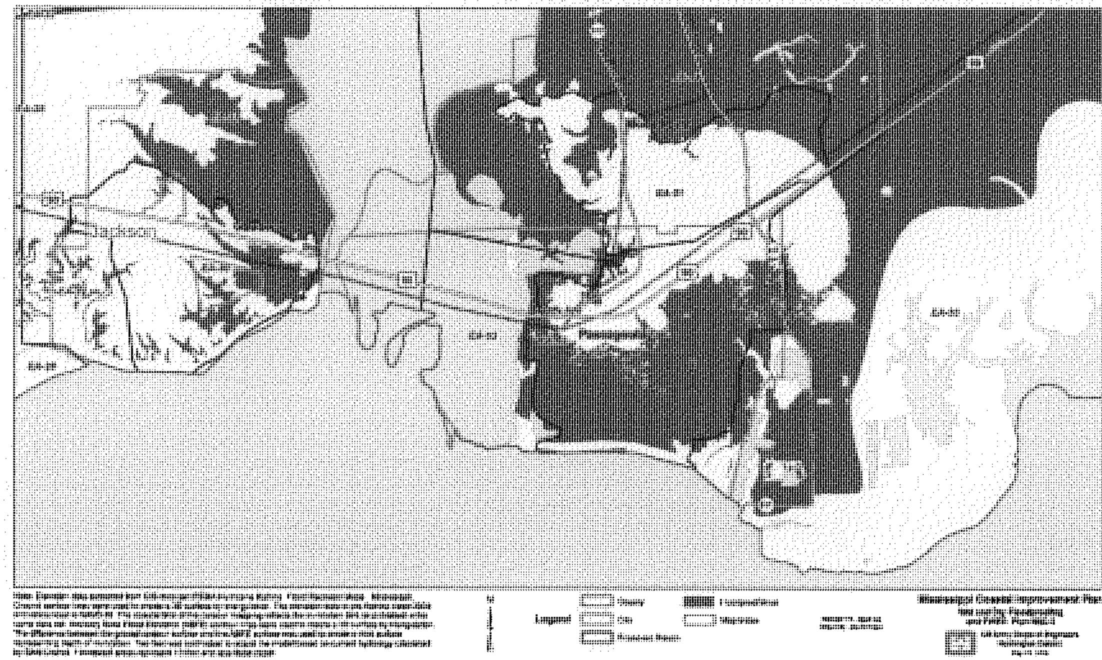


Figure 75 – Plan NSC-2 Dry and Wet Floodproofing w/FWEE Upgrades (A5)



6.7.2.3. Plan NSC-3 – Joint Federal/Non-Federal Jurisdiction Plan

This plan includes an integrated combination of measures that can be accomplished by the Federal government and State and local governments. In effect, this plan is a combination of Plan NSC-1 and Plan NSC-4 integrating all of the components found in both plans. Integration of the measures in each separate plan is complicated by the fact that some of the measures that can effectively reduce flood damages and address losses of life are similar in their effect, but widely different in their application (i.e. Permanent Acquisition and either TDR or PDR) on individual parcels – a combinability issue. Through a collaborative effort, the decisions as where to apply these dissimilar measures would be determined by the USACE, FEMA and State and local agencies and departments. Numbers of structures protected by this plan and the approximate costs are shown in Table 22. Figures 76 through 80 show the application of the various measures described below.

As in Plan NSC-1, this plan would provide protection for structures determined to be eligible for the program as a result of suffering damages from Katrina. The Base Flood Elevation established by the new DFIRM from FEMA would be the minimum level of protection afforded by this plan to be in concert with local floodplain ordinances. Briefly, the plan would consist of permanent acquisitions, floodproofing, replacements of public buildings, flood preparedness and emergency evacuations, floodplain zoning and ordinance enforcement, building codes, land use zoning, development impact fees, redirection of development and either TDR or PDR or both. This suite of nonstructural options applied judiciously across the project area could reduce damages substantially and significantly reduce losses of life due to surge flooding and waves from hurricanes and storms. This plan would require direct expenditures (outside of a normal cost sharing arrangement) of both Federal and non-Federal funds to accomplish the proposed measures – an opportunity for significant in-kind contributions by the non-Federal partner to the overall project cost.

Permanent acquisitions of structures and facilities located in defined high-hazard zones with application of full relocations assistance from the Uniform Relocations Act would reduce the numbers of at-risk structures in these hazardous areas. From a plan formulation standpoint, all acquisitions were considered to be mandatory. During actual project implementation landowners would have the opportunity to participate based upon their personal evaluation of the flood risks and the project benefits that could be made available for relocations to flood-safe properties.

In addition to the structures located in high-hazard zones, other structures located where water depths exceed 13 feet would be acquired as well. Approximately 33,100 parcels (approximately 17,100 structures) would be purchased in this action. Although many of the parcels in the high-hazard zone were found to be vacated immediately after Katrina, it is anticipated (as described in the future without-project condition) that most if not all of the vacated parcels will be rebuilt upon by the time this plan would be implemented. The acquisition costs contain structure and land costs, relocations assistance and structure demolition. The total estimated cost of the permanent acquisition measures (high-hazard zones and areas with water depth greater than 13 feet) is $7.9B.

The acquisition plan could be implemented jointly by the Corps through an authorized project and through FEMA's HMGP program discussed earlier. Since the HMGP funds are administered locally by municipal and county governments in accordance with approved mitigation plans, coordination of those plans with the proposed nonstructural acquisitions in the Corps plan would be paramount in achieving a successful program. In addition, since the HMGP targets primarily insured structures and properties, the Corps' acquisition program could concentrate its resources on uninsured properties in the high-hazard zones. Under any number of possible acquisition scenarios, the high-hazard zones would be cleared of existing structures and facilities (with the exception of certain entertainment, military and industrial uses). Site specific emergency evacuation plans would be prepared for those land uses that could not be removed from high-hazard zones.

In comparison to Plan NCS-1 which relies heavily on direct purchase of properties through the acquisition program, Plan NSC-3 opens the potential for using either TDR or PDR to secure property development rights indefinitely without owning the property. Using these proven techniques, the counties could secure the development rights of those interspersed vacant properties indefinitely while leaving the owner responsible for maintaining the property and paying property taxes (at a somewhat reduced rate). As those programs are funded and administered by state or local governments, costs to the Federal government for reducing flood damages on that interspersed vacant property would be zero while accomplishing the same results indefinitely. A beneficial impact of using the TDR program would be the potential for increasing development densities north of the I-10 corridor where redevelopment communities could be established under the program. The TDR and PDR programs would cost approximately $1.5M to establish and would require annual non-Federal sponsor funding to purchase properties.

In consideration of the number of households that could be displaced as a result of a large acquisition program as described above and the slow redevelopment process in the project area, one or more redevelopment sites would be constructed to accommodate these displaced homeowners and renters. Those redevelopment sites would be selected in close coordination with local planning agencies and community leaders. The redevelopment sites would be planned with standard subdivision amenities and designed and constructed according to local subdivision regulations (where present). Site grading, stormwater drainage, streets, access roads, utilities, platted lots, lighting and signage would be provided for each new subdivision. Relocation funds through the Uniform Relocations Act would provide necessary resources for displaced landowners to construct replacement housing at these flood-safe sites. Total costs of the redevelopment sites are estimated to be $270.0M (based upon a per-lot development cost of $45,000 and 6,000 lots).

As described in Plan NSC-1, voluntary floodproofing in all of its forms would be applied across the project area for eligible structures in this plan. First floor elevation up to 15 feet from the ground surface would be used on residential, commercial and institutional structures as determined to be appropriate for the use and available lot space. Those structures that could not be elevated in-place would be either acquired (see acquisitions above) or offered a rebuilt, floodproofed structure on-site. In any case the most cost effective alternative would be offered to the landowner. For those structures that could not be protected by elevation, other techniques such a dry floodproofing (veneer wall, wall sealants, ringwall, ring-levee, etc.) would be considered. Again, the most cost effective option (floodproofing, acquisition, or rebuilt on-site) would be offered to the landowner. Special needs of the household (handicapped occupants or elderly) can be considered in the access design to the elevated first floor. On-site utilities would be modified to service the raised structure and a 300 square foot enclosed area would be constructed beneath the raised first floor for storage and utility chase. Total estimated costs for elevation of eligible structures (25,419) to the BFE are $10.8B. Table 22 shows the numbers and costs of floodproofing by economic reach.

Public buildings that could not be floodproofed in-place because of their location in a high-hazard zone, depth of flooding or other limitations could be replaced through a relocations contract and reconstructed to current day standards. Approximately 7 public buildings, some of which are considered as critical facilities would be eligible for replacement to a flood safe site. The total estimated cost of those replacements would be approximately $51.2M as shown on Table 22.

Modification and updating of current floodplain zoning and floodplain management ordinances would be implemented by the 11 municipalities and three counties to help reduce flood damages to new construction and rehabilitation of damaged structures. Each of the local jurisdictions would adopt the anticipated new DFIRM's and make necessary modifications within their existing floodplain management ordinances to enforce the new floodplain mapping. In addition, all three counties and 10 municipal areas (Pascagoula exempted) would adopt cumulative, storm-related damages (period of accumulation determined by each locality) as the value (along with improvements value) that triggers compliance with NFIP regulations when compared to 50 percent of the structure value. Also, local jurisdictions would adopt the FEMA 550 guidelines for floodproofing on the Gulf Coast as a part of their floodplain management ordinances so that any new construction in flood-prone areas would be using flood resistant materials and reliable construction techniques. Estimated costs for this measure would be $280,000 in the project area.

Local jurisdictions would adopt the newly revised International Building Code (2006) and provide training for their staff and primary users in the community. Enforcement of the updated codes would help to assure that new construction or any rehabilitation of existing structures would be completed in such a manner as to reduce future flood damages. Adoption of the new codes would take place through appropriate administrative procedures with public involvement and comment. Any training or education seminars concerning use of the new codes would be arranged with the IBC Association at minimal cost since the construction permit process collects fees to offset these costs.

The various municipalities and counties would make modifications to their existing zoning ordinances that would change the types and densities of land uses that could be developed in identified flood-hazard areas. This coastal zoning could take one of two pathways: either very low density development in the higher hazard zones along the coast (just short of a taking) or a mixed use (commercial and high-density residential) that crowds the beachfront with high-rise condominiums and commercial business and entertainment. In addition, counties would revise zoning ordinances to allow higher densities of development (especially residential and commercial) in the flood-free zones. Costs to modify the ordinances as well as the supporting comprehensive plans are estimated to be $500,000 in the project area. To thwart development of new land uses in hazard zones, counties and municipalities would revise their subdivisions regulations such that development in high-hazard zones would be accomplished in such a way to reduce flood damages. Also, development impact fees would be instituted for all new subdivisions with individual lots that are subject to flooding. The costs to initiate this fee structure are estimated to be $370,000 within the project area.

To reduce flood damages and the potential for loss of life, the local jurisdictions would initiate activities identified in flood preparedness, emergency evacuations and public education. Activities such as installation of warning sirens and flashing lights at strategic locations within the communities as well as the purchase and distribution of weather radios to citizens would help to warn at-risk occupants of impending hurricane and storm related flooding. In addition, local jurisdictions would disseminate information brochures on potential hurricane threats and emergency measures to schools, chamber of commerce, hotels and motels and all ports of entry (airports, visitor centers) so that both residents and tourists would be better informed of the threats and evacuation procedures. In cooperation with MDOT the counties could install hurricane evacuation route signage and make minor modifications to intersection signaling that would facilitate the movement of evacuees. In addition, the counties could arrange for the emergency usage of county-owned schools and community centers (located outside of the surge inundation zone) as evacuation centers as well as stockpiling supplies at those centers for emergency use. The estimated cost to implement these improvements to the system is approximately $2.9M.

With all components of the plan combined, the estimated total cost of Plan NSC-3 is $19.1B.

Table 22
NCS-3 – Combined Federal/Non-Federal Jurisdiction Plan

Economic Reaches	Permanent Acquisition Parcels	Cost	Flood proofing	Cost	Relocations	Cost	Flood Warning and Emergency Evacuations	Cost	Floodplain Management	Cost	Land Use Zoning	Cost	TDR & PDR	Cost	Development Impact Fees	Cost
1	997	$194,118,218	394	$124,162,500	0	0	2062	$62,540	2062	$6,042	2062	$10,784	718	$38,715	718	$9,549
2	9911	$2,992,128,131	3294	$1,910,805,000	0	0	19363	$587,280	19363	$56,734	19363	$101,268	6248	$336,892	6248	$83,098
3	2202	$668,691,437	376	$333,327,500	0	0	2673	$81,072	2673	$7,832	2673	$13,980	182	$9,813	182	$2,421
4	922	$120,307,917	16	$30,715,000	0	0	901	$27,327	901	$2,640	901	$4,712	6	$324	6	$80
5	2714	$238,388,794	119	$79,272,500	0	0	3109	$94,296	3109	$9,109	3109	$16,260	346	$18,656	346	$4,602
6	567	$107,292,775	590	$311,335,000	1	$8,536,147	1123	$34,061	1123	$3,290	1123	$5,873	10	$539	10	$133
7	450	$33,303,080	232	$186,928,125	0	0	1574	$47,739	1574	$4,612	1574	$8,232	1012	$54,567	1012	$13,460
8	3623	$476,153,333	1730	$691,816,250	4	$25,608,442	8716	$264,356	8716	$25,538	8716	$45,585	4772	$257,306	4772	$63,468
9	44	$16,145,783	16	$16,552,500	0	0	52	$1,577	52	$152	52	$272	16	$863	16	$213
10	1945	$432,607,234	62	$24,201,250	0	0	1727	$52,380	1727	$5,060	1727	$9,032	32	$1,725	32	$426
11	0	0	8	$2,105,000	0	0	44	$1,335	44	$129	44	$230	36	$1,941	36	$479
12	1047	$179,783,825	1136	$438,818,125	0	0	2777	$84,226	2777	$8,137	2777	$14,524	849	$45,778	849	$11,292
13	650	$583,121,543	0	0	0	0	500	$15,165	500	$1,465	500	$2,615	0	0	0	0
14	0	0	0	0	0	0	788	$23,900	788	$2,309	788	$4,121	221	$11,897	221	$2,935
15	85	$44,354,843	9	$28,406,250	0	0	76	$2,305	76	$223	76	$397	1	$54	1	$13
16	78	$16,399,728	121	$38,542,500	0	0	209	$6,339	209	$612	209	$1,093	35	$1,887	35	$466
17	0	0	0	0	0	0	6	$182	6	$18	6	$31	2	$91	2	$22
18	1502	$409,463,532	5	$1,396,250	0	0	1223	$3,7094	1223	$3,583	1223	$6,396	3	$162	3	$40
19	46	$292,728,063	0	0	0	0	22	$667	22	$64	22	$115	0	0	0	0
20	1397	$238,563,082	2050	$853,008,125	1	$8,536,147	3064	$92,931	3064	$8,978	3064	$16,025	592	$31,921	592	$7,874
21	2108	$301,824,272	419	$174,587,500	0	0	1867	$56,626	1867	$5,470	1867	$9,764	497	$26,798	497	$6,610
22	61	$26,330,663	92	$44,933,750	0	0	157	$4,762	157	$460	157	$821	4	$216	4	$53
23	0	0	44	$24,735,000	0	0	65	$1,971	65	$190	65	$340	42	$2,265	42	$559
24	220	$65,229,821	178	$58,153,750	0	0	524	$15,893	524	$1,535	524	$2,741	119	$6,416	119	$1,583
25	0	0	0	0	0	0	327	$9,918	327	$958	327	$1,710	92	$4,937	92	$1,218
26	37	$9,210,336	952	$321,001,875	0	0	1279	$38,792	1279	$3,747	1279	$6,689	289	$15,583	289	$3,844
27	53	$12,880,944	1029	$264,738,125	0	0	2145	$65,058	2145	$6,285	2145	$11,218	1063	$57,317	1063	$14,138
28	961	$90,294,697	122	$59,837,500	0	0	1718	$52,107	1718	$5,034	1718	$8,985	633	$34,131	633	$8,419
29	147	$23,394,829	168	$63,560,625	0	0	546	$16,560	546	$1,600	546	$2,856	231	$12,456	231	$3,072
30	90	$29,459,003	467	$197,030,000	0	0	626	$18,987	626	$1,834	626	$3,274	64	$3,451	64	$851
31	51	$14,959,829	447	$209,015,000	0	0	708	$21,474	708	$2,074	708	$3,703	307	$16,553	307	$4,083
32	0	0	208	$64,368,750	0	0	398	$12,071	398	$1,166	398	$2,082	269	$14,504	269	$3,578
33	0	0	0	0	0	0	77	$2,335	77	$226	77	$403	22	$1,163	22	$287
34	0	0	0	0	0	0	600	$18,198	600	$1,758	600	$3,138	168	$9,059	168	$2,234
35	12	$682,228	1406	$431,113,125	0	0	1599	$48,498	1599	$4,685	1599	$8,363	758	$40,871	758	$10,081
36	32	$3,834,485	2	$6,312,500	0	0	62	$1,880	62	$182	62	$324	51	$2,750	51	$678
37	0	0	0	0	0	0	540	$16,378	540	$1,582	540	$2,824	151	$8,153	151	$2,011
38	50	$21,424,866	78	$19,440,625	0	0	364	$11,040	364	$1,067	364	$1,904	259	$13,965	259	$3,445
39	0	0	6	$1,204,375	0	0	25	$758	25	$73	25	$131	19	$1,024	19	$253
40	0	0	0	0	0	0	7824	$237,302	7824	$22,924	7824	$40,920	2191	$118,124	2191	$29,137
41	0	0	0	0	0	0	536	$16,257	536	$1,570	536	$2,803	150	$8,092	150	$1,996
42	0	0	0	0	0	0	667	$20,230	667	$1,954	667	$3,488	187	$10,070	187	$2,484
43	0	0	1	$206,250	0	0	25	$61	25	$6	25	$10	1	$54	1	$13
44	0	0	0	0	0	0	2587	$78,464	2587	$7,580	2587	$13,350	724	$39,057	724	$9,634
45	0	0	0	0	0	0	2267	$68,758	2267	$6,642	2267	$11,856	635	$34,226	635	$8,442

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Economic Reaches	Permanent Acquisition Parcels	Cost	Flood proofing	Cost	Relocations	Cost	Flood Warning and Emergency Evacuations	Cost	Floodplain Management	Cost	Land Use Zoning	Cost	TDR & PDR	Cost	Development Impact Fees	Cost
46	0	0	0	0	0	0	3331	$101,029	3331	$9,760	3331	$17,421	933	$50,290	933	$12,405
47	0	0	0	0	0	0	1303	$39,520	1303	$3,818	1303	$6,815	365	$19,672	365	$4,852
48	0	0	2	$445,000	0	0	1	$61	1	$6	1	$10	0	0	0	0
49	0	0	0	0	0	0	338	$10,252	338	$990	338	$1,768	95	$5,103	95	$1,259
50	495	$89,312,661	848	$263,763,750	0	0	1594	$48,346	1594	$4,670	1594	$8,337	410	$22,107	410	$5,453
51	0	0	786	$299,966,875	0	0	1089	$33,029	1089	$3,191	1089	$5,695	302	$16,284	302	$4,017
52	285	$103,016,211	6838	$2,300,775,000	1	$8,536,147	7628	$231,357	7628	$22,350	7628	$39,894	485	$26,151	485	$6,451
53	399	$113,054,873	360	$256,581,875	0	0	1557	$38,125	1557	$3,683	1557	$6,574	499	$26,906	499	$6,637
54	9	$1,114,862	808	$396,536,875	0	0	1548	$46,951	1548	$4,536	1548	$8,096	726	$39,146	726	$9,656
Subtotals	**33,191***	**$7,928,411,301**	**25,419**	**$10,803,744,154**	**7**	**$51,216,883**	**95,931**	**$2,899,820**	**95,931**	**$280,133**	**95,931**	**$499,852**	**27,822**	**$1,500,025**	**27,822**	**$370,004**
H&CD Sites		Jackson, Harrison and Hancock Counties				6,000 lots in 3 counties at $45,000 per lot								Total Cost for H&CD sites - **$270,000,000**		
Safe harborages		Jackson, Harrison and Hancock Counties				3 safe harborages – $7.7M each								Total Cost of Safe Harborages - **$23,100,000**		
Total Plan Cost														**$19,082,022,338**		

Notes: 1) The numbers of tracts listed under the TDR/PDR and Development Impact Fees measures are estimated vacated tracts within each reach to which the measures would be applied.

2) Building Codes as a measure were omitted from the table due to space limitations in the table. There are no project costs for upgrading and enforcing building codes since the building construction permitting fee system reimburses the administrative costs for this local measure. The parcels affected by the building codes and the $0 cost is shown in Table 23 for Plan NSC-4.

* The total number of parcels eligible for purchase contain approximately 17,100 structures (residential and commercial)

Figure 76 – Plan NSC-3 Joint Federal/Non-Federal Jurisdiction Plan (A1)

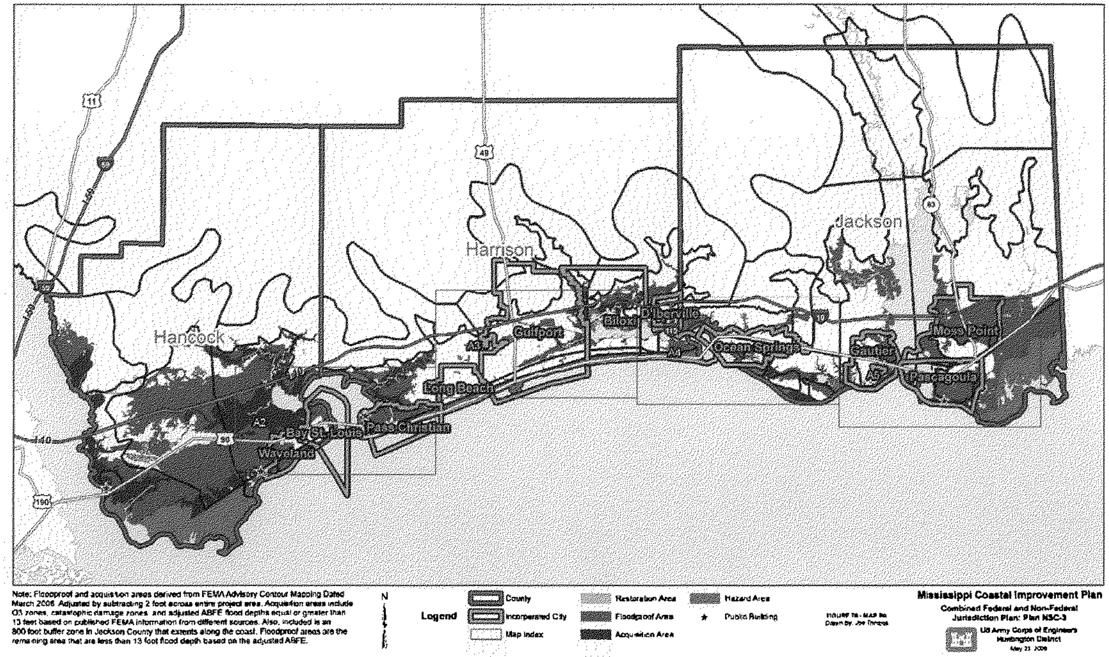


Figure 77 – Plan NSC-3 Joint Federal/Non-Federal Jurisdiction Plan (A2)

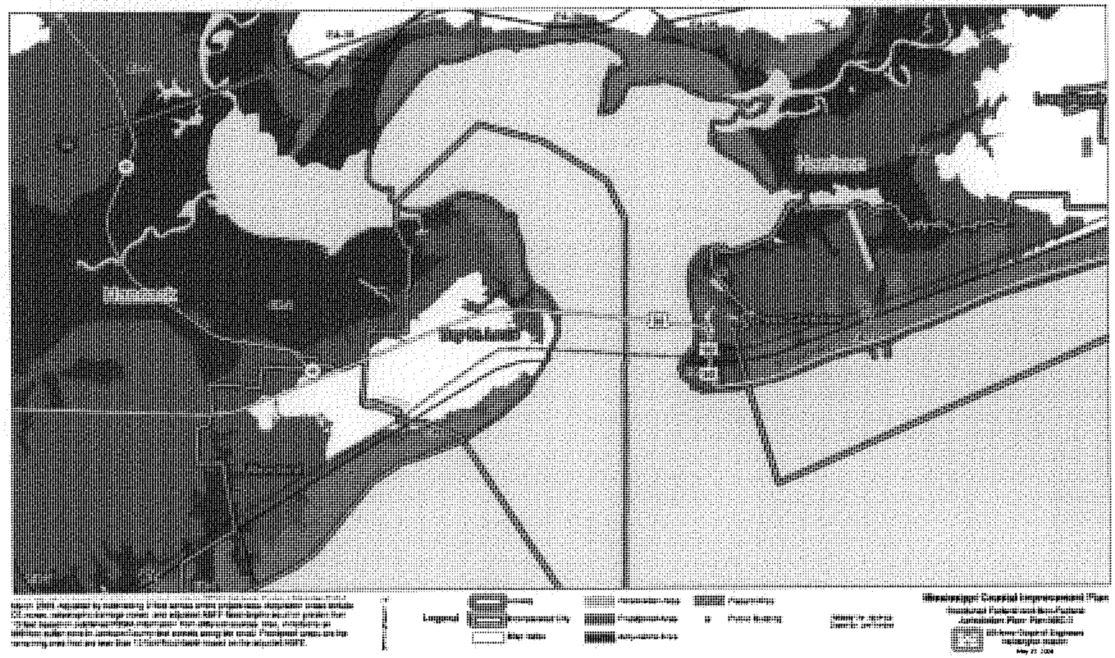


Figure 78 – Plan NSC-3 Joint Federal/Non-Federal Jurisdiction Plan (A3)

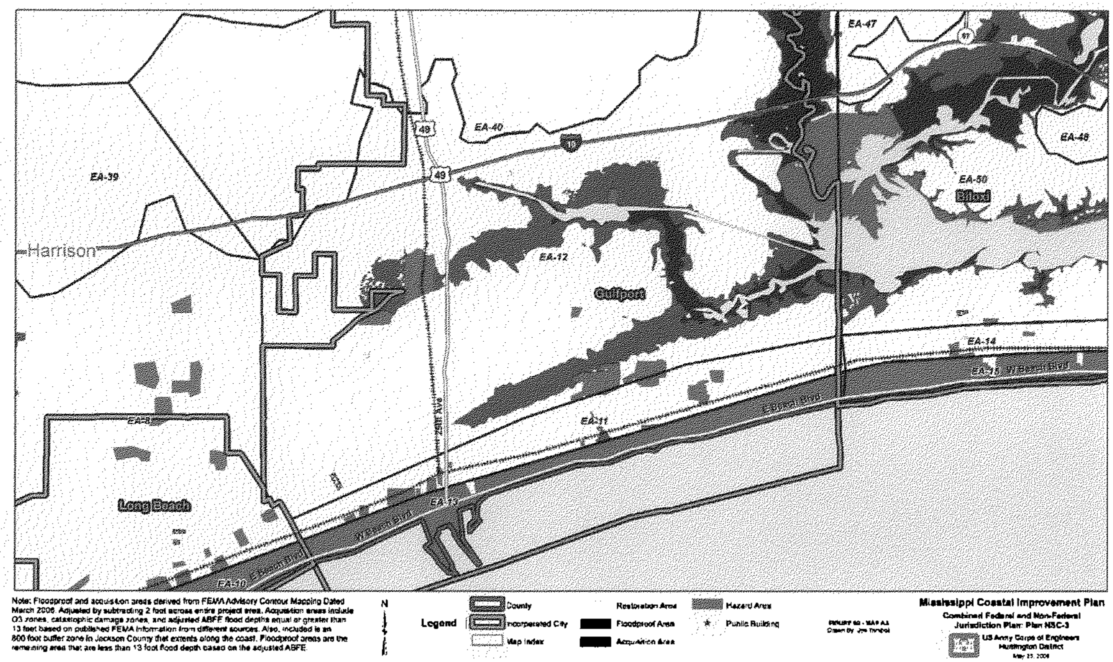


Figure 79 – Plan NSC-3 Joint Federal/Non-Federal Jurisdiction Plan (A4)

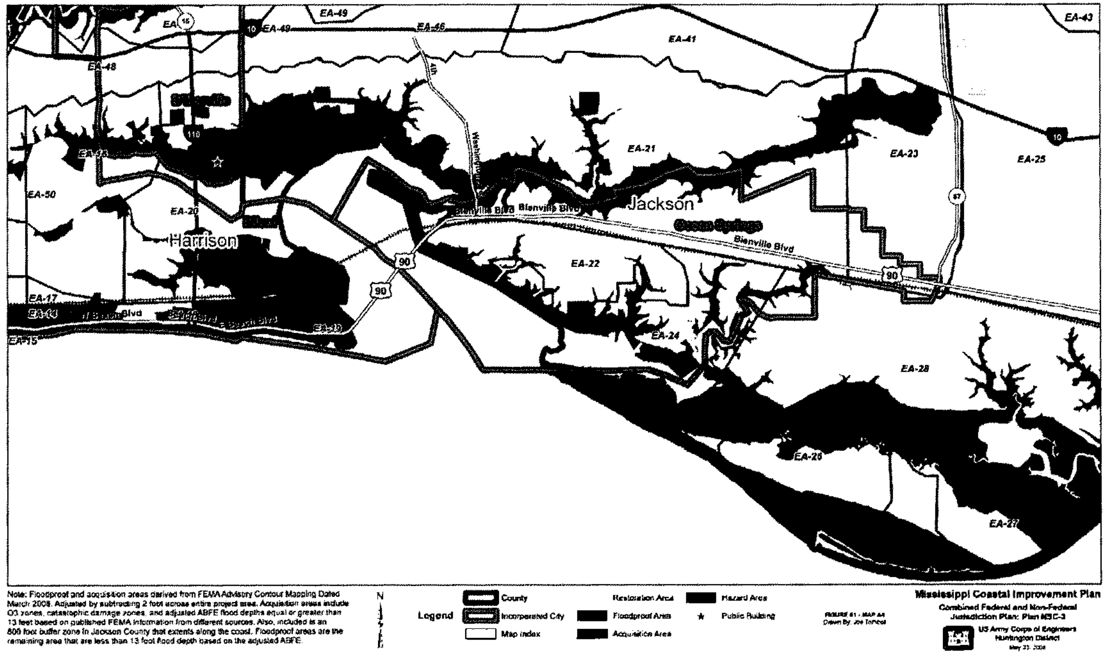
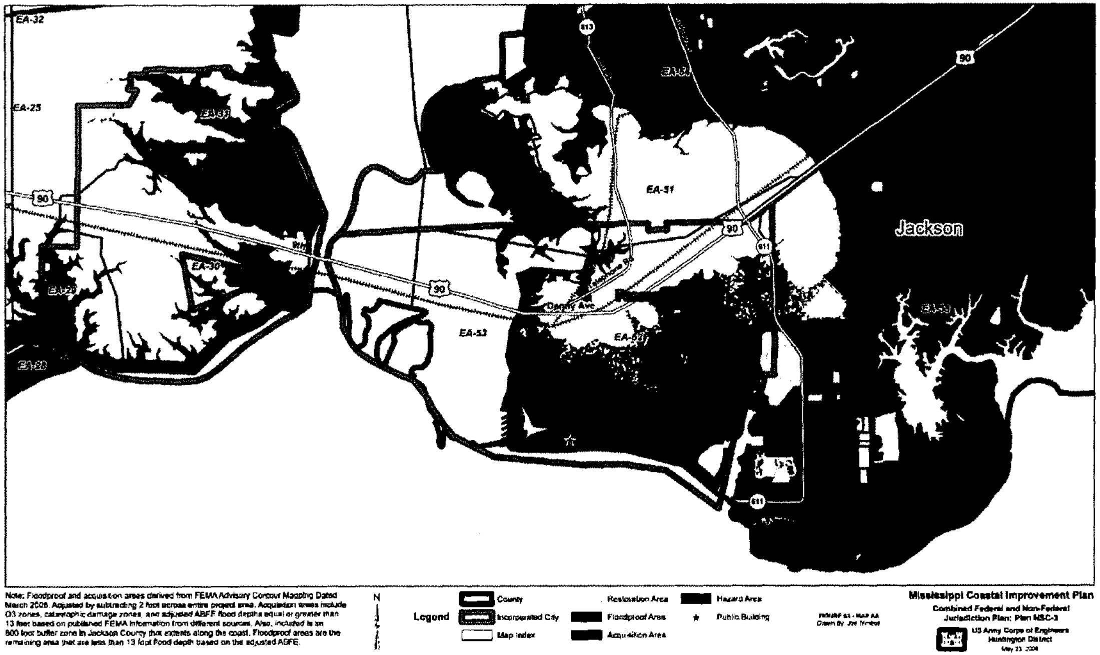


Figure 80 – Plan NSC-3 Joint Federal/Non-Federal Jurisdiction Plan (A5)



In an effort to redirect new development away from high-hazard flooding areas, the local jurisdictions (especially the three counties) would establish either a Transfer of Development Rights or Purchase of Development Rights program within each of the three counties in the project area. Prior to establishing one or more of these programs, the local jurisdictions would have to petition the state legislature through their local representatives to enact enabling legislation that would authorize the three affected counties (and other jurisdictions as may be applicable) within the project area to create the necessary organizations (non-profit) that would administer the TDR and/or PDR programs. Once the enabling legislation is in place, the counties could establish non-profit organizations that would administer the programs and provide start-up funding for administration costs.

Then, in cooperation with the Corps of Engineers, the non-profit organizations would determine the boundaries of the sending (high-hazard zone) and receiving (flood-safe areas) districts for the TDR program or determine only the high-hazard zone from which development rights would be purchased under a PDR program. With property valuation information from the tax assessor's office, the non-profit organization would calculate monetary amounts for the development rights on each property in the sending area. In addition to these programmatic activities, the local jurisdictions would implement a project-wide advertisement and education program informing people of the flood-damage reduction benefits of the TDR/PDR programs and to encourage participation in this voluntary program. In the absence of a Federally-funded permanent acquisition program for the high-hazard zones, the non-profit organization would be unencumbered in their program to either transfer or purchase development rights in those delineated zones. The estimated administrative costs to initiate the TDR and PDR programs are $1.5M ($500,000 for each planning unit). Total acquisition costs for a PDR program may approximate between 60 and 80 percent of the total Federal purchase costs since only the development rights portion of the total land rights package would be acquired. Landowners would retain the land value and continue to operate and maintain the property while assuming a much reduced property tax burden.

6.7.2.4 Plan NSC-4 – Non-Federal Jurisdiction Plan

This plan consists of measures that can be enacted by the local municipalities and counties to reduce flood damages and loss of life. Over 95,000 individual parcels of land in the project area would be affected by these measures enacted by the municipal and county governments. The approximate numbers of parcels that would be affected by these measures and the estimated costs (local and administrative) to implement the measures are shown in Table 23 by economic reach. Figures 81 through 85 show the areas of county and municipal jurisdiction where these measures would be applied.

Implementation of each of these measures is through the police powers granted to individual municipal and county governments by the state and is generally outside the purview of the Federal or state Government. Their implementation would be contingent in part upon the local perception of the flood risks, the political will of the local government leadership and the willingness to invest local funds in the needed changes. The costs of these measures would be largely borne by local jurisdictions (see below for exceptions) and therefore do not generate Federal project costs per se, but there would be flood damage reduction benefits (albeit difficult to quantify) accruing to the project area. The benefits of these locally implemented measures would be found in the incremental inundation damages that would be suffered in the absence of upgrades to the existing control and enforcements systems recommended in this plan.

Some funding for the proposed measures (i.e. Flood Preparedness and Public Education) may be provided by Federal or state agencies (FEMA, MEMA), but generally the administration of the measures would be through local jurisdictions. Although the NFIP is a Federal program administered through FEMA, enforcement of the floodplain ordinances and zoning mapping is clearly the responsibility of local jurisdictions. The ability of the local governments to enact and administer either a TDR or PDR program would be based upon enabling legislation enacted by the state legislature.

Modification and updating of current floodplain zoning and floodplain management ordinances would be implemented by the 11 municipalities and three counties to help reduce flood damages to new construction and rehabilitation of damaged structures. Each of the local jurisdictions would adopt the anticipated new DFIRM's and make necessary modifications within their existing floodplain management ordinances to enforce the new floodplain mapping. In addition, each county and municipality (Pascagoula exempted) would adopt the concept of cumulative storm-related damages as a trigger for determining when a structure must comply with NFIP regulations. Also, local jurisdictions would adopt the FEMA 550 guidelines for floodproofing on the Gulf Coast as a part of their floodplain management ordinances so that any new construction in flood-prone areas would be using flood resistant materials and reliable construction techniques. The estimated administrative and legal costs to update and modify the local ordinances across the project area are $280,000 for the 11 municipalities and 3 counties.

Local jurisdictions would adopt the newly revised International Building Code (circa 2006) and provide training for their staff and primary users in the community. All of the local jurisdictions are using at least the 2003 IBC standards now. Enforcement of the updated codes would help to assure that new construction or any rehabilitation of existing structures would be completed in such a manner as to reduce future flood damages. Adoption of the new codes would take place through appropriate administrative procedures with public involvement and comment. Costs to modify the codes would be offset by building permit fees charged by the municipalities and counties. Any training or education seminars concerning use of the new codes would be arranged with the IBC Association at minimal cost.

The various municipalities and counties would make modifications to their existing zoning ordinances that would change the types and densities of land uses that could be developed in identified flood-hazard areas. This coastal zoning could take one of two pathways: either very low density development in the higher hazard zones along the coast (just short of a taking) or a mixed use (commercial and high-density residential) that crowds the beachfront with high-rise condominiums and commercial business and entertainment. In addition, counties would revise zoning ordinances to allow higher densities of development (especially residential and commercial) in the flood-free zones. To thwart development of new land uses in hazard zones, counties and municipalities would revise their subdivision regulations such that development in high-hazard zones would be accomplished in such a way to reduce flood damages. Also, development impact fees would be instituted for all new subdivisions with individual lots that are subject to flooding at an approximate local cost of $370,000. The estimated cost for modifying the zoning ordinances across the project area is $500,000 and is largely composed of local administrative and legal costs.

To reduce flood damages and the potential for loss of life, the local jurisdictions would initiate activities identified in flood preparedness, emergency evacuations and public education. Activities such as installation of warning sirens and flashing lights at strategic locations within the communities as well as the purchase and distribution of weather radios to citizens would help to warn at-risk occupants of impending hurricane and storm related flooding. In addition, local jurisdictions would disseminate information brochures on potential hurricane threats and emergency measures to schools, chamber of commerce, hotels and motels and all ports of entry (airports, visitor centers) so that both residents and tourists would be better informed of the threats and evacuation procedures. In cooperation with MDOT the counties could install hurricane evacuation route signage and make minor modifications to intersection signaling that would facilitate the movement of evacuees. In addition, the counties could arrange for the emergency usage of county owned schools and community centers as evacuation centers as well as stockpiling supplies at those centers for emergency use. The estimated cost to implement the upgrades to this system is $2.9M.

In an effort to redirect new development away from high-hazard flooding areas, the local jurisdictions (especially the three counties) would establish either a Transfer of Development Rights or Purchase of Development Rights program within each of the three counties in the project area. Prior to establishing one or more of these programs, the local jurisdictions would have to petition the state legislature through their local representatives to enact enabling legislation that would authorize the three affected counties (and other jurisdictions as may be applicable) within the project area to create the necessary organizations (non-profit) that would administer the TDR and/or PDR programs. Once the enabling legislation is in place, the counties would establish non-profit organizations that would administer the programs and provide start-up funding for administration costs. Then, in cooperation with the Corps of Engineers, the non-profit organizations would determine the boundaries of the sending (high-hazard flood-prone) and receiving (flood-safe) districts for the TDR program or determine only the high-hazard areas from which development rights would be purchased under a PDR program. With property valuation information from the tax assessor's office, the non-profit organization would calculate monetary amounts for the development rights on each property in the sending area.

In addition to these programmatic activities, the local jurisdictions would implement a project wide advertisement and education program informing people of the flood-damage reduction benefits of the TDR/PDR programs and to encourage participation in this voluntary program. In the absence of a Federally-funded permanent acquisition program for the high-hazard zones, the non-profit organization would be unencumbered in their program to either transfer or purchase development rights in those delineated zones. The estimated administrative cost to initiate the TDR and PDR programs is $1.5M for the three counties. Annual costs of acquiring development rights under the PDR program would be funded through non-Federal sources (state and local).

Table 23
Plan NSC-4 – Non-Federal Jurisdiction Plan

Economic Reaches	Land Use Zoning	Cost	Floodplain Management	Cost	TDR & PDR	Cost	Flood Warning and Emergency Evacuation	Cost	Building Codes	Cost	Development Impact Fees	Cost
1	2062	$10,784	2062	$6,042	718	$38,715	2062	$62,540	2062	$0	718	$9,549
2	19363	$101,268	19363	$56,734	6248	$336,892	19363	$587,280	19363	$0	6248	$83,098
3	2673	$13,980	2673	$7,832	182	$9,813	2673	$81,072	2673	$0	182	$2,421
4	901	$4,712	901	$2,640	6	$324	901	$27,327	901	$0	6	$80
5	3109	$16,260	3109	$9,109	346	$18,656	3109	$94,296	3109	$0	346	$4,602
6	1123	$5,873	1123	$3,290	10	$539	1123	$34,061	1123	$0	10	$133
7	1574	$8,232	1574	$4,612	1012	$54,567	1574	$47,739	1574	$0	1012	$13,460
8	8716	$45,585	8716	$25,538	4772	$257,306	8716	$264,356	8716	$0	4772	$63,468
9	52	$272	52	$152	16	$863	52	$1,577	52	$0	16	$213
10	1727	$9,032	1727	$5,060	32	$1,725	1727	$52,380	1727	$0	32	$426
11	44	$230	44	$129	36	$1,941	44	$1,335	44	$0	36	$479
12	2777	$14,524	2777	$8,137	849	$45,778	2777	$84,226	2777	$0	849	$11,292
13	500	$2,615	500	$1,465	0	0	500	$15,165	500	$0	0	0
14	788	$4,121	788	$2,309	221	$11,897	788	$23,900	788	$0	221	$2,935
15	76	$397	76	$223	1	$54	76	$2,305	76	$0	1	$13
16	209	$1,093	209	$612	35	$1,887	209	$6,339	209	$0	35	$466
17	6	$31	6	$18	2	$91	6	$182	6	$0	2	$22
18	1223	$6,396	1223	$3,583	3	$162	1223	$3,7094	1223	$0	3	$40
19	22	$115	22	$64	0	0	22	$667	22	$0	0	0
20	3064	$16,025	3064	$8,978	592	$31,921	3064	$92,931	3064	$0	592	$7,874
21	1867	$9,764	1867	$5,470	497	$26,798	1867	$56,626	1867	$0	497	$6,610
22	157	$821	157	$460	4	$216	157	$4,762	157	$0	4	$53
23	65	$340	65	$190	42	$2,265	65	$1,971	65	$0	42	$559
24	524	$2,741	524	$1,535	119	$6,416	524	$15,893	524	$0	119	$1,583
25	327	$1,710	327	$958	92	$4,937	327	$9,918	327	$0	92	$1,218
26	1279	$6,689	1279	$3,747	289	$15,583	1279	$38,792	1279	$0	289	$3,844
27	2145	$11,218	2145	$6,285	1063	$57,317	2145	$65,058	2145	$0	1063	$14,138
28	1718	$8,985	1718	$5,034	633	$34,131	1718	$52,107	1718	$0	633	$8,419
29	546	$2,856	546	$1,600	231	$12,456	546	$16,560	546	$0	231	$3,072
30	626	$3,274	626	$1,834	64	$3,451	626	$18,987	626	$0	64	$851
31	708	$3,703	708	$2,074	307	$16,553	708	$21,474	708	$0	307	$4,083
32	398	$2,082	398	$1,166	269	$14,504	398	$12,071	398	$0	269	$3,578
33	77	$403	77	$226	22	$1,163	77	$2,335	77	$0	22	$287
34	600	$3,138	600	$1,758	168	$9,059	600	$18,198	600	$0	168	$2,234
35	1599	$8,363	1599	$4,685	758	$40,871	1599	$48,498	1599	$0	758	$10,081
36	62	$324	62	$182	51	$2,750	62	$1,880	62	$0	51	$678
37	540	$2,824	540	$1,582	151	$8,153	540	$16,378	540	$0	151	$2,011
38	364	$1,904	364	$1,067	259	$13,965	364	$11,040	364	$0	259	$3,445
39	25	$131	25	$73	19	$1,024	25	$758	25	$0	19	$253
40	7824	$40,920	7824	$22,924	2191	$118,124	7824	$237,302	7824	$0	2191	$29,137

Economic Reaches	Land Use Zoning	Cost	Floodplain Management	Cost	TDR & PDR	Cost	Flood Warning and Emergency Evacuation	Cost	Building Codes	Cost	Development Impact Fees	Cost
41	536	$2,803	536	$1,570	150	$8,092	536	$16,257	536	$0	150	$1,996
42	667	$3,488	667	$1,954	187	$10,070	667	$20,230	667	$0	187	$2,484
43	25	$10	25	$6	1	$54	25	$61	25	$0	1	$13
44	2587	$13,350	2587	$7,580	724	$39,057	2587	$78,464	2587	$0	724	$9,634
45	2267	$11,856	2267	$6,642	635	$34,226	2267	$68,758	2267	$0	635	$8,442
46	3331	$17,421	3331	$9,760	933	$50,290	3331	$101,029	3331	$0	933	$12,405
47	1303	$6,815	1303	$3,818	365	$19,672	1303	$39,520	1303	$0	365	$4,852
48	1	$10	1	$6	0	0	1	$61	1	$0	0	0
49	338	$1,768	338	$990	95	$5,103	338	$10,252	338	$0	95	$1,259
50	1594	$8,337	1594	$4,670	410	$22,107	1594	$48,346	1594	$0	410	$5,453
51	1089	$5,695	1089	$3,191	302	$16,284	1089	$33,029	1089	$0	302	$4,017
52	7628	$39,894	7628	$22,350	485	$26,151	7628	$231,357	7628	$0	485	$6,451
53	1557	$6,574	1557	$3,683	499	$26,906	1557	$38,125	1557	$0	499	$6,637
54	1548	$8,096	1548	$4,536	726	$39,146	1548	$46,951	1548	$0	726	$9,656
Subtotals	**95931**	**$499,852**	**95931**	**$280,133**	**27822**	**$1,500,025**	**95931**	**$2,899,820**	**95931**	**$0**	**27822**	**$370,004**
Total cost	**Total Nonstructural Parcels in Plan – 95,931**											**$5,550,000**

Note: Building codes are self sufficient through assessed fees for construction permits, therefore the cost to implement and maintain them is $0.00

Figure 81 – Plan NSC-4 Non-Federal Jurisdiction Plan (A1)

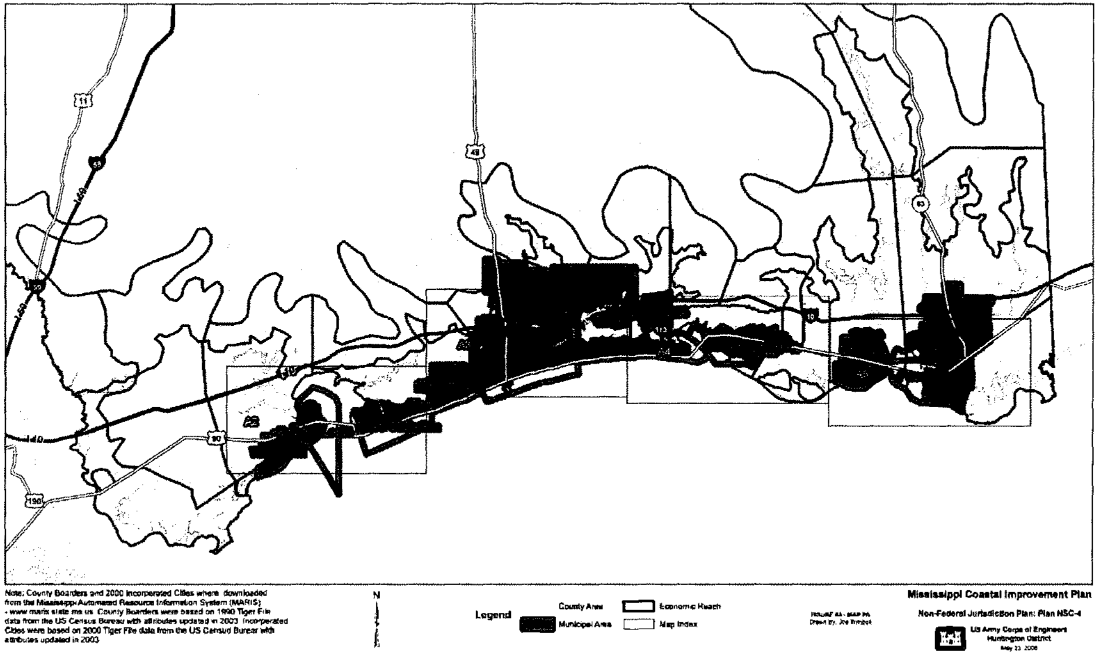


Figure 82 – Plan NSC-4 Non-Federal Jurisdiction Plan (A2)

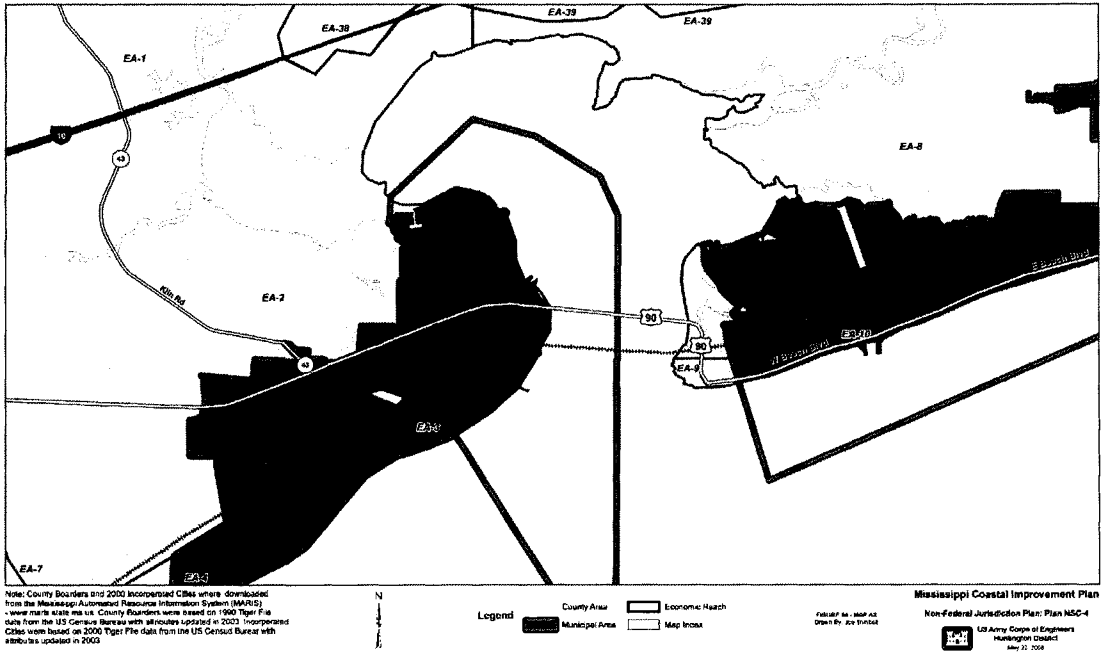


Figure 83 – Plan NSC-4 Non-Federal Jurisdiction Plan (A3)

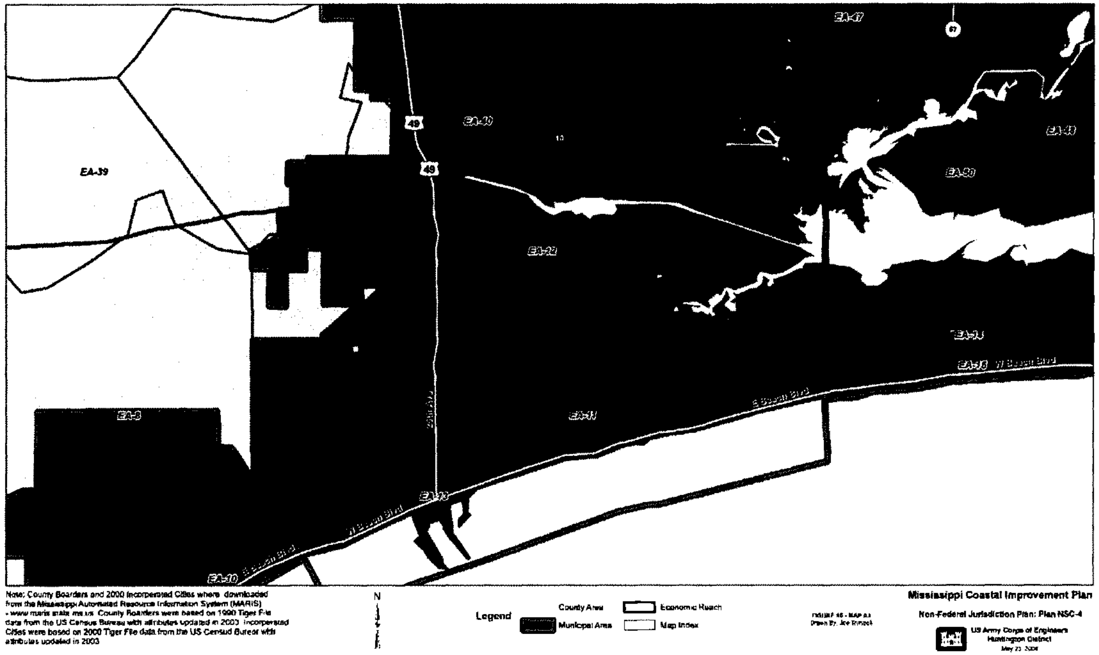


Figure 84 – Plan NSC-4 Non-Federal Jurisdiction Plan (A4)

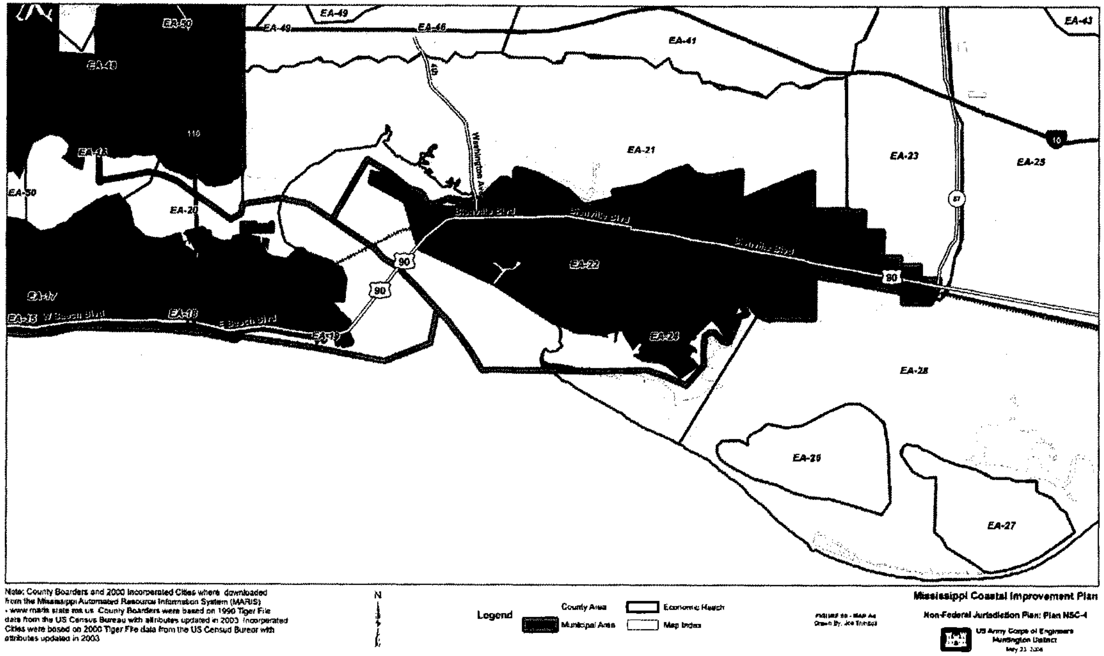
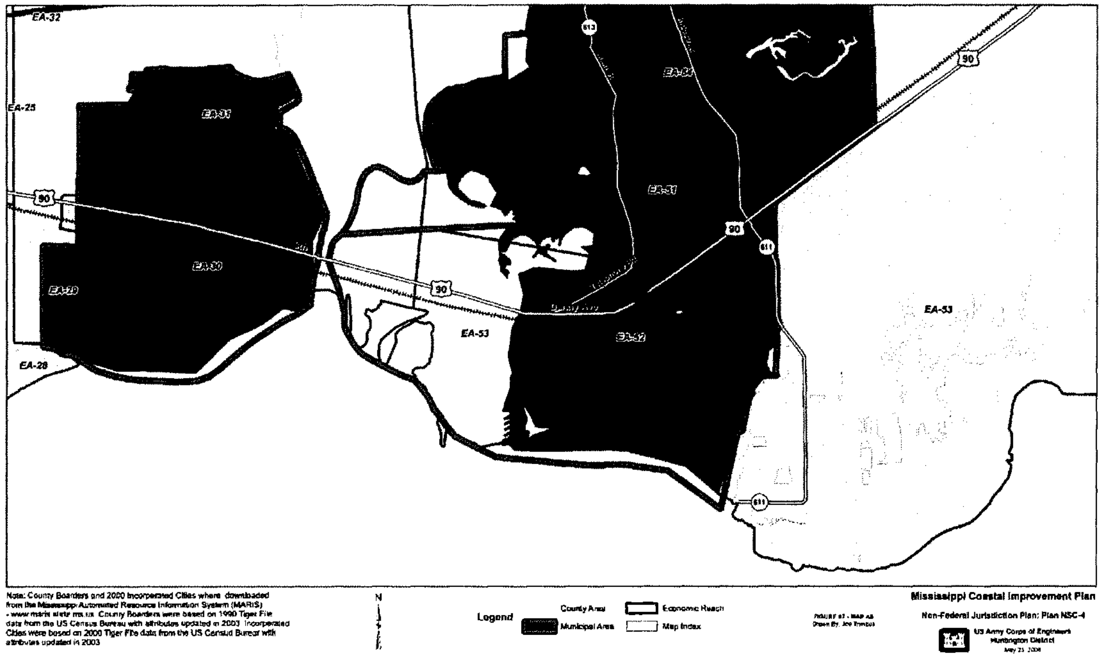


Figure 85 – Plan NSC-4 Non-Federal Jurisdiction Plan (A5)



6.7.2.5 Plan NSC-5 – Loss of Life Reduction Plan

This plan is a mixture of Federal and local measures that specifically address project objectives for reducing losses of life in high and moderate-hazard zones. The approximate number of structures that would be affected by these measures and the estimated costs are shown in Table 24. Figures 88 through 92 show the application of these measures. The Plan relies on three primary measures: 1) Permanent acquisition of parcels, structures and facilities in the high-hazard zones, 2) Flood Preparedness and Emergency Evacuation and 3) Replacement of Public Buildings.

Floodproofing is not included as a measure in this plan since its primary purpose is protection of structures and their contents in-place. A floodproofed structure is not considered to be a reliable shelter for its occupants during a hurricane. Too many uncertainties exist in determining the elevation of the first floor, supporting foundation design and construction to condone using elevated structures as human shelters that may be surrounded by surge inundation and buffeted by hurricane force winds.

Real property and structures and facilities (with some exceptions previously noted) in the high hazard zone identified in the permanent acquisition measure (the HHZ composed of the V-zone, catastrophic damages zone and the 800 foot buffer zone) would be acquired through the Corps' authorized program. That total number of acquisitions is estimated to be 14,997 parcels within the high hazard zone. Current estimates are that approximately 7,500 structures remain in this area and would be purchased during this process. Relocation benefits under the Uniform Relocations Act would be offered to assure that relocatees would have sufficient financial resources to acquire DSS replacement housing. As in other plans featuring permanent acquisitions in the high-hazard zone this plan assumes that the parcels made vacant by Katrina would be redeveloped by the time this plan would be authorized and funded as was described in the future without-project condition. The costs for permanent acquisition include structure and land purchase, relocations assistance and structure demolition.

In addition to the cost of the real estate acquisition, relocations assistance and structure demolition associated with this alternative, the large number of displaced households would probably trigger the need for replacement DSS housing over and above what normal market resources could provide. Based upon current housing construction capacity in the project area, as much as 40 percent of the need may be unmet by the market area. In view of this anticipated shortage of suitable DSS housing, the plan would include several redevelopment sites (at least one in each county) that would hold approximately 3,000 residential lots. Lot sizes would vary within the redevelopment sites but would be no less than quarter-acre in size. At an average cost of $45,000 per lot for site acquisition, site development, infrastructure and site amenities, the total cost of these redevelopment sites would be approximately $135.0M

The total cost for this measure including the redevelopment sites is estimated to be $6.1B and is shown in Table 24 by economic reach. The extent of the permanent acquisitions in the high-hazard zone is shown in Figures 86 through 90.

The second measure in the Plan will be the full application of all components of the flood preparedness and emergency evacuation measure including installation of additional reporting buoys in the Gulf, installation of sirens and flashing strobe lights within communities, acquisition and distribution of weather emergency radios, training and education seminars on appropriate actions following a warning for the public and emergency personnel, dissemination of emergency procedures information brochures and pamphlets to area residents and visitors alike, adjustment of hurricane warning times from 24 to 36 hours for hurricanes greater than Category 3, and development of emergency evacuation plans for those structures and facilities that cannot be moved from the waterfront. In addition to these components, there would be improvements to the evacuation routes themselves including new signage designating evacuation routes, messaging boards that provide needed information to evacuees, and procedures for reverse flow or contraflow routing during emergency evacuation situations.

Also, improvements would be made to all modal crossings that can potentially impede traffic flow, correction of undersized culverts and other stream crossing infrastructure that could endanger evacuees, and improvements to intersections (turning lanes, signaling, etc.). Additional improvements would include enroute emergency resources (fuel, food, emergency services, etc.) along evacuation routes and pre-arranged, safe sheltering with emergency supplies located away from the coast. The estimated cost to implement the improvements to the flood preparedness and emergency evacuation system is approximately $2.9M.

Replacing public buildings would remove several public buildings within the permanent acquisition zones described above that may be filled with residents that have special needs (medical, incarcerated, elderly, children, etc.) for evacuation in advance of a approaching hurricane. A total of 7 structures and facilities determined at this level of planning to be publicly-owned would be eligible for replacement to reduce flood damages. This number would include some schools that would serve as emergency evacuation centers. The total cost of these replacements is estimated to be $51.2M. Replacing those facilities at a flood-safe location in a new building constructed to current standards would significantly reduce the chances for loss of life due to flooding during a hurricane or during the evacuation that would precede such an event. Table 24 shows the total number of units by economic reach and the total estimated cost.

Table 24
NSC-5 Loss of Life Reduction Plan

Economic Reaches	Permanent Acquisition Parcels*	Cost	Public Buildings Relocations	Cost	Flood Warning and Emergency Evacuation	Cost
1	0	0	0	0	2062	$62,540
2	1056	$459,548,812	0	0	19363	$587,280
3	2099	$851,631,850	0	0	2673	$81,072
4	823	$202,919,893	0	0	901	$27,327
5	971	$107,653,678	0	0	3109	$94,296
6	210	$114,862,969	1	$8,536,147	1123	$34,061
7	125	$9,562,216	0	0	1574	$47,739
8	1565	$431,782,512	4	$25,608,442	8716	$264,356
9	4	$6,652,740	0	0	52	$1,577
10	1695	$736,216,496	0	0	1727	$52,380
11	0	0	0	0	44	$1,335
12	450	$138,318,777	0	0	2777	$84,226
13	595	$821,785,431	0	0	500	$15,165
14	0	0	0		788	$23,900
15	66	$88,566,796	0	0	76	$2,305
16	36	$14,594,008	0	0	209	$6,339
17	0	0	0	0	6	$182
18	285	$608,152,730	0	0	1223	$3,7094
19	12	$17,246,403	0	0	22	$667
20	1150	$316,031,090	1	$8,536,147	3064	$92,931

Economic Reaches	Permanent Acquisition Parcels*	Cost	Public Buildings Relocations	Cost	Flood Warning and Emergency Evacuation	Cost
21	2082	$695,355,710	0	0	1867	$56,626
22	62	$39,368,916	0	0	157	$4,762
23	0	0	0	0	65	$1,971
24	138	$45,373,108	0	0	524	$15,893
25	0	0	0	0	327	$9,918
26	31	$11,221,913	0	0	1279	$38,792
27	37	$5,996,209	0	0	2145	$65,058
28	583	$10,167,976	0	0	1718	$52,107
29	132	$14,287,454	0	0	546	$16,560
30	81	$24,818,841	0	0	626	$18,987
31	37	$9,281,900	0	0	708	$21,474
32	0	0	0	0	398	$12,071
33	0	0	0	0	77	$2,335
34	0	0	0	0	600	$18,198
35	0	0	0	0	1599	$48,498
36	0	0	0	0	62	$1,880
37	0	0	0	0	540	$16,378
38	0	0	0	0	364	$11,040
39	0	0	0	0	25	$758
40	0	0	0	0	7824	$237,302
41	0	0	0	0	536	$16,257
42	0	0	0	0	667	$20,230
43	0	0	0	0	25	$61
44	0	0	0	0	2587	$78,464
45	0	0	0	0	2267	$68,758
46	0	0	0	0	3331	$101,029
47	0	0	0	0	1303	$39,520
48	0	0	0	0	1	$61
49	0	0	0	0	338	$10,252
50	96	$24,190,783	0	0	1594	$48,346
51	0	0	0	0	1089	$33,029
52	275	$68,789,089	1	$8,536,147	7628	$231,357
53	300	$46,723,811	0	0	1557	$38,125
54	0	0	0	0	1548	$46,951
Subtotals	**14,997**	**$5,921,102,111**	**7**	**$51,216,883**	**95931**	**$2,899,820**
H&CD Sites		Jackson, Harrison and Hancock		3,000 lots at $45,000 each		**$135,000,000**
Total Plan Cost						**$6,110,218,814**

Notes: The Flood Warning and Emergency Evacuation improvements may be accomplished by other Federal Agencies (FEMA and NOAA) but would be supported by the Corps.

* The total parcel count for acquisition within the high-hazard zone includes approximately 7,500 existing structures (residential and commercial).

Figure 86 – Plan NSC-5 Loss of Life Reduction Plan (A1)

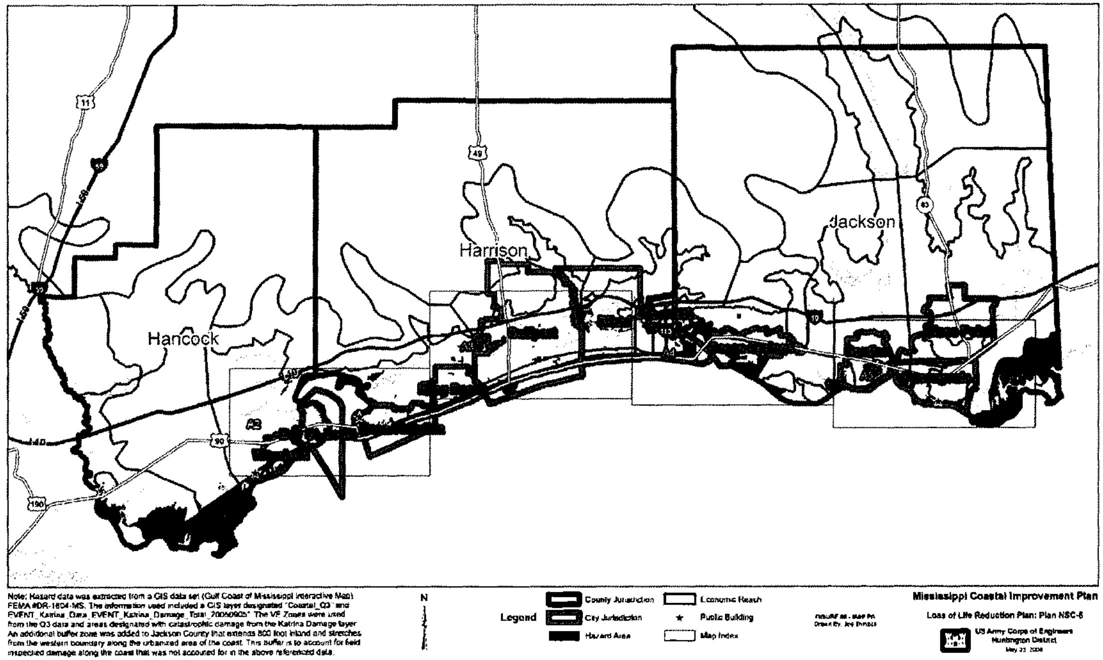


Figure 87 – Plan NSC-5 Loss of Life Reduction Plan (A2)

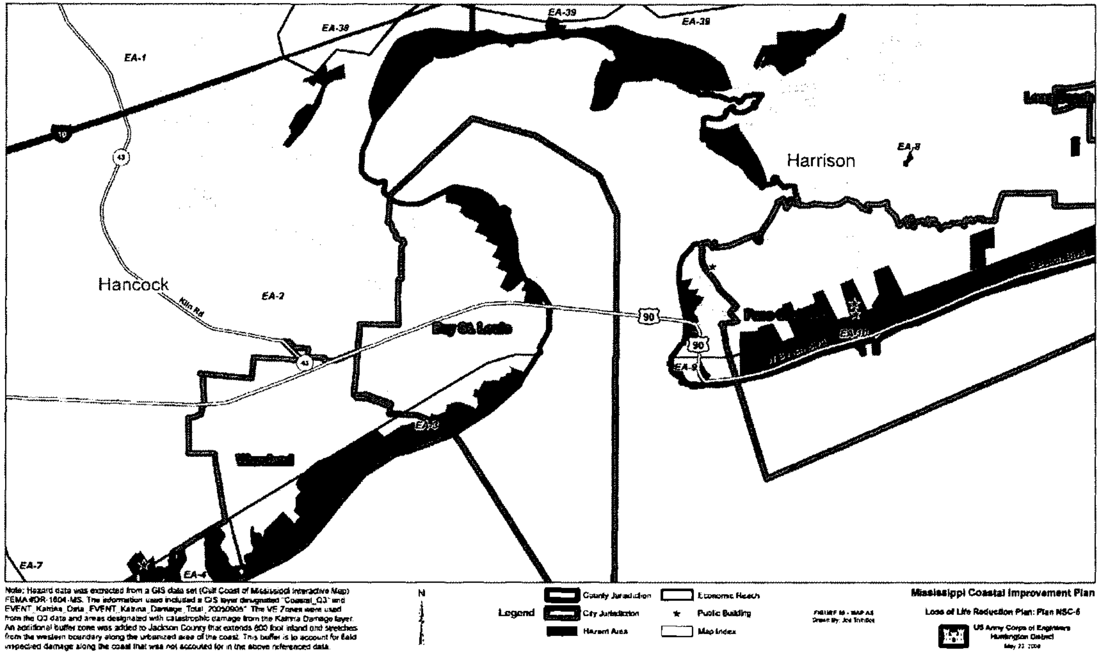


Figure 88 – Plan NSC-5 Loss of Life Reduction Plan (A3)

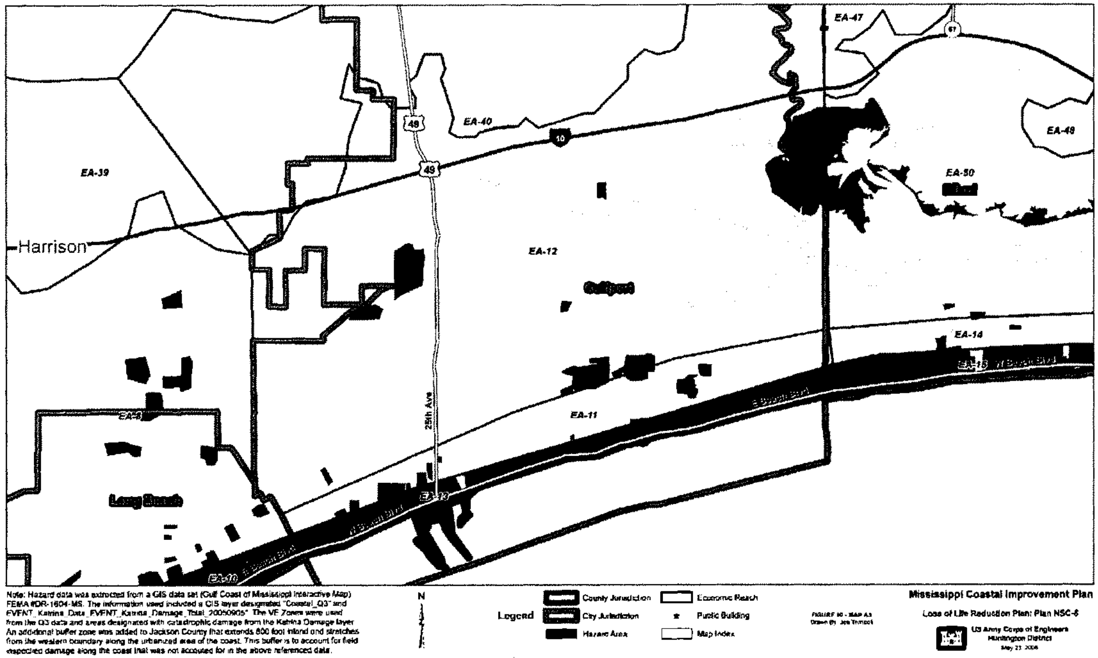


Figure 89 – Plan NSC-5 Loss of Life Reduction Plan (A4)

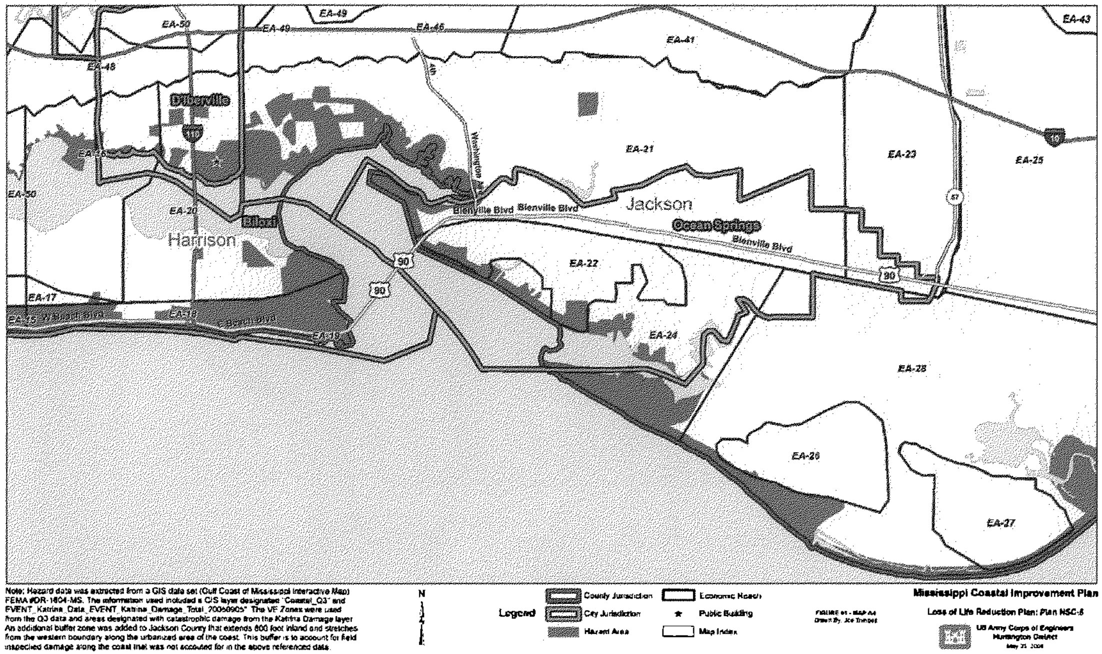
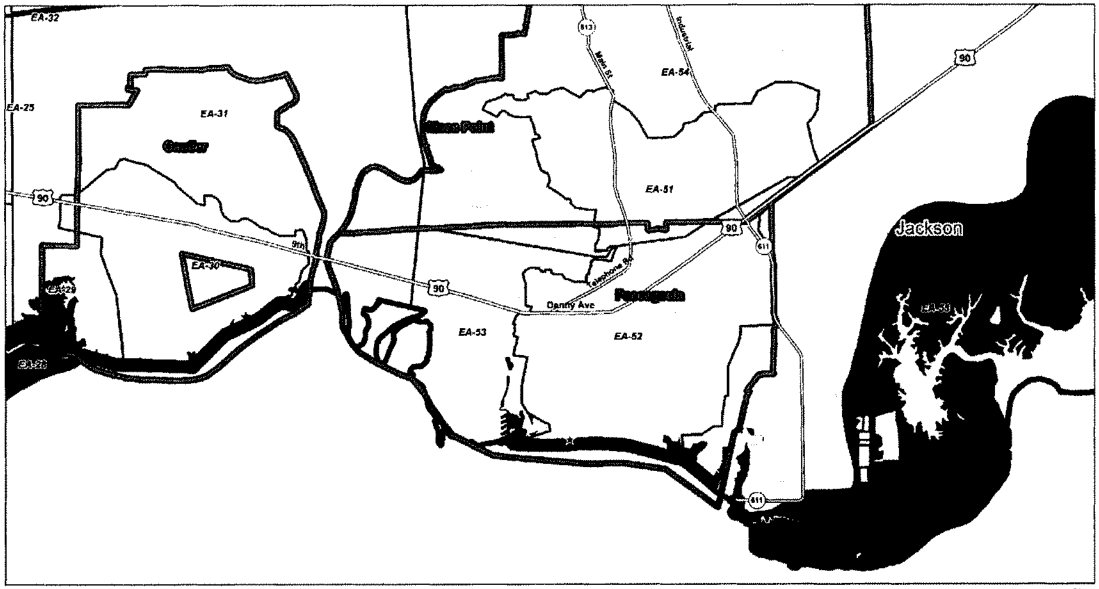


Figure 90 – Plan NSC-5 Loss of Life Reduction Plan (A5)



Note: Hazard data was extracted from a GIS data set (Gulf Coast of Mississippi Interactive Map) FEMA #DR-1604-MS. The information used included a GIS layer designated "Coastal_Q3" and EVENT_Katrina_Data_EVENT_Katrina_Damage_Total_20050905" The VE Zones were used from the Q3 data and areas designated with catastrophic damage from the Katrina Damage layer An additional buffer zone was added to Jackson County that extends 800 foot inland and stretches from the western boundary along the urbanized area of the coast. This buffer is to account for field inspected damage along the coast that was not accouted for in the above referenced data.

6.7.2.6. Plan NSC-6 – Combined Structural/Nonstructural Plan

This Plan would consist of nonstructural measures applied to structures and facilities that would be located outside the protection limits of structural projects described in the comprehensive plan. Line of Defense 4 (LOD 4) and various ringwalls or ring-levees that protect portions of named communities in the project area or any combination of the structural protection schemes are included in these plans. The number of structures that would be affected by these measures and the estimated costs are shown in Tables 26 through 33. The costs for nonstructural measures (primarily permanent acquisition outside the line of protection) that support structural projects are shown for each proposed structural alternative in the tables. These "buffer zones" or areas located outside the line of protection provided by the structural components would be addressed in the nonstructural program using the same procedures already described for other nonstructural alternatives.

Since the protection features of each structural plan are designed with cost effectiveness in mind, there would be many structures and facilities located outside the limits of structural protection. Case in point would be the many structures remaining outside the lines of protection provided by ring levees designed around high-density urban areas in the project area such as Gautier, Pascagoula, Ocean Springs, and Moss Point. In many cases the structural feature alignment was influenced by the ground elevations of the site and in several cases the alignment was adjusted to avoid impacts to wetlands or other environmentally sensitive ecosystems. Likewise the LOD 4 structural component would not provide protection for structures or facilities located between the Gulf and the levee alignment along the CSX railway right-of-way.

The nonstructural plans described in the tables represent the measures that would be available for all of those structures and facilities not protected by the lines of protection provided by structural measures at the various levels of protection. The two primary structural measures considered in the tables are the various ringwalls and ring-levees formulated for individual municipal or communities (i.e. Pascagoula, Moss Point, Gulf Park Estates, Pearlington, Belle Fontaine, and Gautier) and LOD 4 (trackside levee and surge gates at the inlets) with various levels of protection (20 feet, 30 feet and 40 feet of surge inundation). The nonstructural measures applied to these unprotected areas would be the suite of measures described in NSC-1 above with one exception. That exception would be the costs for relocating municipal structures that would be affected by surge inundation at the 20 foot, 30 foot and 40 foot levels of inundation. Numbers of public structures to be relocated and their costs were determined for the ABFE-2 feet inundation level, but time constraints and database constraints (FEMA HAZUS does not calculate surge profiles for 20, 30 and 40 feet of inundation) did not permit determinations of the numbers or costs of public building replacements at the higher levels of inundation. In those higher inundation scenarios, the public buildings were considered to be standard acquisition items and included in the Real Estate permanent acquisition category. Therefore, those costs may be slightly understated at this level of study.

The appropriate nonstructural measures applied to those structures and facilities would be in keeping with the basic parameters of other nonstructural plans regarding potential location in a high-hazard zone, depth of flooding at the structure, condition and use of the structure, and whether the structure or facility is publicly or privately owned. In addition, interspersed vacant property would be either acquired (permanent acquisition), or the development rights secured through either a locally administered TDR or PDR program. Structures and facilities located adjacent to structural protection works may experience slightly greater inundation due to hydraulic effects of surge and waves against the protection works, but those effects can be compensated for in the nonstructural measures' design.

The estimated numbers of structures to be protected by nonstructural measures lying outside the structural alignments for each economic reach are shown in Tables 26 through 33. Figures 91 through 138 show the locations of the proposed nonstructural measures that would be implemented in combination with structural measures.

Of note is the progressively greater number of parcels being included in the nonstructural program as the level of surge inundation increases from the ABFE-2 feet (a minimum level of protection in accordance with local floodplain management ordinances) to the 20 foot, 30 foot and 40 foot levels of inundation. At the ABFE-2 feet level of inundation only 44,098 parcels are included in the program. At the 20 foot level of inundation that total parcel number increases to 77,523 and at the 30 and 40 foot levels that number tops out at 85,447 parcels. There is no difference in total parcels between the 30 foot and 40 foot levels of inundation because the 30 foot level captures all of the eligible parcels.

Also of note is the progression of parcels moving from the floodproofing category to the permanent acquisition category of nonstructural measures. Initially at the 20 foot level the number of parcels eligible for floodproofing increases above that shown for the ABFE-2 level, but at the 30 foot and 40 foot levels that number decreases dramatically. This migration is due to the ever-deepening surge inundation levels that exceed the 13 feet water depth permitted for elevating structures in this program. Table 25 shows the relationship of total parcels and both acquisition and floodproofing parcels among the scales of the NSC-6 plan. As discussed for Plan NSC-1 at the greater levels of inundation (20, 30 and 40 feet of surge), plan costs do not increase in direct proportion to the increase in numbers of structures becoming eligible for the project (exempting the lot costs for displaced landowners). Since permanent acquisition costs per parcel used in the plan are on average slightly less that floodproofing costs per parcel, the migration of parcels from the floodproofing measure to the permanent acquisition measure (due to increased water depths) actually results in lower plan costs. Plan costs at the 30 and 40 foot levels do rise only because of the need for more redevelopment lots for a greater number of displaced owners.

Table 25
Plan NSC-6 - Comparison of Eligible Parcels in Acquisitions and Floodproofing

Plan Designation	Total Parcels	Acquisition Parcels	Potential Lives Protected	Floodproofing Parcels	Potential Lives Protected
NSC-6 ABFE w/ring-levees	44,088	29,445	76,557	14,620	38,012
NSC-6a 20 feet w/ring-levees	77,523	36,559	95,053	40,964	106,506
NSC-6b 30 feet w/ring-levees	85,447	71,448	185,765	13,999	36,397
NSC-6c 40 feet w/ring-levees	85,447	85,447	222,162	0	0
NSC-6d ABFE w/LOD-4 **	30,508	20,156	52,406	10,347	26,902
NSC-6e 20 feet w/LOD-4**	46,315	19,556	50,846	26,759	69,573
NSC-6f 30 feet w/LOD-4**	51,935	40,125	104,325	11,810	30,706
MSC-6g 40 feet w/LOD-4**	51,935	51,935	135,031	0	0

** (See discussion of the status of the LOD 4 structural alternative in the Executive Summary)

Table 26

NSC-6 - Combined Structural and Nonstructural - ABFE w/Ring-Levees

Reaches	Acquisition Parcels	Acquisitions Cost	Public Relocations	Public Relocations Cost	Public Floodproofing	Public Floodproofing Cost	Public Buildings Costs	Floodproofing Parcels	Floodproofing Costs	Subtotal Nonstructural Costs
1	997	$194,118,217.88	0	$0.00	0	$0.00	$0.00	394	$101,229,150.00	$295,347,367.88
2	9911	$2,990,789,131.25	1	$392,586.21	5	$23,778,209.33	$24,170,795.55	3289	$1,543,195,389.00	$4,558,155,315.80
3	2202	$668,691,436.88	0	$0.00	0	$0.00	$0.00	376	$269,175,578.00	$937,867,014.88
4	922	$120,307,916.63	0	$0.00	0	$0.00	$0.00	16	$24,642,670.00	$144,950,586.63
7	450	$33,210,173.75	0	$0.00	0	$0.00	$0.00	232	$149,936,910.00	$183,147,083.75
8	3623	$476,088,332.50	3	$25,478,083.02	1	$3,815,128.75	$29,293,211.77	1729	$569,574,546.00	$1,074,956,090.27
9	44	$16,132,782.50	0	$0.00	0	$0.00	$0.00	16	$13,361,448.00	$29,494,230.50
10	1945	$432,581,233.50	0	$0.00	0	$0.00	$0.00	62	$20,028,706.00	$452,609,939.50
11	0	$0.00	0	$0.00	0	$0.00	$0.00	8	$1,727,008.00	$1,727,008.00
12	1047	$179,614,825.00	0	$0.00	1	$3,815,128.75	$3,815,128.75	1135	$358,050,524.00	$541,480,477.75
13	650	$583,121,543.00	0	$0.00	0	$0.00	$0.00	0	$0.00	$583,121,543.00
15	85	$44,354,843.00	0	$0.00	0	$0.00	$0.00	9	$22,725,000.00	$67,079,843.00
16	78	$16,399,728.00	0	$0.00	0	$0.00	$0.00	121	$31,715,348.00	$48,115,076.00
18	1502	$409,411,532.00	0	$0.00	0	$0.00	$0.00	5	$1,138,504.00	$410,550,036.00
19	46	$292,728,063.00	0	$0.00	0	$0.00	$0.00	0	$0.00	$292,728,063.00
20	1397	$238,433,082.00	1	$8,492,694.34	5	$19,075,643.74	$27,568,338.08	2045	$692,997,655.00	$958,999,075.08
21	2108	$301,798,271.81	0	$0.00	4	$15,260,514.99	$15,260,514.99	415	$142,103,926.00	$459,162,712.81
22	61	$26,330,662.50	0	$0.00	0	$0.00	$0.00	92	$36,587,106.00	$62,917,768.50
23	0	$0.00	0	$0.00	0	$0.00	$0.00	44	$19,986,176.00	$19,986,176.00
24	220	$65,229,820.63	0	$0.00	0	$0.00	$0.00	178	$47,664,846.00	$112,894,666.63
28	961	$90,294,696.75	0	$0.00	0	$0.00	$0.00	122	$47,989,150.00	$138,283,846.75
29	147	$23,394,828.50	0	$0.00	0	$0.00	$0.00	168	$51,396,802.00	$74,791,630.50
31	51	$14,946,829.31	0	$0.00	0	$0.00	$0.00	447	$168,990,104.00	$183,936,933.31
32	1	$216,228.13	0	$0.00	0	$0.00	$0.00	208	$51,710,800.00	$51,927,028.13
35	12	$682,228.13	0	$0.00	0	$0.00	$0.00	1406	$350,816,536.00	$351,498,764.13
36	32	$3,834,485.38	0	$0.00	0	$0.00	$0.00	2	$5,050,000.00	$8,884,485.38
38	50	$21,424,866.13	0	$0.00	0	$0.00	$0.00	78	$15,883,024.00	$37,307,890.13
39	0	$0.00	0	$0.00	0	$0.00	$0.00	6	$991,302.00	$991,302.00
43	0	$0.00	0	$0.00	0	$0.00	$0.00	1	$170,304.00	$170,304.00
48	0	$0.00	0	$0.00	0	$0.00	$0.00	2	$366,298.00	$366,298.00
50	495	$89,247,660.50	0	$0.00	0	$0.00	$0.00	848	$215,363,629.00	$304,611,289.50
53	399	$113,015,334.56	0	$0.00	0	$0.00	$0.00	360	$204,582,670.00	$317,598,004.56
54	9	$1,114,862.06	0	$0.00	2	$7,630,257.50	$7,630,257.50	806	$319,497,144.00	$328,242,263.56
Subtotals	29445	$7,447,513,615	5	$34,363,363	18	$73,374,883	$107,738,246	14620	$5,478,648,253	$13,033,900,114
	H&CD sites	Hancock, Harrison and Jackson Counties					Approx 10,300 lots at $45,000 per lot			$464,000,000
Total Cost	Total Nonstructural Parcels - 44,088									$ 13,497,627,949

Table 27
NSC-6a – Combined Structural and Nonstructural Plan w/20 Feet inundation and Ring-Levees

Reaches	Acquisition Parcels	Acquisitions Cost	Floodproofing Parcels	Floodproofing Costs	Nonstructural Total Costs by Reach
1	795	$242,760,352.63	1068	$111,644,220	$354,404,572.63
2	6119	$1,982,505,118.75	12206	$2,270,306,077	$4,252,811,195.75
3	2029	$869,599,919.38	502	$261,603,614	$1,131,203,533.38
4	769	$137,140,841.63	55	$41,048,722	$178,189,563.63
7	343	$28,183,289.75	1092	$123,833,026	$152,016,315.75
8	6585	$721,036,617.25	2761	$268,481,369	$989,517,986.25
9	23	$10,006,258.75	15	$4,155,724	$14,161,982.75
10	3052	$687,523,634.50	36	$9,985,596	$697,509,230.50
11	45	$13,955,967.50	882	$131,996,005	$145,951,972.50
12	1617	$398,388,336.75	2184	$925,803,107	$1,324,191,443.75
13	2284	$1,059,037,972.50	1	$275,000	$1,059,312,972.50
14	10	$3,531,145.00	3	$0	$3,531,145.00
15	407	$321,467,398.75	5	$195,994	$321,663,392.75
16	178	$45,986,843.00	420	$89,816,180	$135,803,023.00
18	1650	$531,842,684.50	29	$7,968,172	$539,810,856.50
19	15	$238,143,653.50	0	$0	$238,143,653.50
20	1046	$197,002,707.50	1756	$491,997,409	$689,000,116.50
21	2142	$698,779,207.38	1688	$518,126,016	$1,216,905,223.38
22	314	$142,425,847.38	1921	$475,539,586	$617,965,433.38
23	59	$18,831,864.50	104	$23,208,676	$42,040,540.50
24	301	$134,113,558.00	854	$131,106,828	$265,220,386.00
25	0	$0.00	27	$3,700,964	$3,700,964.00
28	1318	$162,484,163.75	444	$40,032,082	$202,516,245.75
29	491	$115,704,667.88	1081	$180,905,804	$296,610,471.88
31	472	$150,421,617.50	810	$206,865,030	$357,286,647.50
32	236	$44,686,667.38	461	$71,960,724	$116,647,391.38
35	630	$92,739,948.25	1277	$453,335,528	$546,075,476.25
36	0	$0.00	29	0	$0.00
37	0	$0.00	5	0	$0.00
38	33	$23,256,254.25	304	$16,587,864	$39,844,118.25
39	8	$1,627,170.00	287	$16,374,482	$18,001,652.00
40	1	$100,211.25	4	0	$100,211.25
43	0	$0.00	4	$366,298	$366,298.00
46	0	$0.00	3	$114,092	$114,092.00
47	0	$0.00	5	$587,982	$587,982.00
48	1	$1,457,777.50	5	$587,982	$2,045,759.50
49	0	$0.00	63	$2318648	$2,318,648.00
52	1840	$535,059,176.25	7305	$4,108,479,076	$4,643,538,252.25
53	646	$134,435,107.63	613	$207,158,892	$341,593,999.63
54	1100	$276,596,580.13	655	$219,619,572	$496,216,152.13
Subtotals	**36559**	**$10,020,832,560**	**40964**	**$ 11,416,086,341**	**$21,436,918,901**
H&CD Sites	Hancock, Harrison & Jackson Co		Approx 12,700 Lots at $45,000/lot		**$572,000,000**
	Total Plan Costs	**Total Nonstructural Parcels – 77,523**			**$22,008,918,901**

Table 28
NSC-6b – Combined Structural and Nonstructural Plan w/30 feet inundation and Ring-Levees

Reaches	Acquisition Parcels	Acquisitions Costs	Floodproofing Parcels	Floodproofing Costs	Nonstructural Total Costs by Reach
1	1591	$470,268,503.50	511	$ 80,353,606.00	$550,622,109.50
2	15864	$3,364,937,903.75	6331	$ 2,006,692,184.00	$5,371,630,087.75
3	2565	$1,036,199,788.88	557	$ 239,155,950.00	$1,275,355,738.88
4	823	$143,859,191.50	1	$ 195,994.00	$144,055,185.50
7	1222	$127,404,692.38	267	$ 18,389,310.00	$145,794,002.38
8	8591	$913,966,937.50	755	$ 201,679,104.00	$1,115,646,041.50
9	38	$12,583,953.75	0	$ -	$12,583,953.75
10	3088	$696,444,472.00	0	$ -	$696,444,472.00
11	79	$17,236,421.25	848	$ 315,371,358.00	$332,607,779.25
12	3801	$1,250,095,756.75	0	$ -	$1,250,095,756.75
13	2284	$1,059,037,972.50	1	$ 2,525,000.00	$1,061,562,972.50
14	10	$3,531,145.00	3	$ -	$3,531,145.00
15	412	$326,617,775.00	0	$ -	$326,617,775.00
16	598	$173,917,626.75	0	$ -	$173,917,626.75
18	1655	$533,199,240.00	24	$ 11,739,556.00	$544,938,796.00
19	15	$238,143,653.50	0	$ -	$238,143,653.50
20	2144	$416,967,996.50	1802	$ 861,061,816.00	$1,278,029,812.50
21	3830	$1,483,891,217.50	0	$ -	$1,483,891,217.50
22	2235	$872,740,336.25	0	$ -	$872,740,336.25
23	163	$57,221,763.88	0	$ -	$57,221,763.88
24	539	$264,338,265.75	616	$ 110,725,374.00	$375,063,639.75
25	27	$11,661,813.00	0	$ -	$11,661,813.00
28	1687	$241,776,845.63	1742	$ 249,531,974.00	$491,308,819.63
29	1572	$359,722,100.25	0	$ -	$359,722,100.25
31	1282	$415,121,092.13	0	$ -	$415,121,092.13
32	697	$173,934,340.75	0	$ -	$173,934,340.75
35	1907	$416,542,564.88	0	$ -	$416,542,564.88
36	15	$2,306,708.13	36	$ -	$2,306,708.13
37	1	$340,434.38	4	$ -	$340,434.38
38	198	$59,672,860.88	452	$ 74,116,316.00	$133,789,176.88
39	295	$34,977,357.00	0	$ -	$34,977,357.00
40	5	$417,288.75	0	$ -	$417,288.75
43	4	$1,269,975.00	0	$ -	$1,269,975.00
46	3	$322,862.50	0	$ -	$322,862.50
47	5	$1,720,815.00	0	$ -	$1,720,815.00
48	6	$5,485,907.50	0	$ -	$5,485,907.50
49	63	$8,814,550.50	0	$ -	$8,814,550.50
52	9145	$3,199,336,671.63	0	$ -	$3,199,336,671.63
53	1234	$464,412,757.75	49	$ 26,056,898.00	$490,469,655.75
54	1755	$541,259,959.00	0	$ -	$541,259,959.00
Subtotals	**71448**	**$19,401,701,518**	**13999**	**$4,197,594,440**	**$23,599,295,958**
H&CD Sites	**Hancock, Harrison & Jackson Co**		**Approx. 25,000 lots at $45,000/lot**		**$ 1,125,000,000**
Total Cost	**Total Nonstructural Parcels – 85,447**				**$24,724,295,958**

Table 29

NSC-6c – Combined Structural and Nonstructural w/40 inundation and Ring-Levees

Reaches	Acquisition Parcels	Acquisitions Cost	Floodproofing Parcels	Floodproofing Costs	Nonstructural Costs by Reach
1	2102	$632,549,786.38	0	0	$632,549,786.38
2	22195	$5,686,835,321.25	0	0	$5,686,835,321.25
3	3122	$1,266,472,734.00	0	0	$1,266,472,734.00
4	824	$144,644,086.50	0	0	$144,644,086.50
7	1489	$159,349,868.63	0	0	$159,349,868.63
8	9346	$1,119,589,307.50	0	0	$1,119,589,307.50
9	38	$12,583,953.75	0	0	$12,583,953.75
10	3088	$696,444,472.00	0	0	$696,444,472.00
11	927	$238,310,263.50	0	0	$238,310,263.50
12	3801	$1,250,095,756.75	0	0	$1,250,095,756.75
13	2285	$1,059,287,941.25	0	0	$1,059,287,941.25
14	13	$5,321,020.00	0	0	$5,321,020.00
15	412	$326,617,775.00	0	0	$326,617,775.00
16	598	$173,917,626.75	0	0	$173,917,626.75
18	1679	$542,567,877.25	0	0	$542,567,877.25
19	15	$238,143,653.50	0	0	$238,143,653.50
20	3946	$829,880,446.50	0	0	$829,880,446.50
21	3830	$1,483,891,217.50	0	0	$1,483,891,217.50
22	2235	$872,740,336.25	0	0	$872,740,336.25
23	163	$57,221,763.88	0	0	$57,221,763.88
24	1155	$598,237,712.00	0	0	$598,237,712.00
25	27	$11,661,813.00	0	0	$11,661,813.00
28	3429	$714,783,499.38	0	0	$714,783,499.38
29	1572	$359,722,100.25	0	0	$359,722,100.25
31	1282	$415,121,092.13	0	0	$415,121,092.13
32	697	$173,934,340.75	0	0	$173,934,340.75
35	1907	$416,542,564.88	0	0	$416,542,564.88
36	51	$6,438,158.75	0	0	$6,438,158.75
37	5	$1,911,196.25	0	0	$1,911,196.25
38	650	$214,970,390.38	0	0	$214,970,390.38
39	295	$34,977,357.00	0	0	$34,977,357.00
40	5	$417,288.75	0	0	$417,288.75
43	4	$1,269,975.00	0	0	$1,269,975.00
46	3	$322,862.50	0	0	$322,862.50
47	5	$1,720,815.00	0	0	$1,720,815.00
48	6	$5,485,907.50	0	0	$5,485,907.50
49	63	$8,814,550.50	0	0	$8,814,550.50
52	9145	$3,199,336,671.63	0	0	$3,199,336,671.63
53	1283	$496,107,037.25	0	0	$496,107,037.25
54	1755	$541,259,959.00	0	0	$541,259,959.00
Subtotals	**85447**	**$23,999,500,500**	**0**	**0**	**$23,999,500,500**
H&CD Sites	Hancock, Harrison & Jackson C.		Approx. 29,900 lots at $45,000/lot		$ 1,345,500,000
Total Cost	**Total Nonstructural Parcels – 85,447**				**$25,345,000,500**

Table 30

NSC-6d – Combined Structural and Nonstructural - ABFE w/LOD4 **

Reaches	Acquisition Parcels	Acquisition Parcels Cost	Public Relocations	Public Relocations Cost	Public Floodproofing	Public Floodproofing Costs	Public Buildings Costs	Floodproofing parcels	Floodproofing Costs	Total Nonstructural Costs by Reach
1	997	$194,118,217.88	0	$0.00	0	$0.00	$0.00	394	$101,229,150.00	$295,347,367.88
2	9911	$2,990,789,131.25	1	$392,586.21	5	$23,778,209.33	$24,170,795.55	3289	$1,543,195,389.00	$4,558,155,315.80
7	450	$33,210,173.75	0	$0.00	0	$0.00	$0.00	232	$149,936,910.00	$183,147,083.75
8	3623	$476,088,332.50	3	$25,478,083.02	1	$3,815,128.75	$29,293,211.77	1729	$569,574,546.00	$1,074,956,090.27
11	0	$0.00	0	$0.00	0	$0.00	$0.00	8	$1,727,008.00	$1,727,008.00
12	1047	$179,614,825.00	0	$0.00	1	$3,815,128.75	$3,815,128.75	1135	$358,050,524.00	$541,480,477.75
16	78	$16,399,728.00	0	$0.00	0	$0.00	$0.00	121	$31,715,348.00	$48,115,076.00
20	1397	$238,433,082.00	1	$8,492,694.34	5	$19,075,643.74	$27,568,338.08	2045	$692,997,655.00	$958,999,075.08
21	2108	$301,798,271.81	0	$0.00	4	$15,260,514.99	$15,260,514.99	415	$142,103,926.00	$459,162,712.81
23	0	$0.00	0	$0.00	0	$0.00	$0.00	44	$19,986,176.00	$19,986,176.00
38	50	$21,424,866.13	0	$0.00	0	$0.00	$0.00	78	$15,883,024.00	$37,307,890.13
39	0	$0.00	0	$0.00	0	$0.00	$0.00	6	$991,302.00	$991,302.00
43	0	$0.00	0	$0.00	0	$0.00	$0.00	1	$170,304.00	$170,304.00
48	0	$0.00	0	$0.00	0	$0.00	$0.00	2	$366,298.00	$366,298.00
50	495	$89,247,660.50	0	$0.00	0	$0.00	$0.00	848	$215,363,629.00	$304,611,289.50
Subtotals	**20156**	**$4,541,124,288**	**5**	**$34,363,363**				**10347**	**$3,843,291,189**	**$8,484,523,466**
H&CD Sites	**Hancock, Harrison & Jackson Counties**			**Approx. 7,000 lots at $45,000 per lot**						**$315,000,000**
Totals	**Total Parcels in Nonstructural Plan – 30,508**									**$8,799,523,466**

** (See discussion of the LOD 4 structural alternative in the Executive Summary)

Table 31

NSC-6e – Combined Structural and Nonstructural 20 Feet Inundation w/LOD4 **

Reaches	Acquisition Parcels	Acquisitions Cost	Floodproofing Parcels	Floodproofing Costs	Total Nonstructural Costs by Reach
1	795	$242,760,352.63	1068	$ 111,644,220.00	$354,404,572.63
2	6119	$1,982,505,118.75	12206	$2,270,306,077.00	$4,252,811,195.75
7	343	$28,183,289.75	1092	$ 123,833,026.00	$152,016,315.75
8	6585	$721,036,617.25	2761	$ 268,481,369.00	$989,517,986.25
11	45	$13,955,967.50	882	$ 131,996,005.00	$145,951,972.50
12	1617	$398,388,336.75	2184	$ 925,803,107.00	$1,324,191,443.75
14	10	$3,531,145.00	3	$	$3,531,145.00
16	178	$45,986,843.00	420	$ 89,816,180.00	$135,803,023.00
20	1046	$197,002,707.50	1756	$ 491,997,409.00	$689,000,116.50
21	2142	$698,779,207.38	1688	$ 518,126,016.00	$1,216,905,223.38
23	59	$18,831,864.50	104	$ 23,208,676.00	$42,040,540.50
37	0	$0.00	5	$ -	$0.00
38	33	$23,256,254.25	304	$ 16,587,864.00	$39,844,118.25
39	8	$1,627,170.00	287	$ 16,374,482.00	$18,001,652.00
40	1	$100,211.25	4	$	$100,211.25
43	0	$0.00	4	$ 366,298.00	$366,298.00
46	0	$0.00	3	$ 114,092.00	$114,092.00
47	0	$0.00	5	$ 587,982.00	$587,982.00
48	1	$1,457,777.50	5	$ 587,982.00	$2,045,759.50
49	0	$0.00	63	$ 2,318,648.00	$2,318,648.00
50	574	$204,376,584.50	1915	$ 363,408,582.00	$567,785,166.50
Subtotals	**19556**	**$4,581,779,447**	**26759**	**$5,355,558,015**	**$9,937,337,462**
H&CD Sites	Hancock, Harrison &Jackson		Approx. 6,800 lots at $45,000/lot		**$306,000,000**
Totals	**Total Nonstructural Parcels – 46,315**				**$10,243,337,462**

** (See discussion of the LOD 4 structural alternative in the Executive Summary)

Table 32

NSC-6f – Combined Structural and Nonstructural 30 Feet Inundation w/LOD4 **

Reaches	Acquisition Parcels	Acquisition Costs	Floodproofing Parcels	Floodproofing Costs	Total Nonstructural Costs by Reach
1	1591	$470,268,503.50	511	$ 80,353,606.00	$550,622,109.50
2	15864	$3,364,937,903.75	6331	$ 2,006,692,184.00	$5,371,630,087.75
7	1222	$127,404,692.38	267	$ 18,389,310.00	$145,794,002.38
8	8591	$913,966,937.50	755	$ 201,679,104.00	$1,115,646,041.50
11	79	$17,236,421.25	848	$ 315,371,358.00	$332,607,779.25
12	3801	$1,250,095,756.75	0	$ -	$1,250,095,756.75
14	10	$3,531,145.00	3	$ -	$3,531,145.00
16	598	$173,917,626.75	0	$ -	$173,917,626.75
20	2144	$416,967,996.50	1802	$ 861,061,816.00	$1,278,029,812.50
21	3830	$1,483,891,217.50	0	$ -	$1,483,891,217.50
23	163	$57,221,763.88	0	$ -	$57,221,763.88
37	1	$340,434.38	4	$ -	$340,434.38
38	198	$59,672,860.88	452	$ 74,116,316.00	$133,789,176.88
39	295	$34,977,357.00	0	$ -	$34,977,357.00
40	5	$417,288.75	0	$ -	$417,288.75
43	4	$1,269,975.00	0	$ -	$1,269,975.00
46	3	$322,862.50	0	$ -	$322,862.50
47	5	$1,720,815.00	0	$ -	$1,720,815.00
48	6	$5,485,907.50	0	$ -	$5,485,907.50
49	63	$8,814,550.50	0	$ -	$8,814,550.50
50	1652	$665,887,180.75	837	$ 176,952,378.00	$842,839,558.75
Subtotals	**40125**	**$9,058,349,197**	**11810**	**$ 3,734,616,072**	**$12,792,965,269**
H&CD Sites	Hancock, Harrison & Jackson		Approx 14,000 lots at $45,000/lot		**$630,000,000**
Totals	**Total Nonstructural Parcels – 51,935**				**$13,422,965,269**

** (See discussion of the LOD 4 structural alternative in the Executive Summary)

Table 33

NSC-6g – Combined Structural and Nonstructural 40 Feet Inundation with LOD4 **

Reaches	Acquisition Parcels	Acquisition Costs	Floodproofing Parcels	Floodproofing Costs	Total Nonstructural Costs by Reach
1	2102	$632,549,786.38	0	0	$632,549,786.38
2	22195	$5,686,835,321.25	0	0	$5,686,835,321.25
7	1489	$159,349,868.63	0	0	$159,349,868.63
8	9346	$1,119,589,307.50	0	0	$1,119,589,307.50
11	927	$238,310,263.50	0	0	$238,310,263.50
12	3801	$1,250,095,756.75	0	0	$1,250,095,756.75
14	13	$5,321,020.00	0	0	$5,321,020.00
16	598	$173,917,626.75	0	0	$173,917,626.75
20	3946	$829,880,446.50	0	0	$829,880,446.50
21	3830	$1,483,891,217.50	0	0	$1,483,891,217.50
23	163	$57,221,763.88	0	0	$57,221,763.88
37	5	$1,911,196.25	0	0	$1,911,196.25
38	650	$214,970,390.38	0	0	$214,970,390.38
39	295	$34,977,357.00	0	0	$34,977,357.00
40	5	$417,288.75	0	0	$417,288.75
43	4	$1,269,975.00	0	0	$1,269,975.00
46	3	$322,862.50	0	0	$322,862.50
47	5	$1,720,815.00	0	0	$1,720,815.00
48	6	$5,485,907.50	0	0	$5,485,907.50
49	63	$8,814,550.50	0	0	$8,814,550.50
50	2489	$1,063,036,000.75	0	0	$1,063,036,000.75
Subtotals	**51935**	**$12,969,888,722**	**0**	**0**	**$12,969,888,722**
H&CD Sites	Hancock, Harrison & Jackson Counties		Approx. 18,200 Lots at $45,000/lot		**$819,000,000**
Totals	**Total Nonstructural Parcels in Plan – 51,935**				**$13,788,888,722**

** (See discussion of the LOD 4 structural alternative in the Executive Summary)

Figure 91 – Plan NSC-6 Combined Nonstructural and Structural Plan (A1)

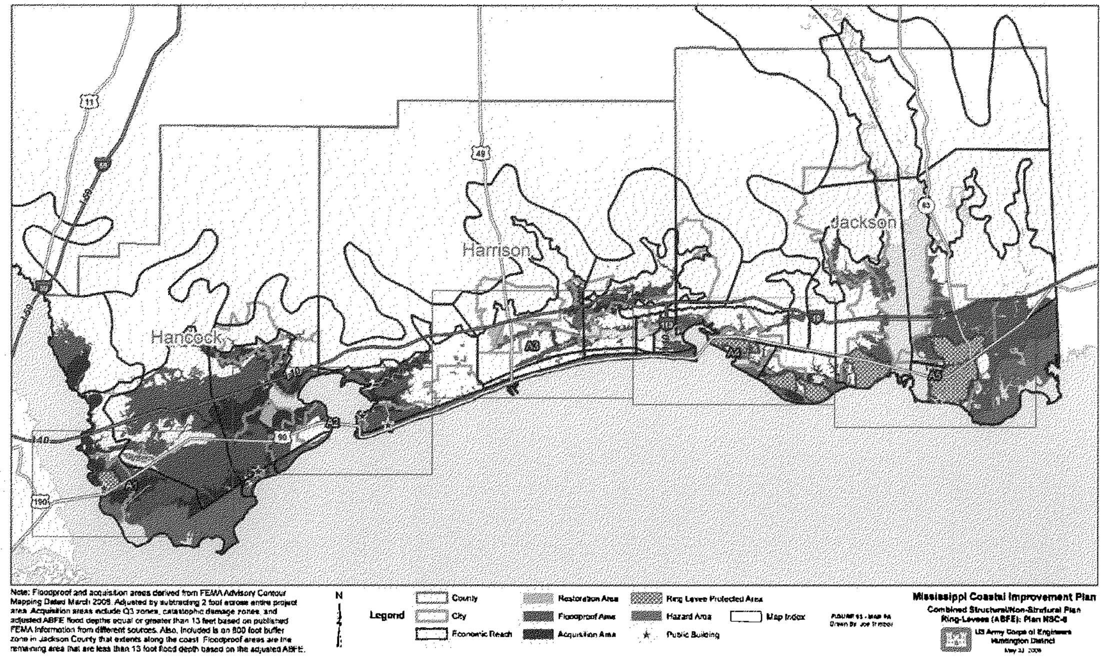


Figure 92 – Plan NSC-6 Combined Nonstructural and Structural Plan (A2)

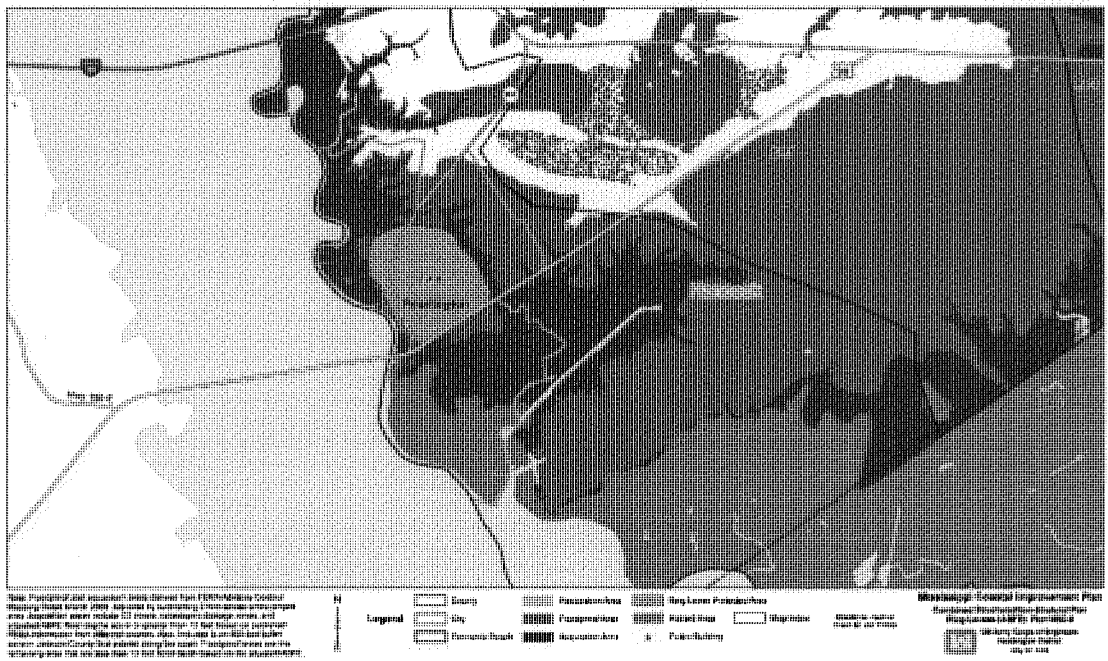


Figure 93 – Plan NSC-6 Combined Nonstructural and Structural Plan (A3)

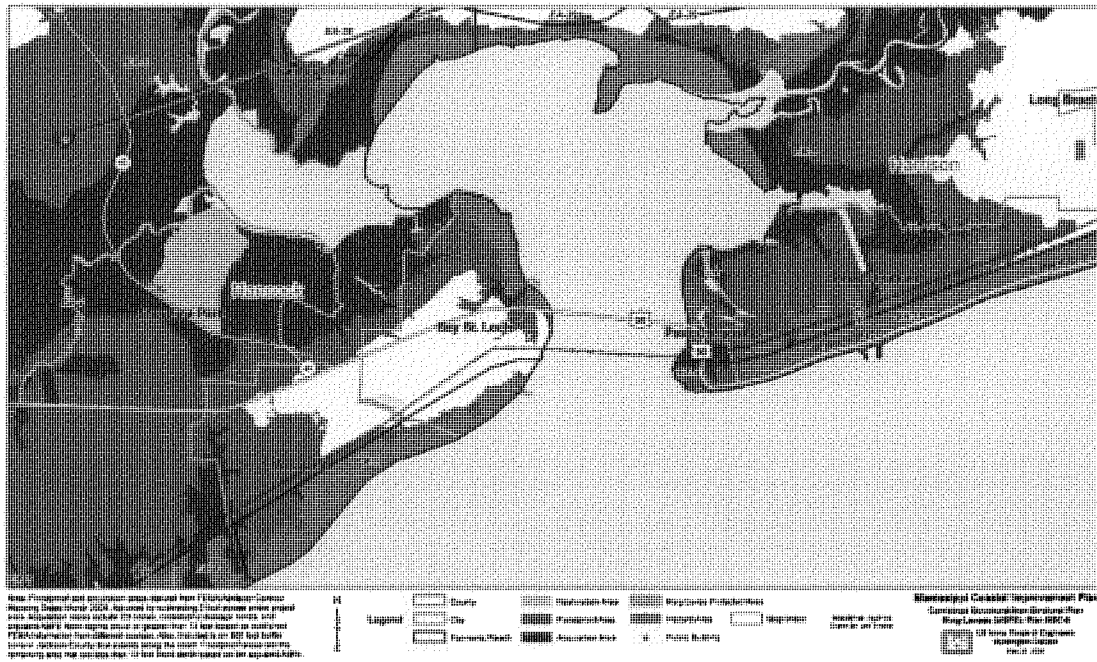


Figure 94 – Plan NSC-6 Combined Nonstructural and Structural Plan (A4)

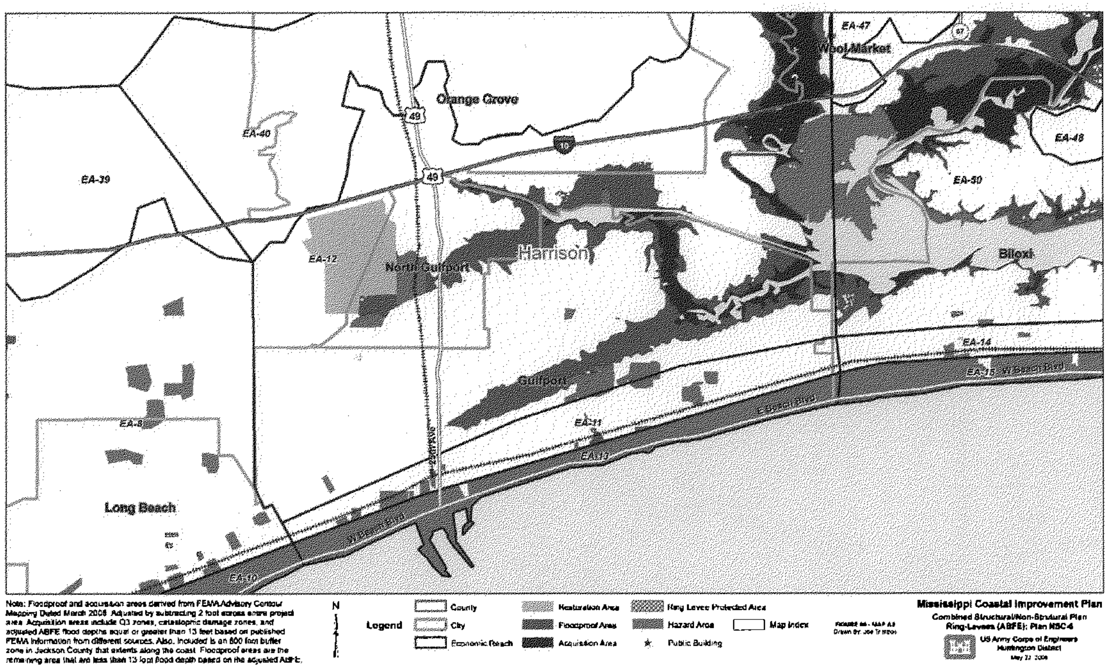


Figure 95 – Plan NSC-6 Combined Nonstructural and Structural Plan (A5)

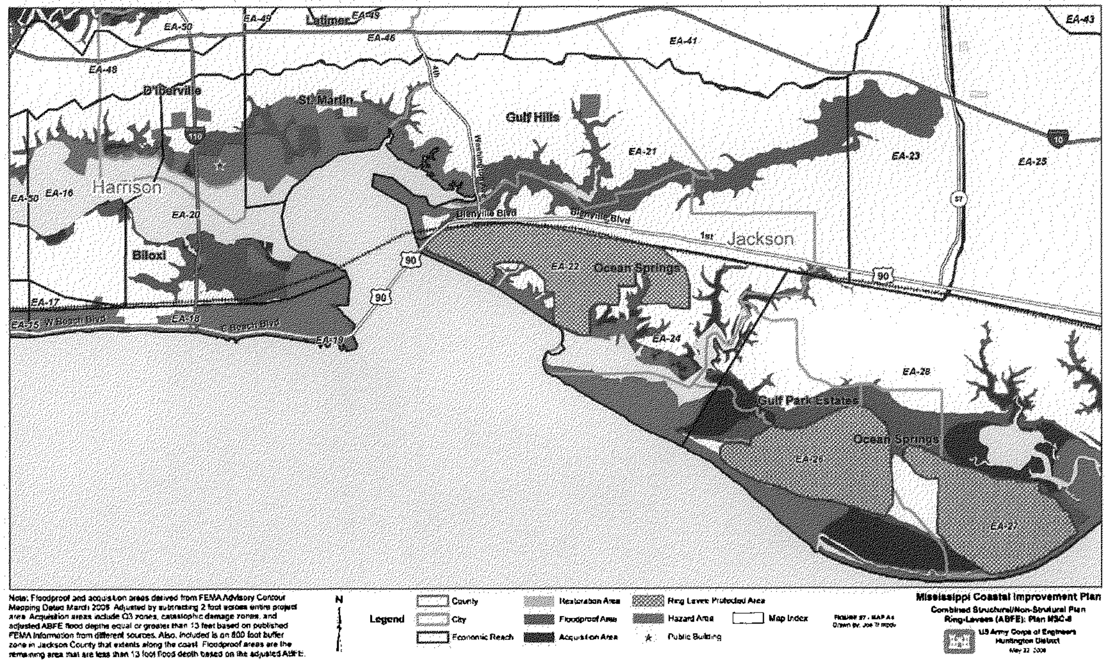


Figure 96 – Plan NSC-6 Combined Nonstructural and Structural Plan (A6)

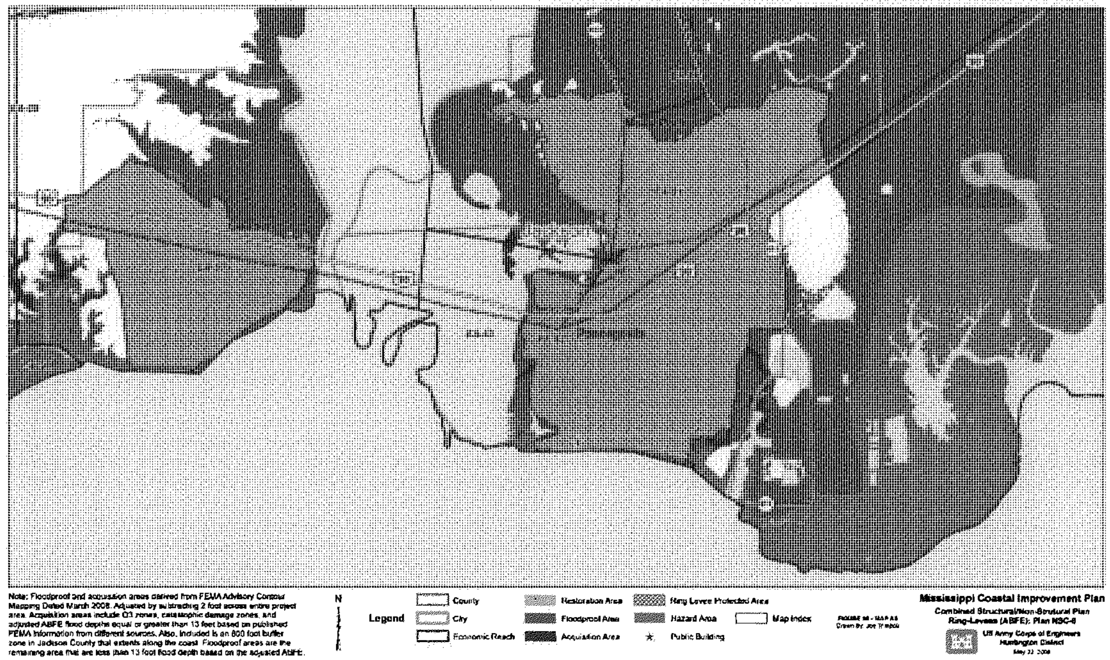


Figure 97 - Plan NSC-6a Combined Nonstructural and Structural Plan (A1)

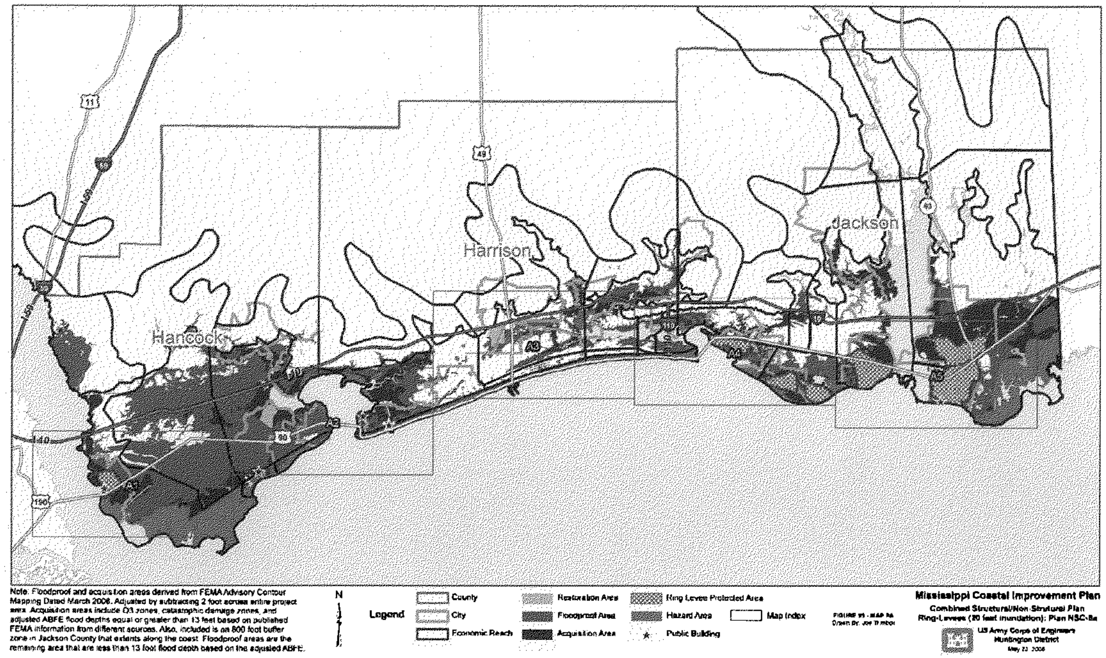


Figure 98 - Plan NSC-6a Combined Nonstructural and Structural Plan (A2)

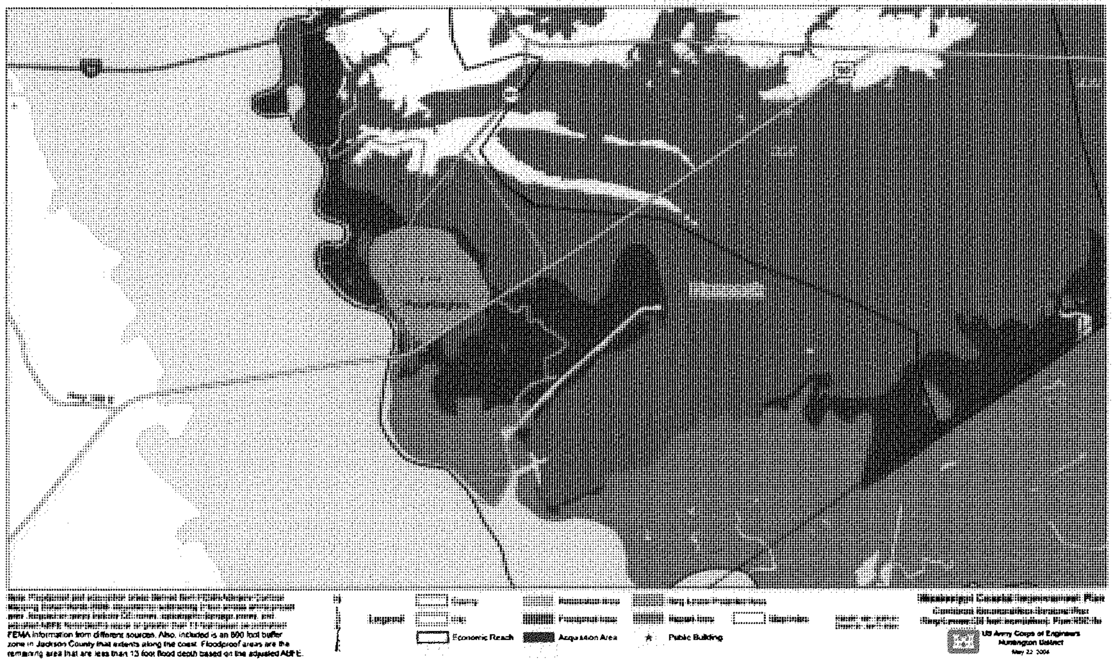
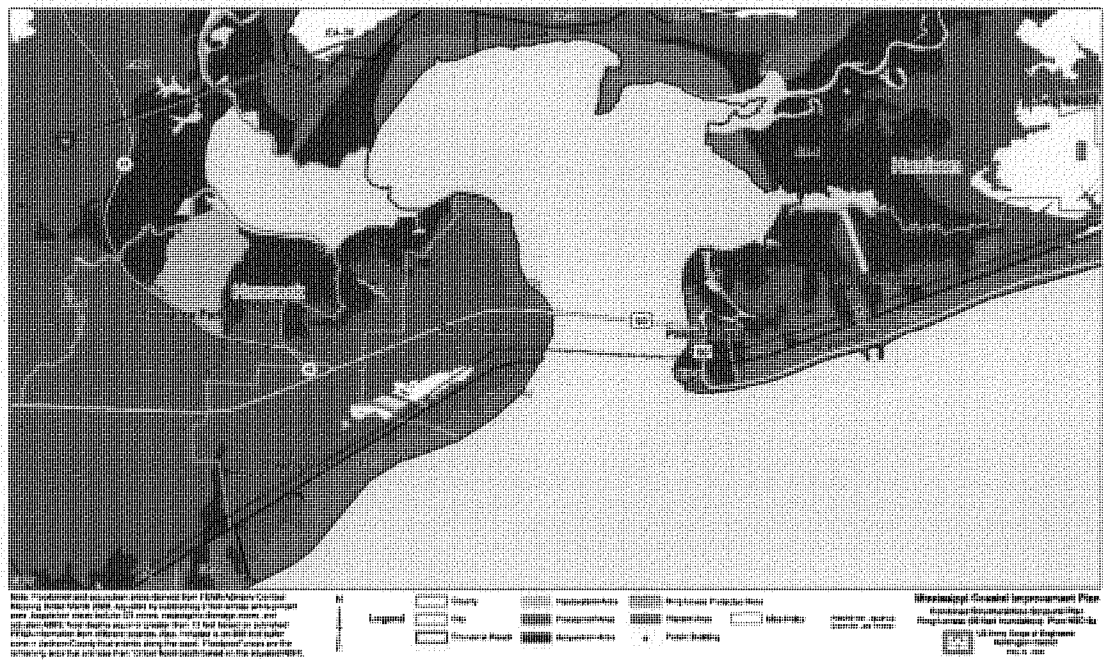


Figure 99 - Plan NSC-6a Combined Nonstructural and Structural Plan (A3)



1941

Figure 100 - Plan NSC-6a Combined Nonstructural and Structural Plan (A4)

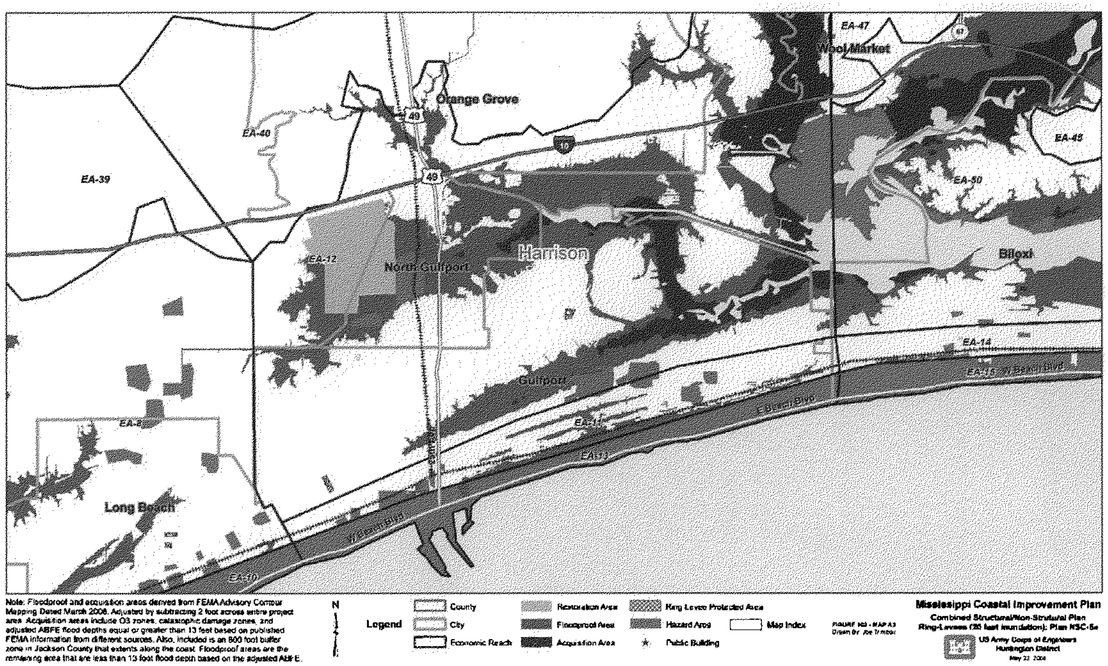


Figure 101 - Plan NSC-6a Combined Nonstructural and Structural Plan (A5)

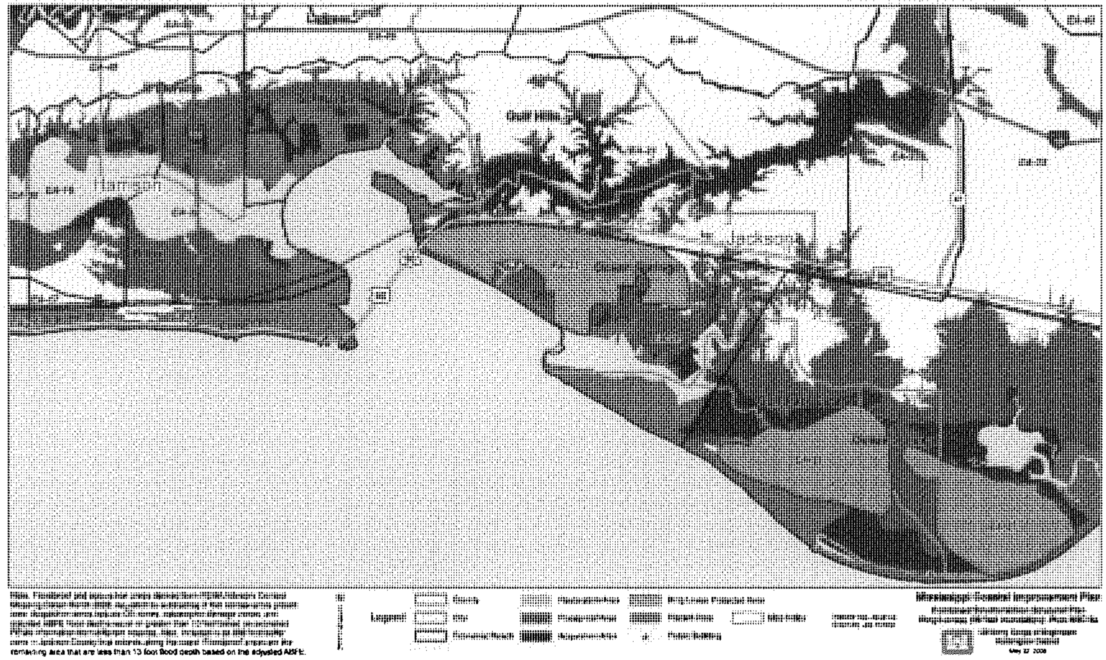


Figure 102 - Plan NSC-6a Combined Nonstructural and Structural Plan (A6)

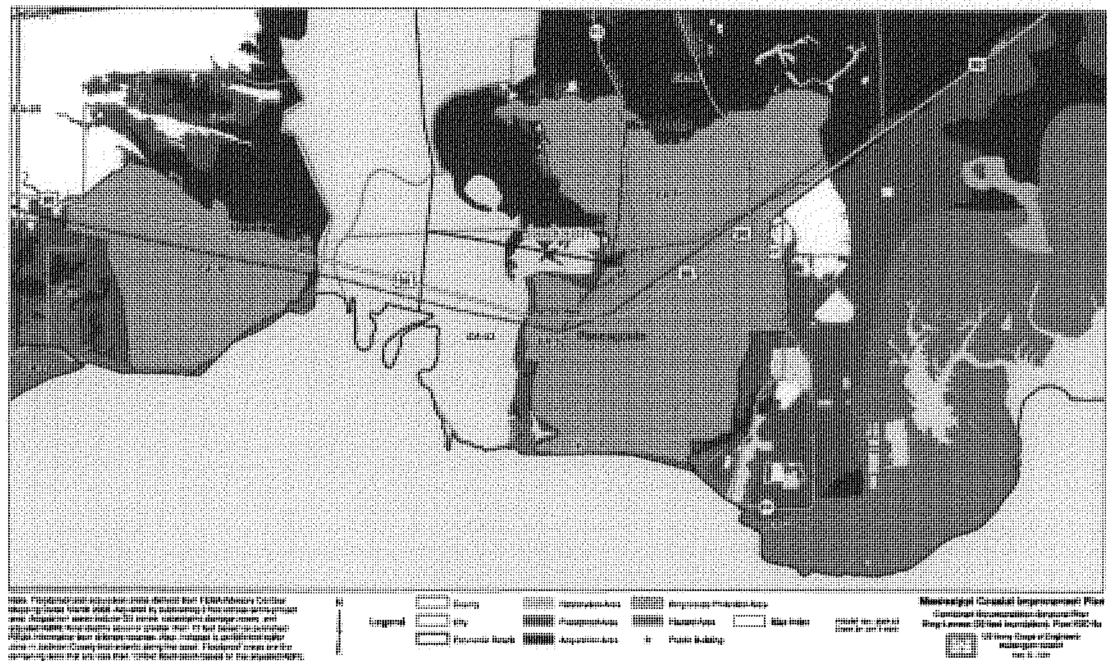


Figure 103 - Plan NSC-6b Combined Nonstructural and Structural Plan (A1)

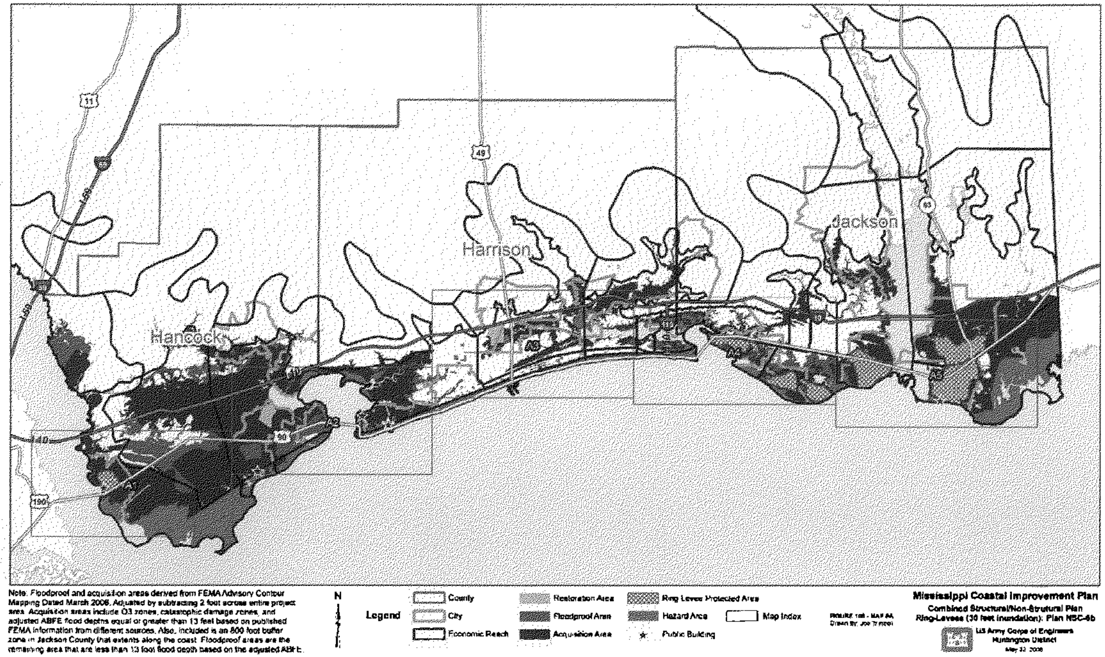


Figure 104 - Plan NSC-6b Combined Nonstructural and Structural Plan (A2)

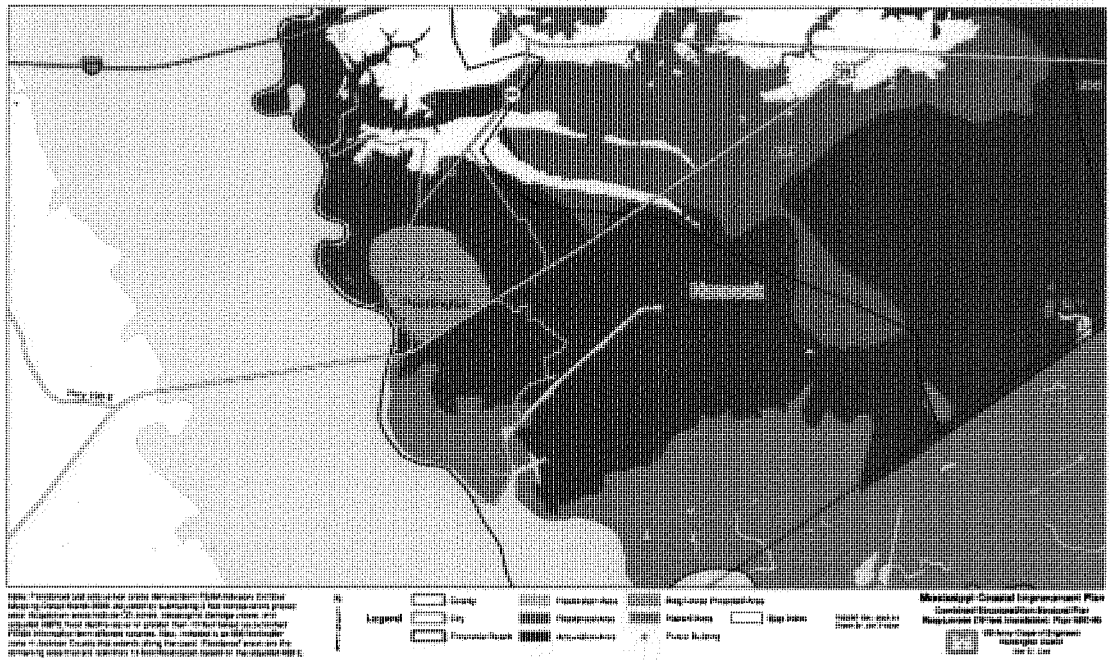


Figure 105 - Plan NSC-6b Combined Nonstructural and Structural Plan (A3)

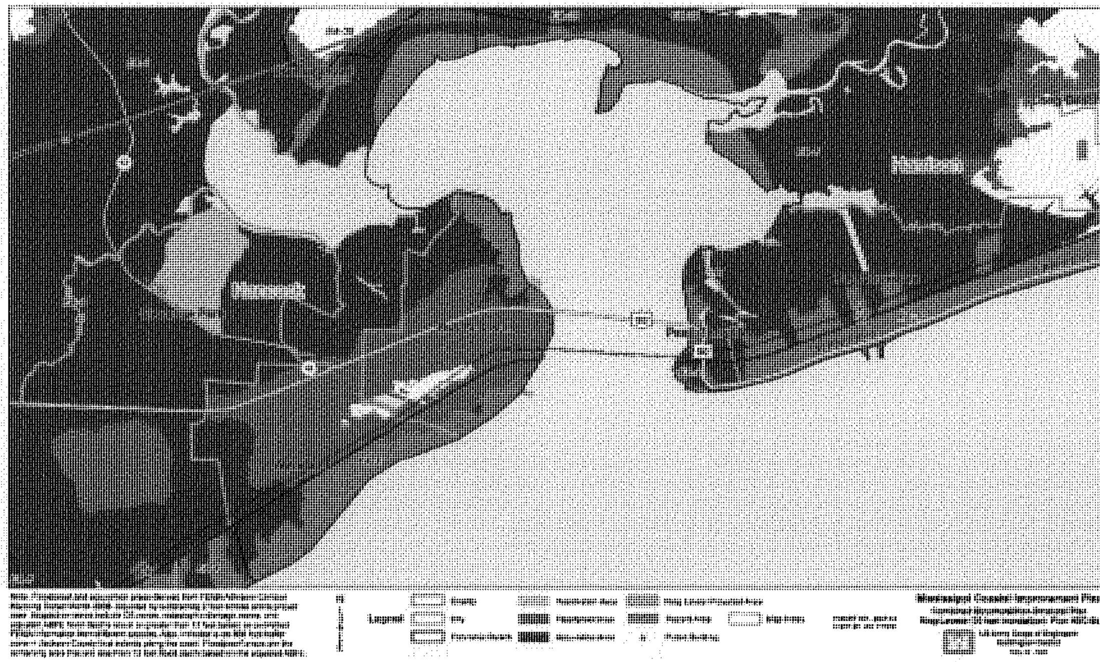


Figure 106 - Plan NSC-6b Combined Nonstructural and Structural Plan (A4)

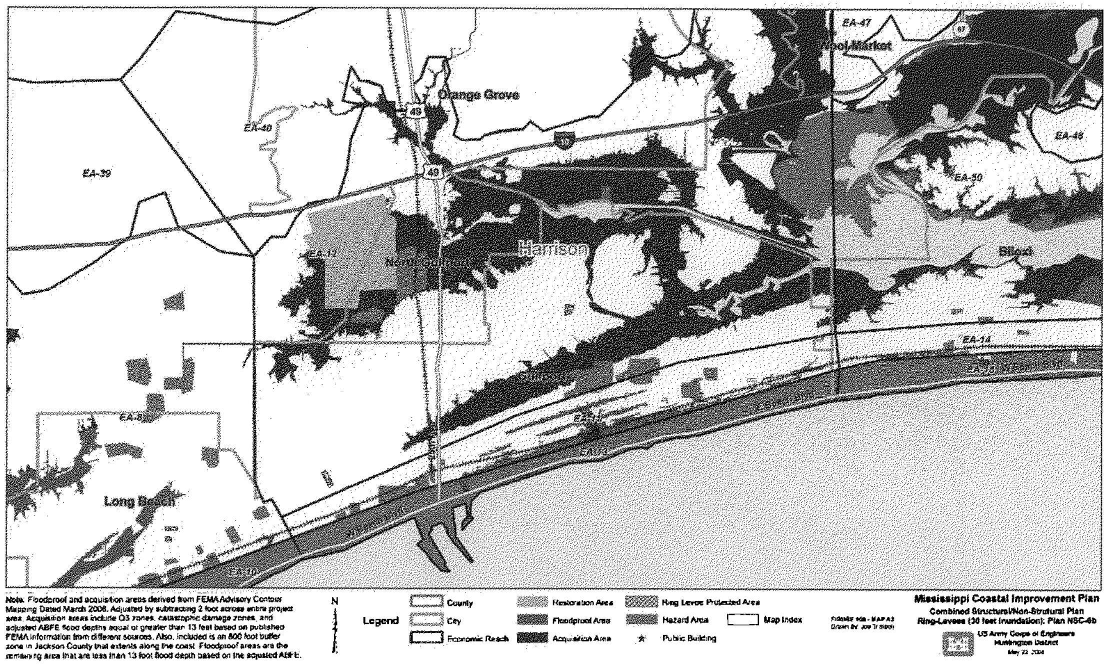


Figure 107 - Plan NSC-6b Combined Nonstructural and Structural Plan (A5)

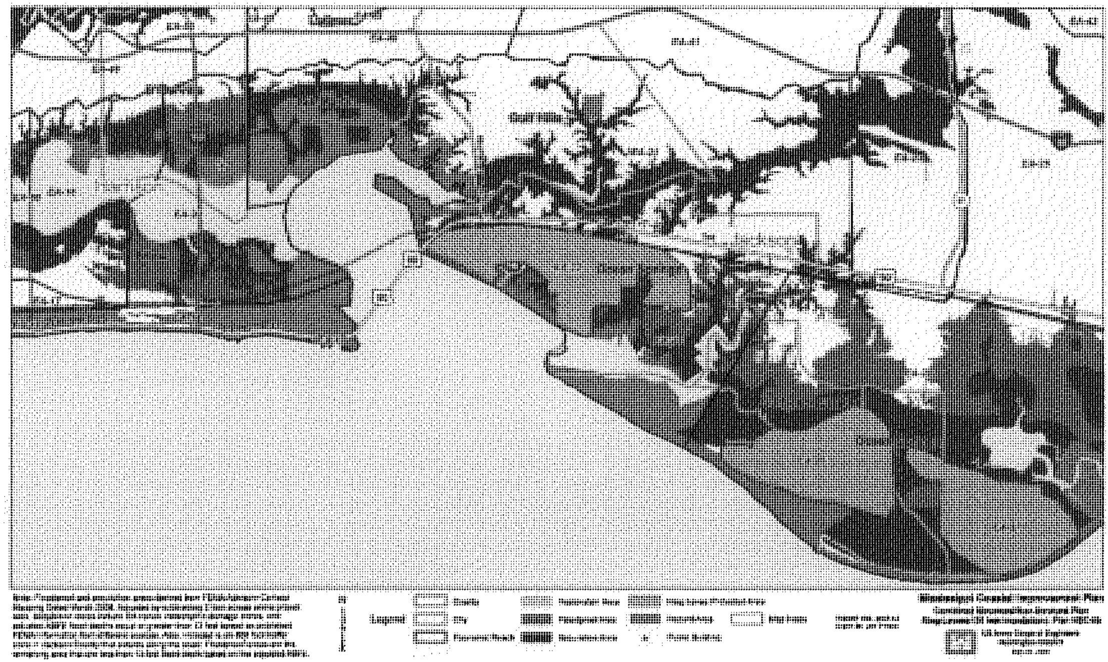


Figure 108 - Plan NSC-6b Combined Nonstructural and Structural Plan (A6)

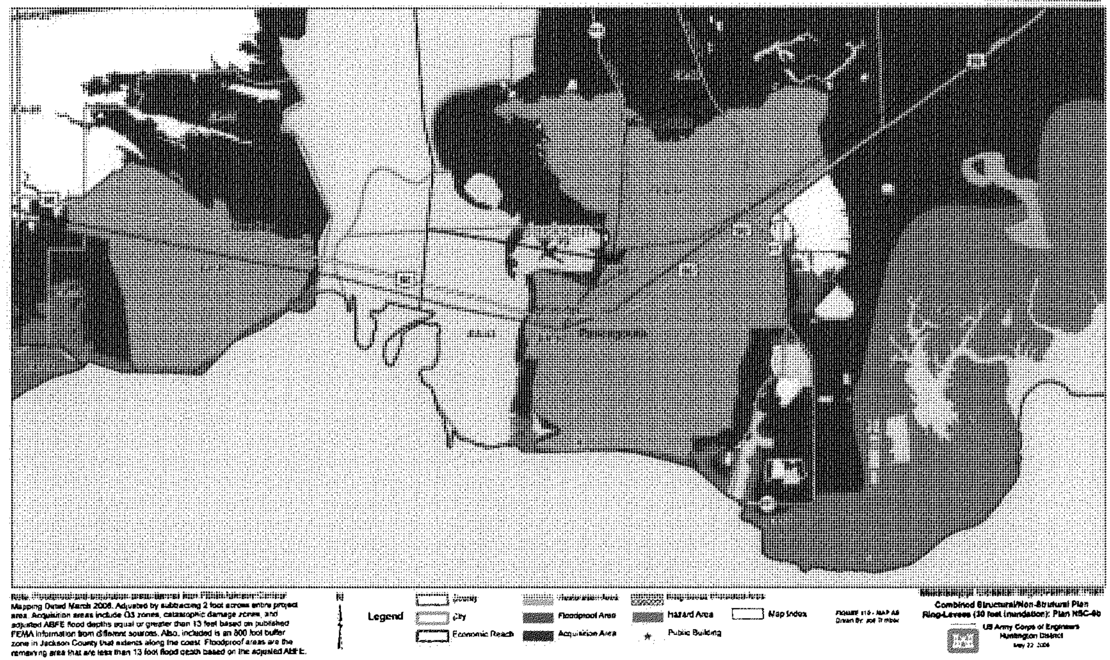
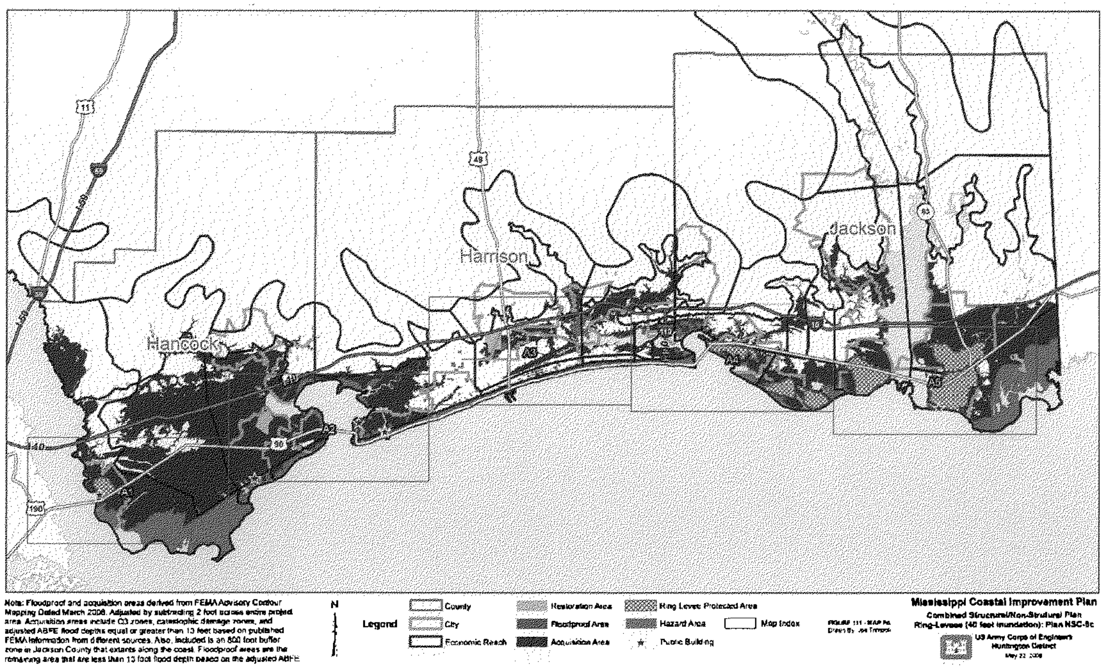


Figure 109 - Plan NSC-6c Combined Nonstructural and Structural Plan (A1)



Note: Floodproof and acquisition areas derived from FEMA Advisory Contour Mapping Dated March 2006. Adjusted by subtracting 2 foot across entire project area. Acquisition areas include C3 zones, catastrophic damage zones, and adjusted ABFE flood depths equal or greater than 13 feet based on published FEMA information from different sources. Also, included is an 800 foot buffer zone in Jackson County that extends along the coast. Floodproof areas are the remaining area that are less than 13 foot flood depth based on the adjusted ABFE

Figure 110 - Plan NSC-6c Combined Nonstructural and Structural Plan (A2)

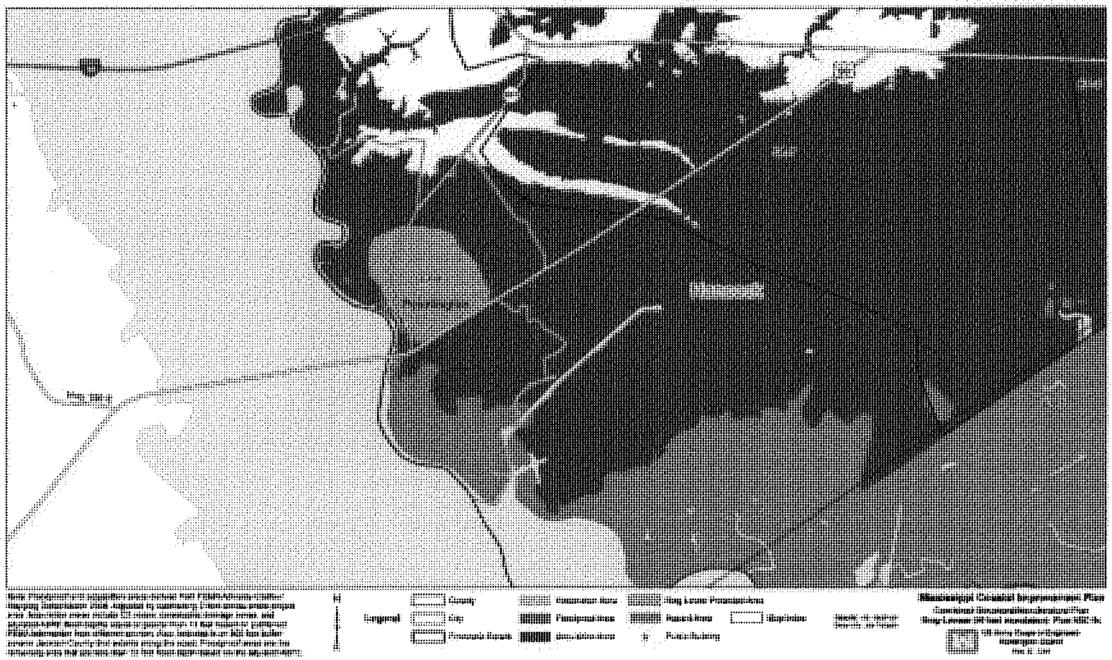


Figure 111 - Plan NSC-6c Combined Nonstructural and Structural Plan (A3)

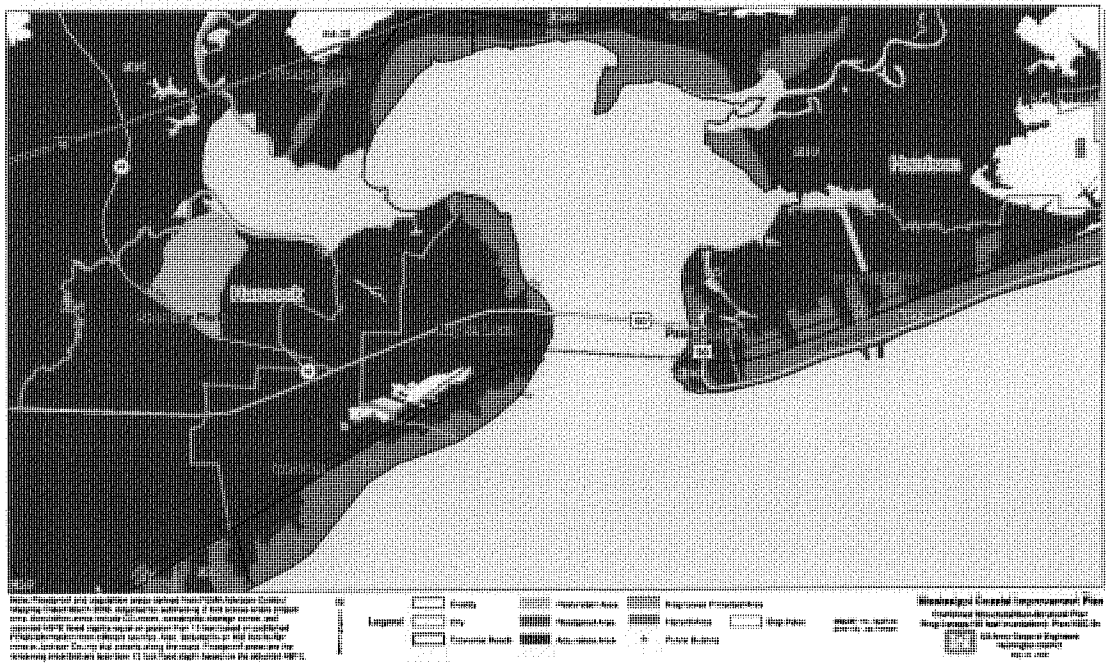


Figure 112 - Plan NSC-6c Combined Nonstructural and Structural Plan (A4)

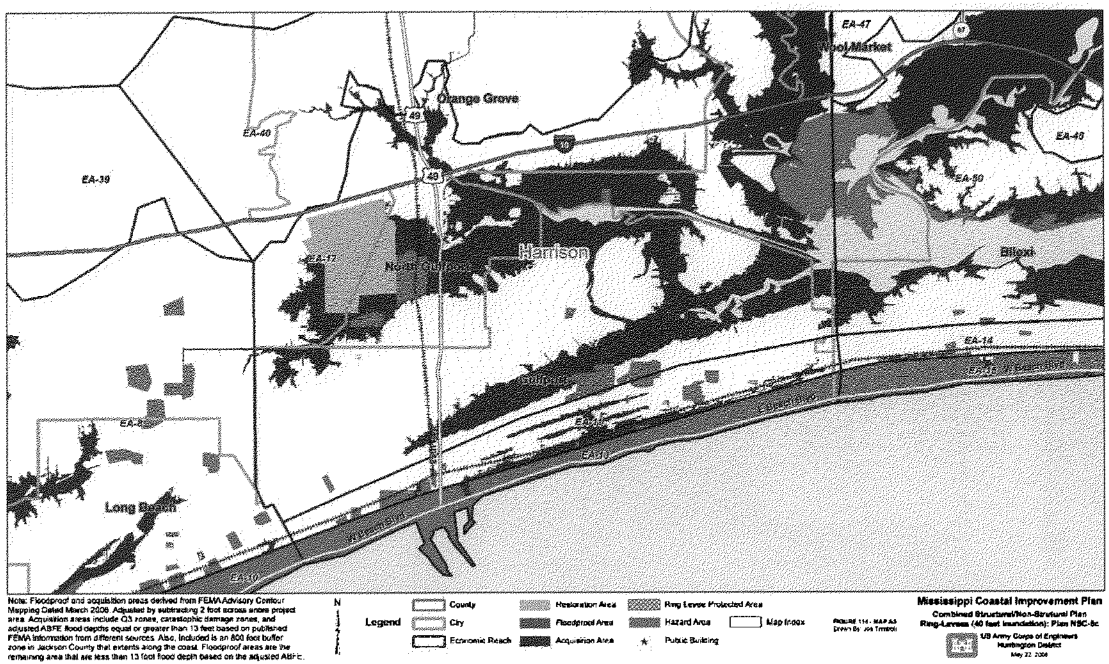


Figure 113 - Plan NSC-6c Combined Nonstructural and Structural Plan (A5)

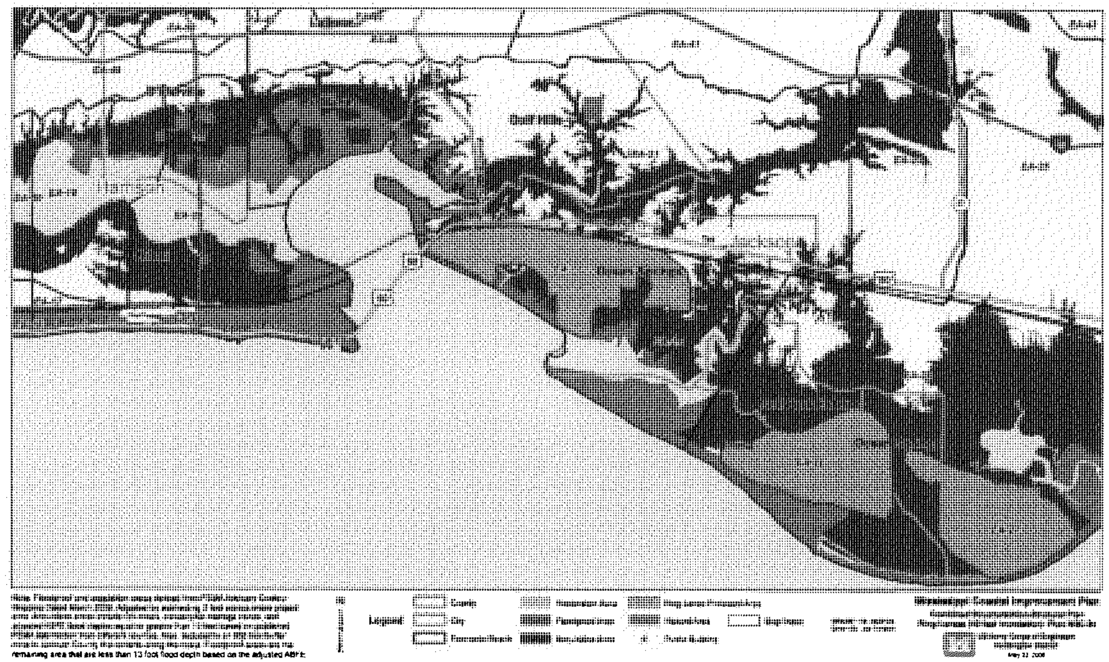


Figure 114 - Plan NSC-6c Combined Nonstructural and Structural Plan (A6)

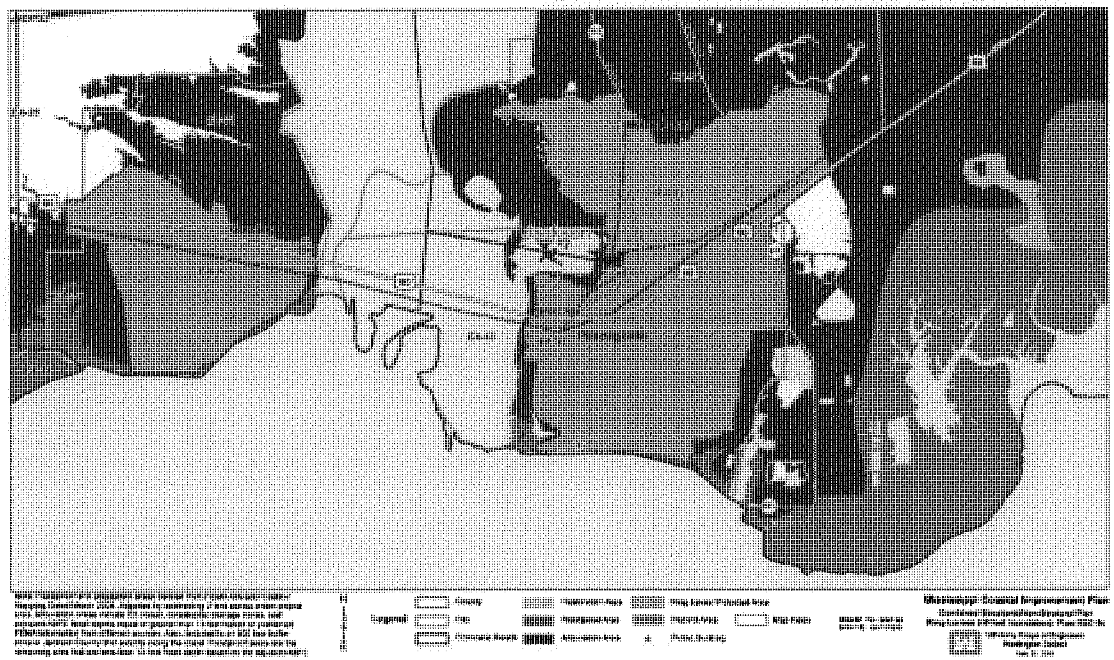


Figure 115 - Plan NSC-6d Combined Nonstructural and Structural Plan (A1)

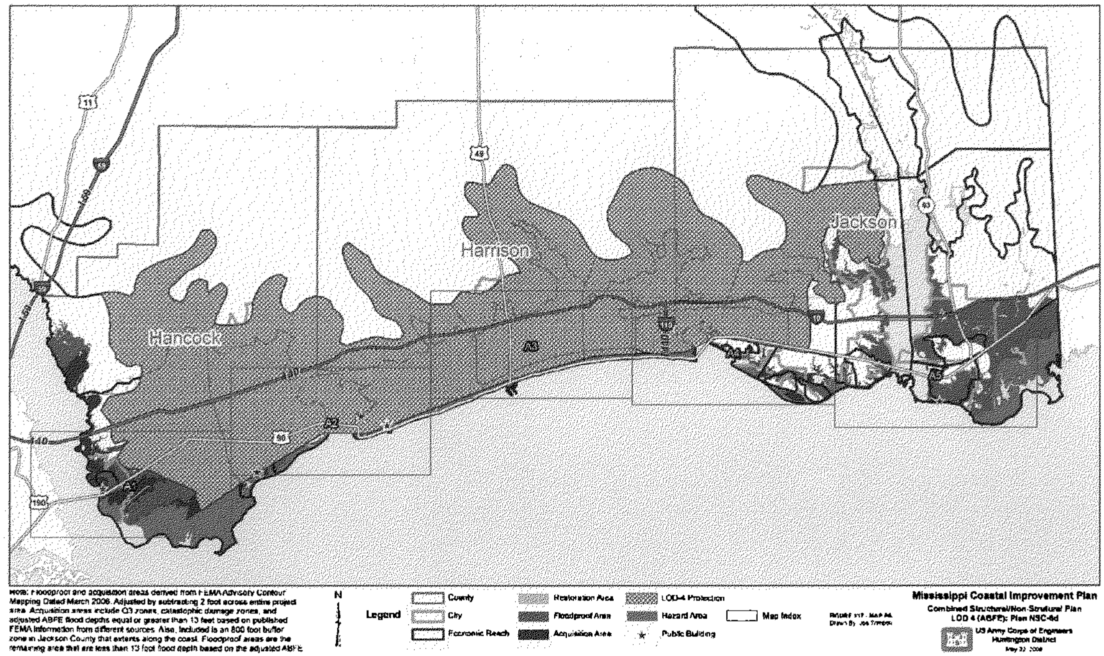


Figure 116 - Plan NSC-6d Combined Nonstructural and Structural Plan (A2)

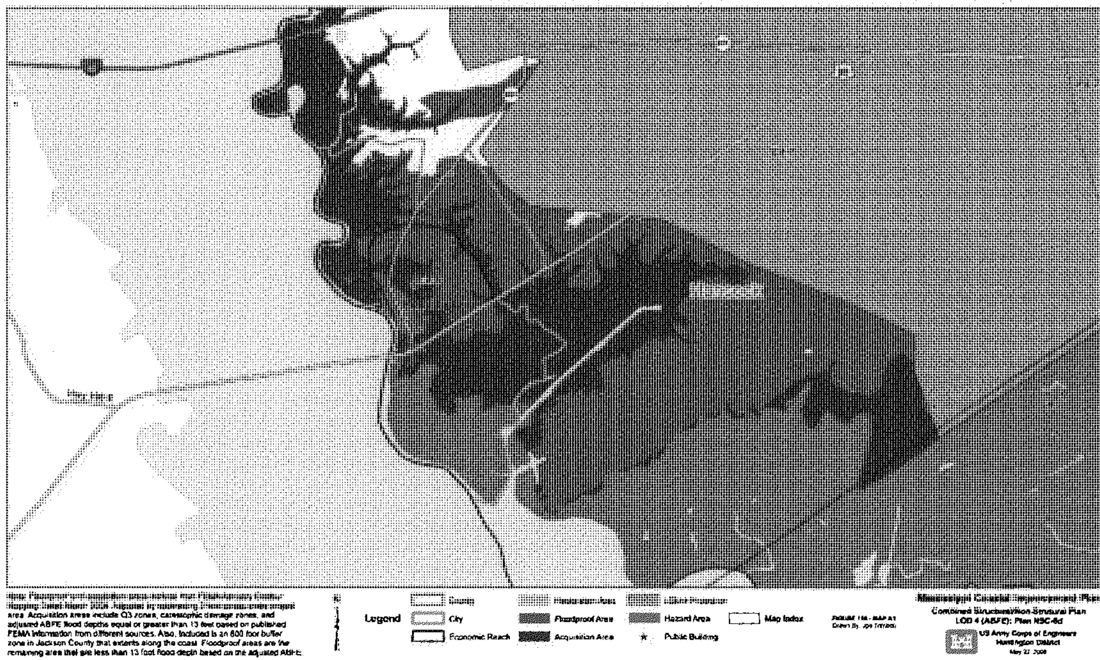


Figure 117 - Plan NSC-6d Combined Nonstructural and Structural Plan (A3)

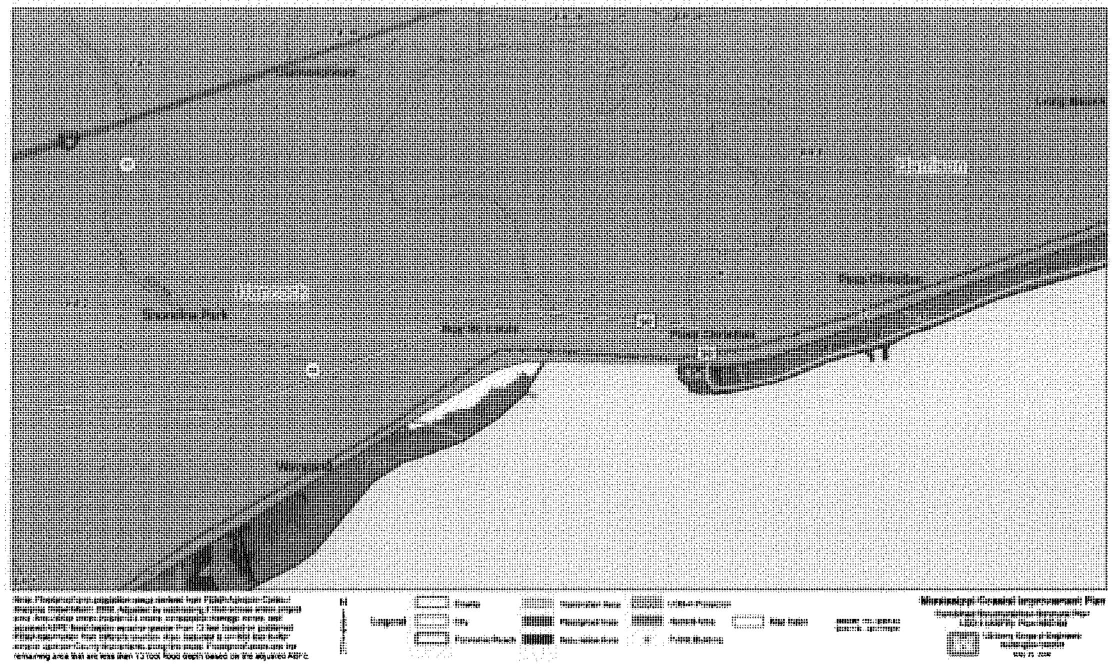


Figure 118 - Plan NSC-6d Combined Nonstructural and Structural Plan (A4)

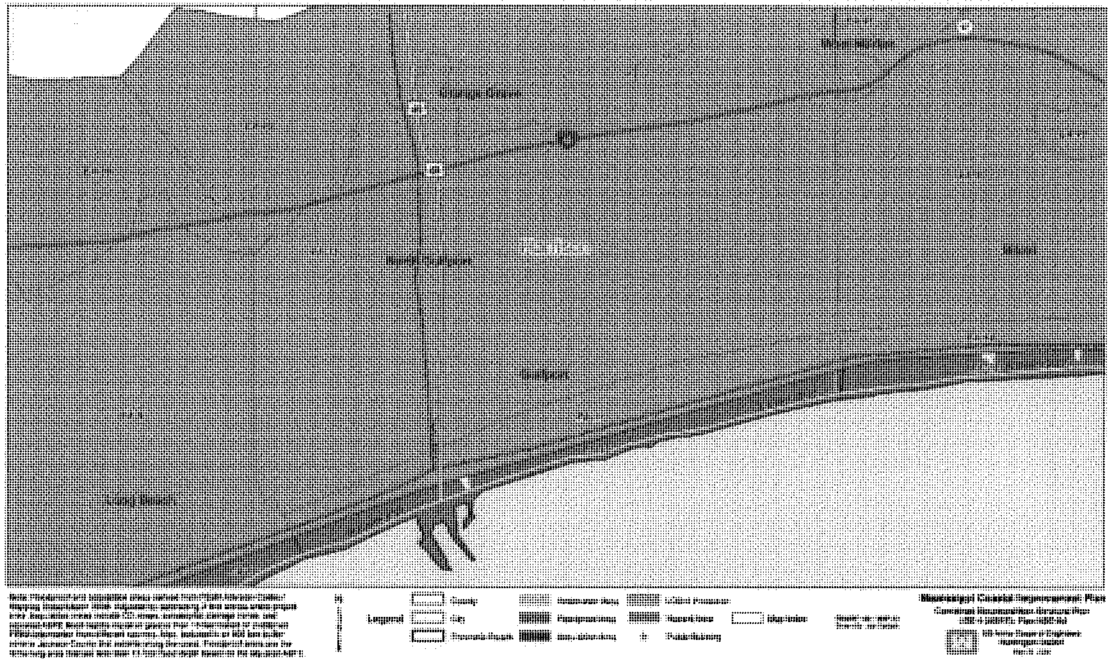
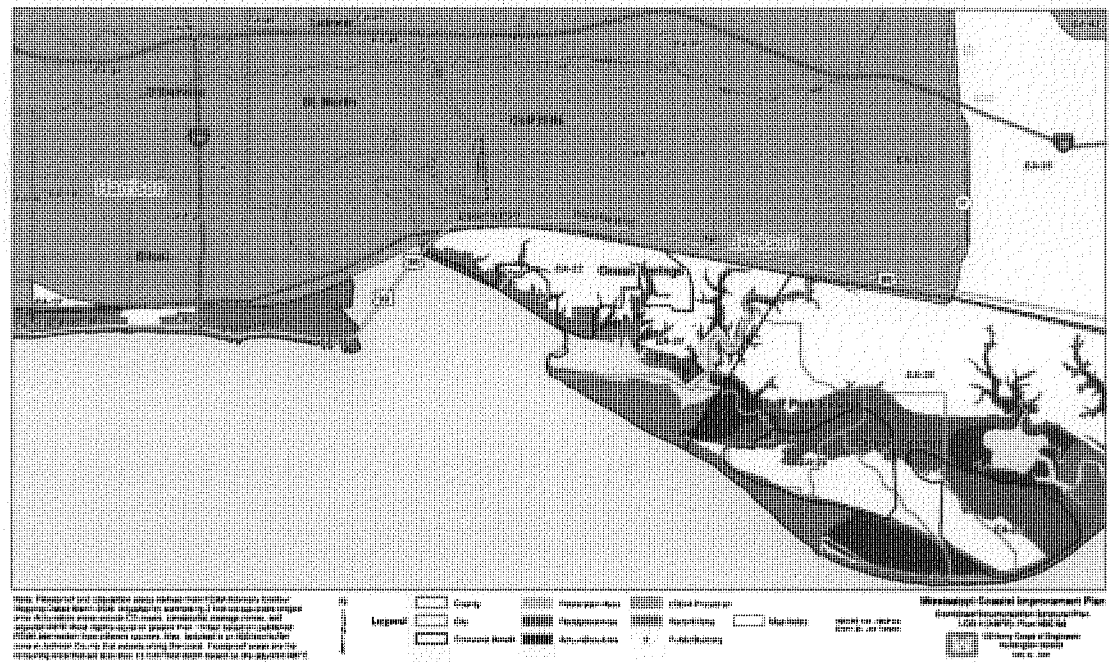


Figure 119 - Plan NSC-6d Combined Nonstructural and Structural Plan (A5)



1961

Figure 120- Plan NSC-6d Combined Nonstructural and Structural Plan (A6)

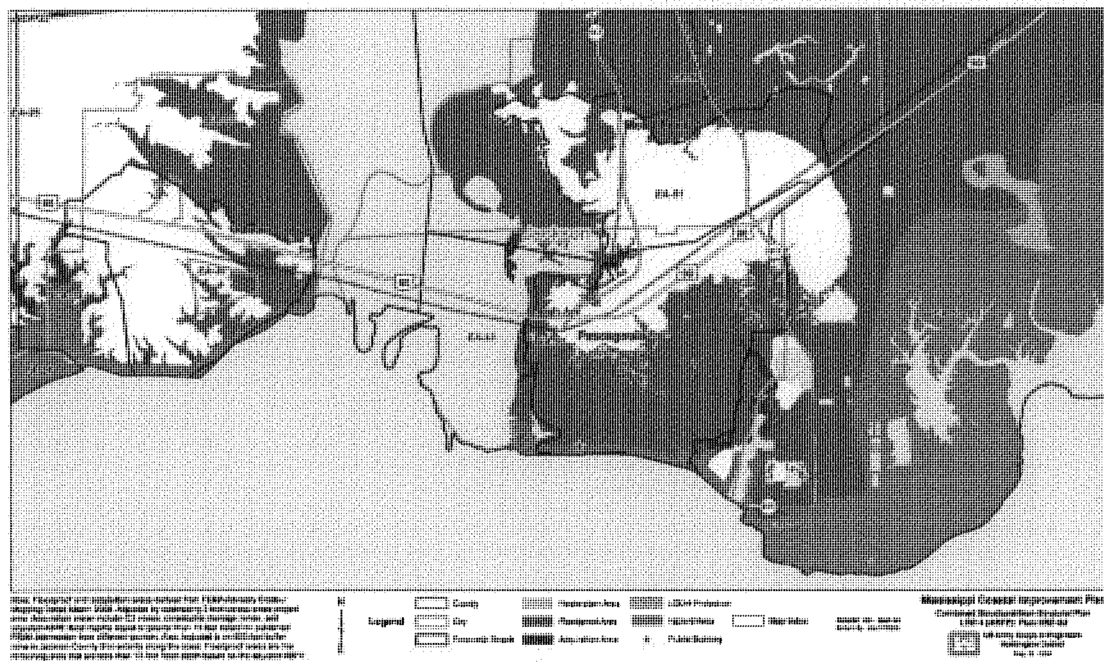


Figure 121- Plan NSC-6e Combined Nonstructural and Structural Plan (A1)

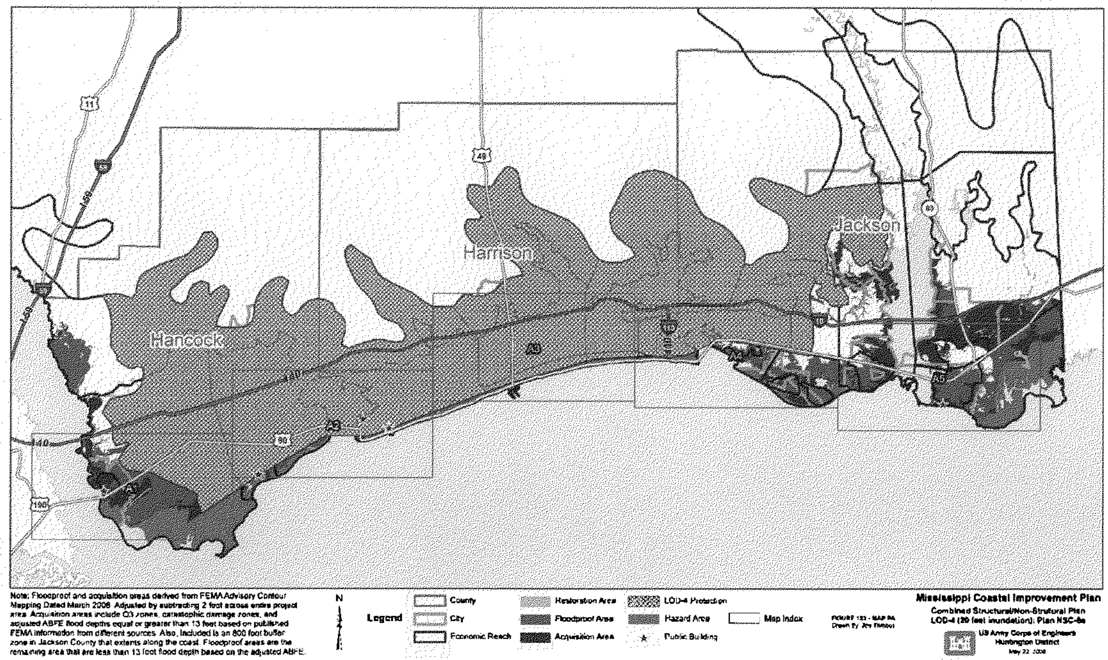


Figure 122- Plan NSC-6e Combined Nonstructural and Structural Plan (A2)

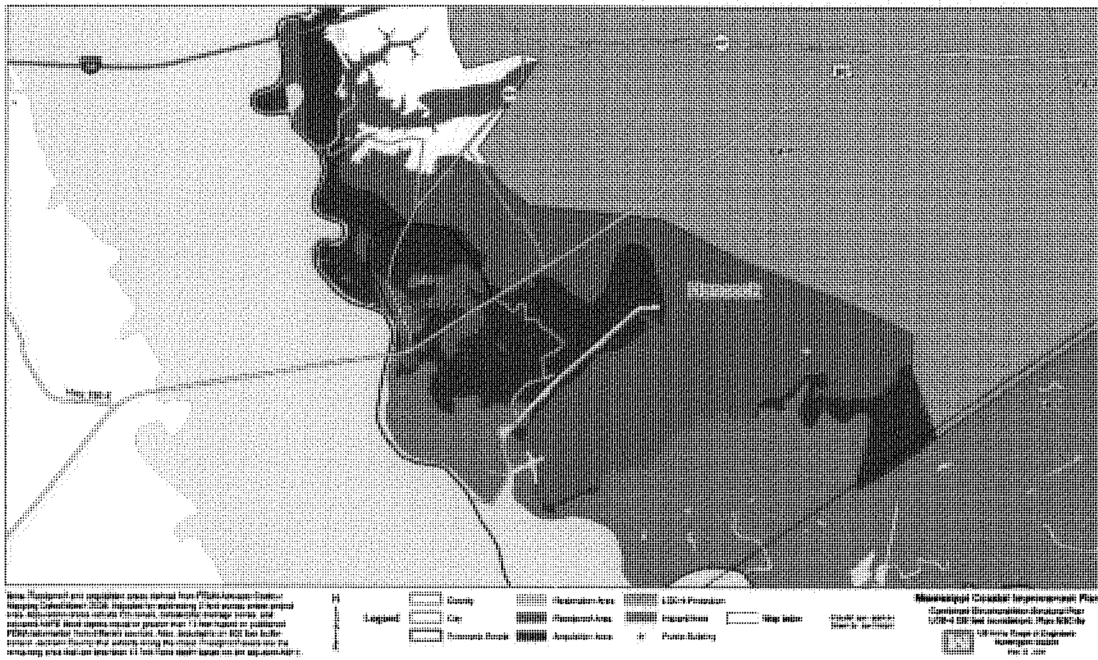
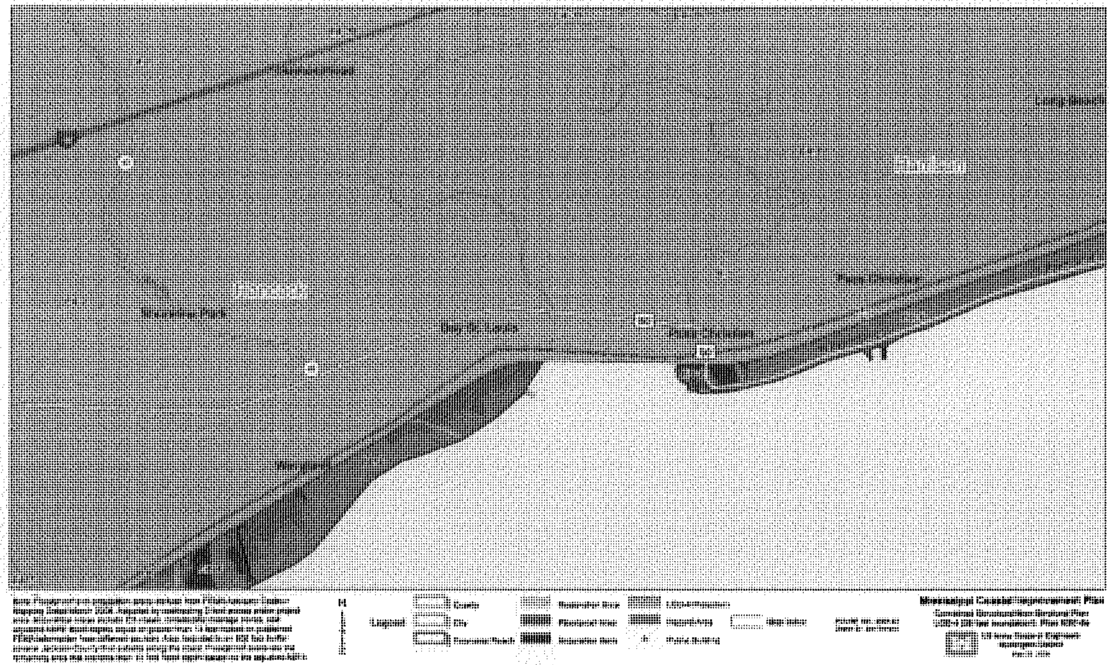


Figure 123 - Plan NSC-6e Combined Nonstructural and Structural Plan (A3)



1965

Figure 124 - Plan NSC-6e Combined Nonstructural and Structural Plan (A4)

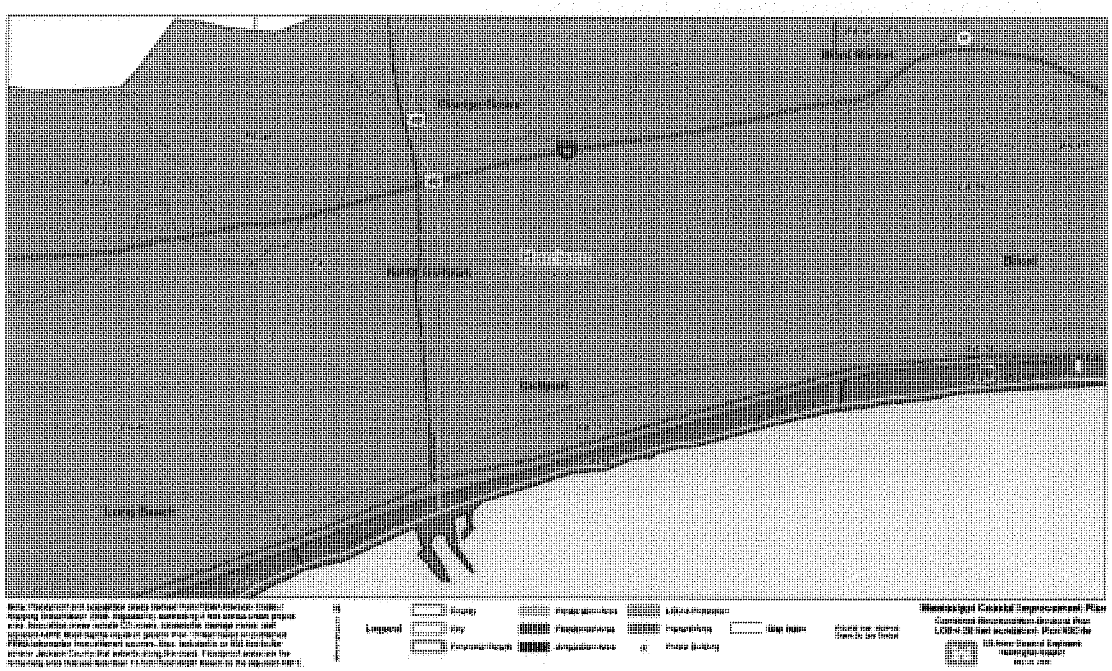


Figure 125 - Plan NSC-6e Combined Nonstructural and Structural Plan (A5)

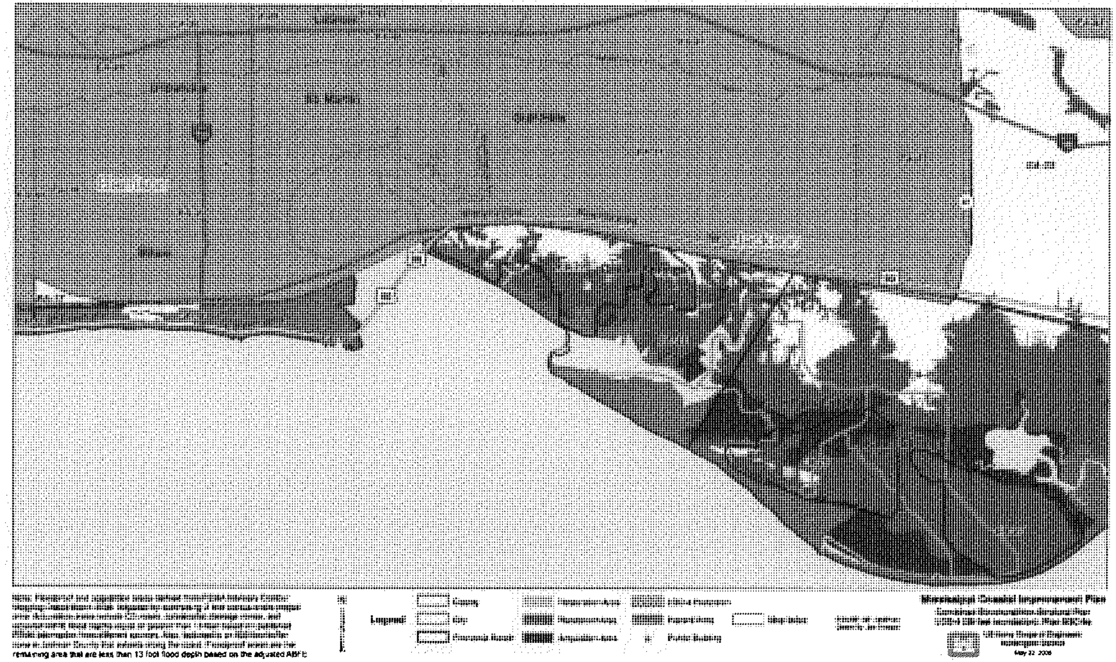


Figure 126 - Plan NSC-6e Combined Nonstructural and Structural Plan (A6)

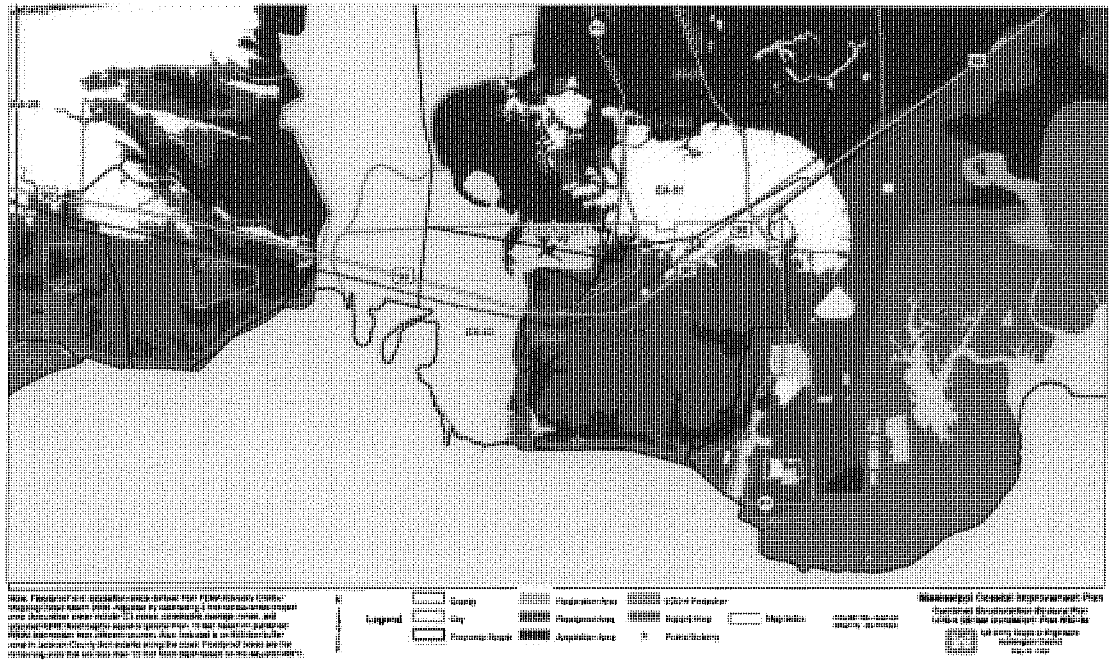


Figure 127 - Plan NSC-6f Combined Nonstructural and Structural Plan (A1)

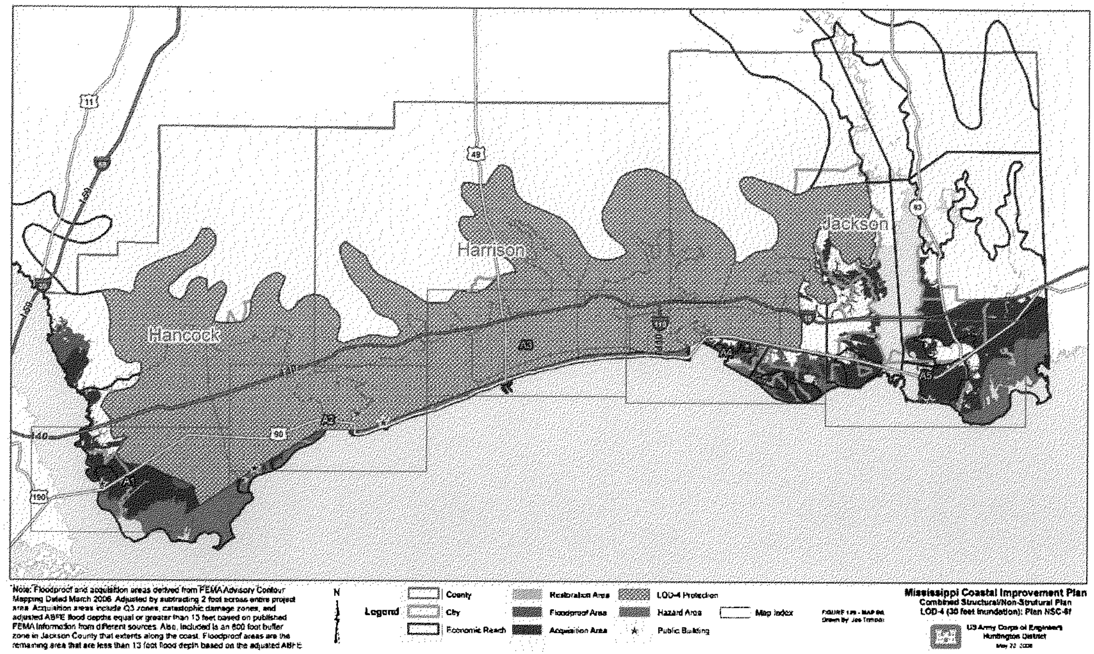


Figure 128 - Plan NSC-6f Combined Nonstructural and Structural Plan (A2)

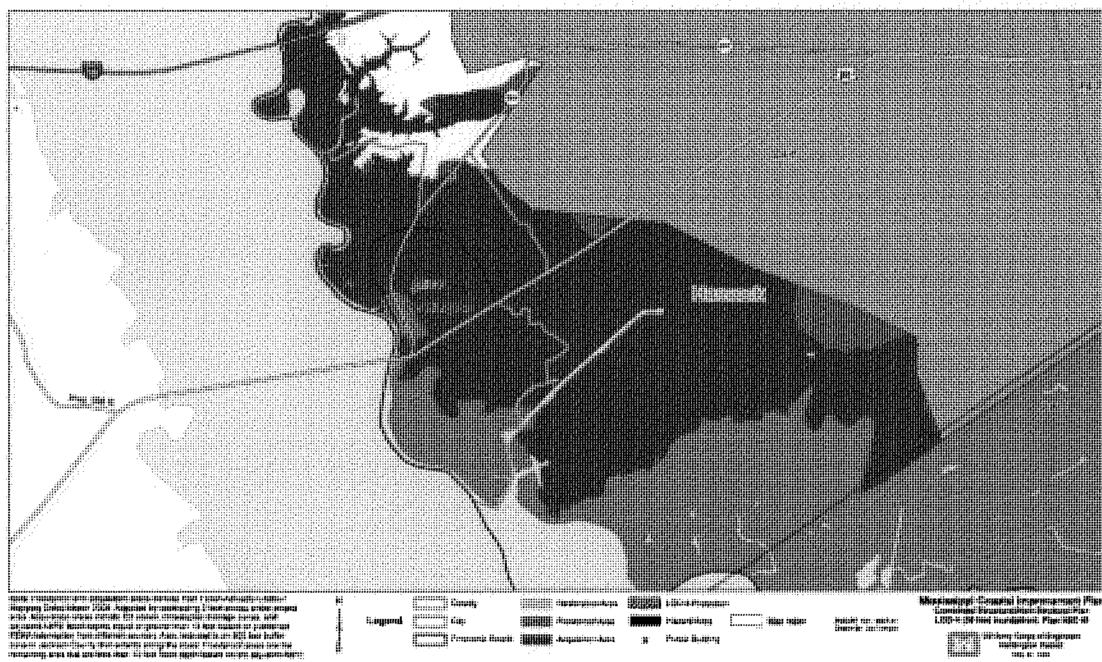


Figure 129 - Plan NSC-6f Combined Nonstructural and Structural Plan (A3)

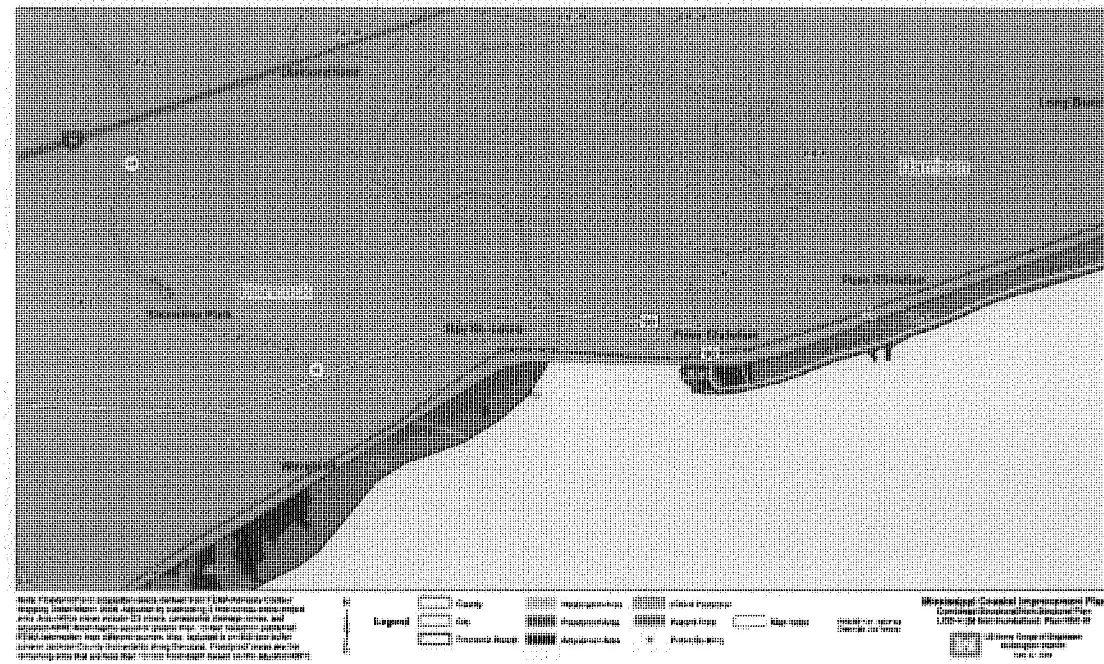


Figure 130 - Plan NSC-6f Combined Nonstructural and Structural Plan (A4)

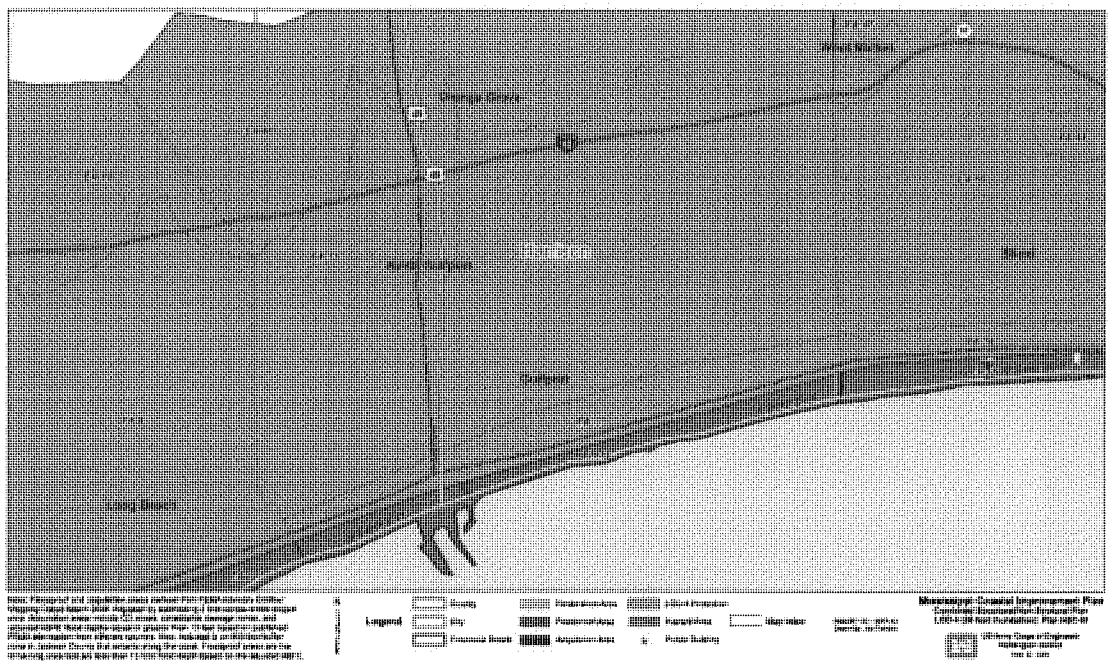
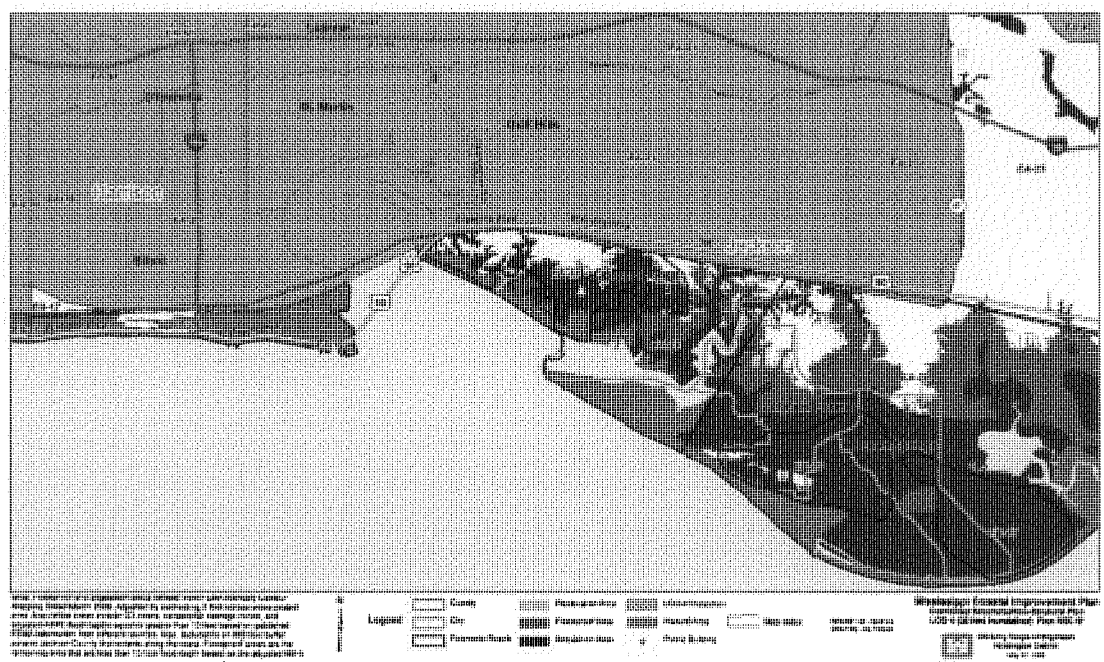


Figure 131 - Plan NSC-6f Combined Nonstructural and Structural Plan (A5)



1973

Figure 132- Plan NSC-6f Combined Nonstructural and Structural Plan (A6)

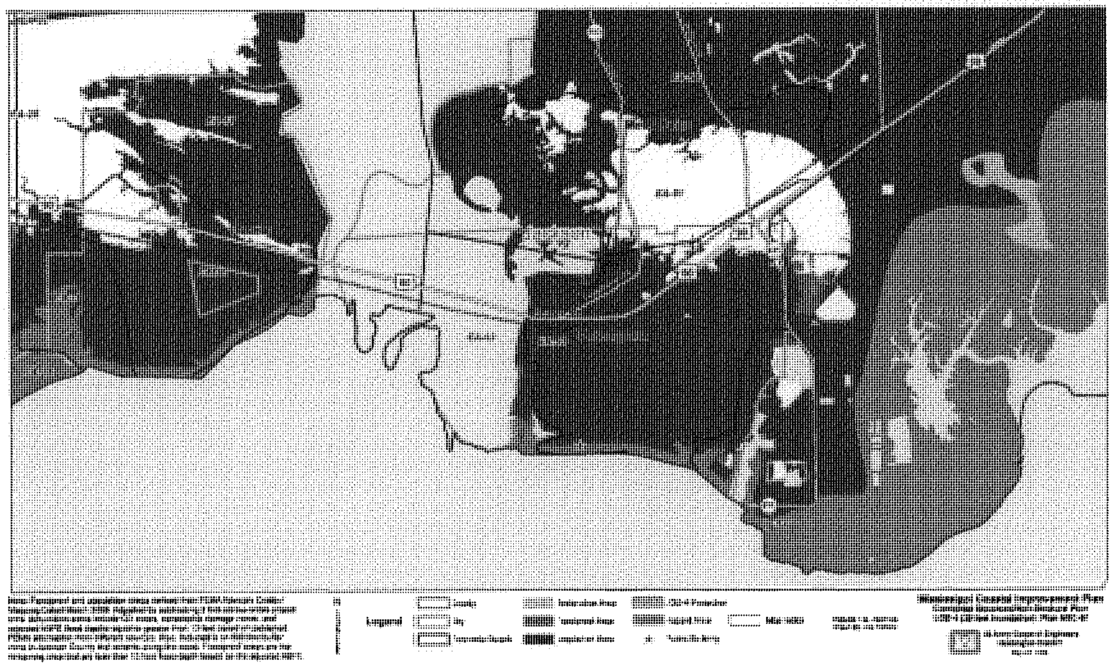


Figure 133 - Plan NSC-6g Combined Nonstructural and Structural Plan (A1)

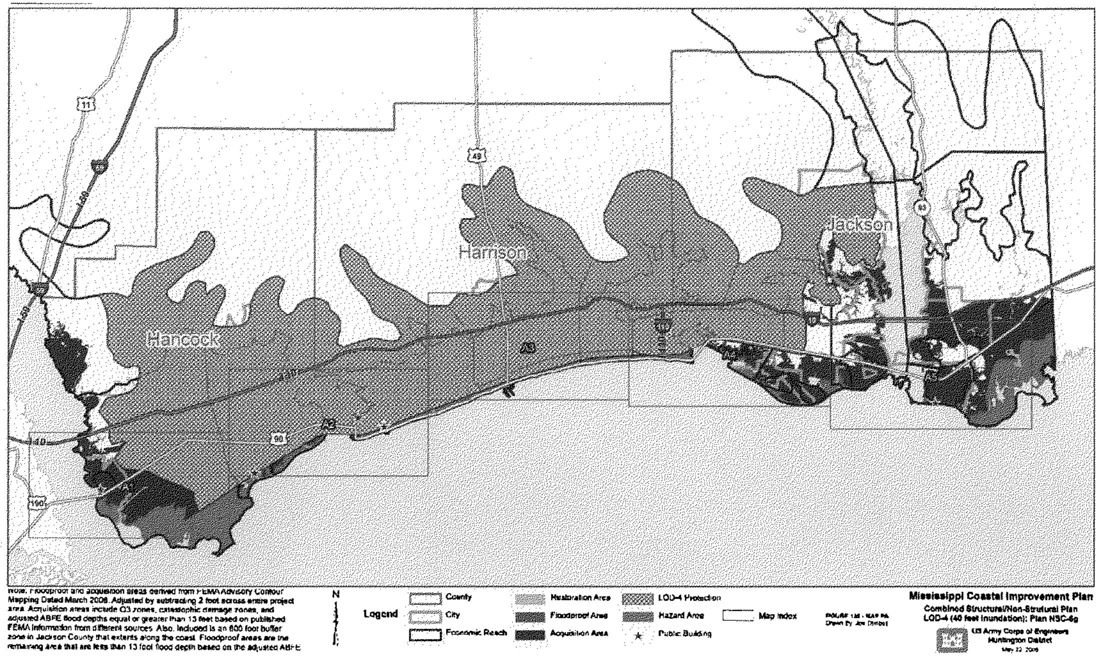


Figure 134 - Plan NSC-6g Combined Nonstructural and Structural Plan (A2)

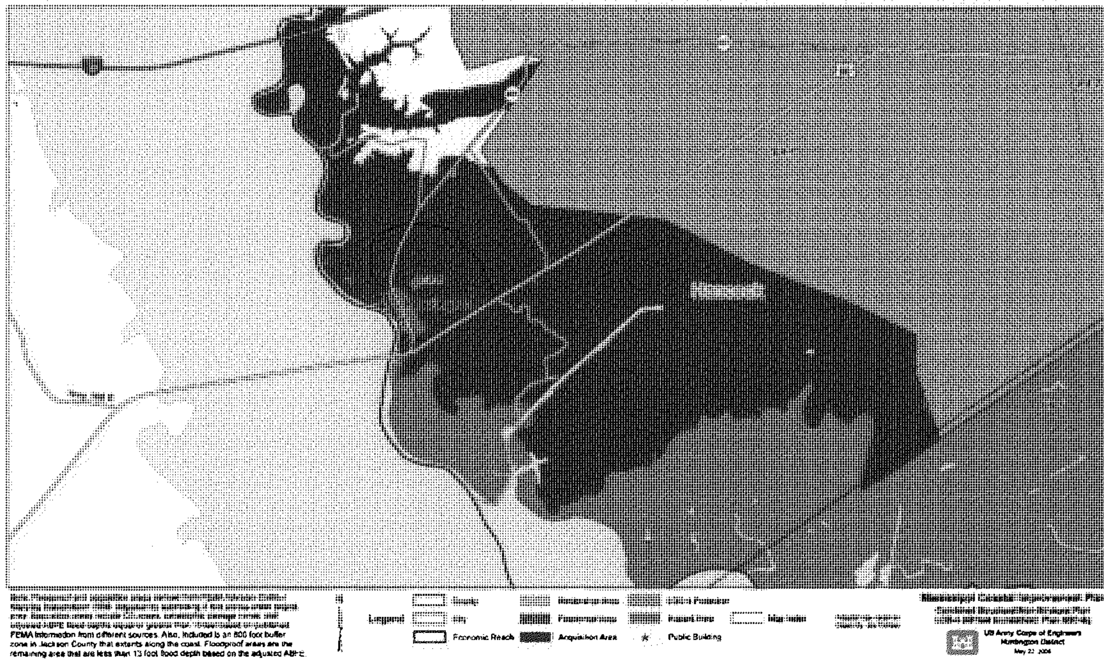


Figure 135 - Plan NSC-6g Combined Nonstructural and Structural Plan (A3)

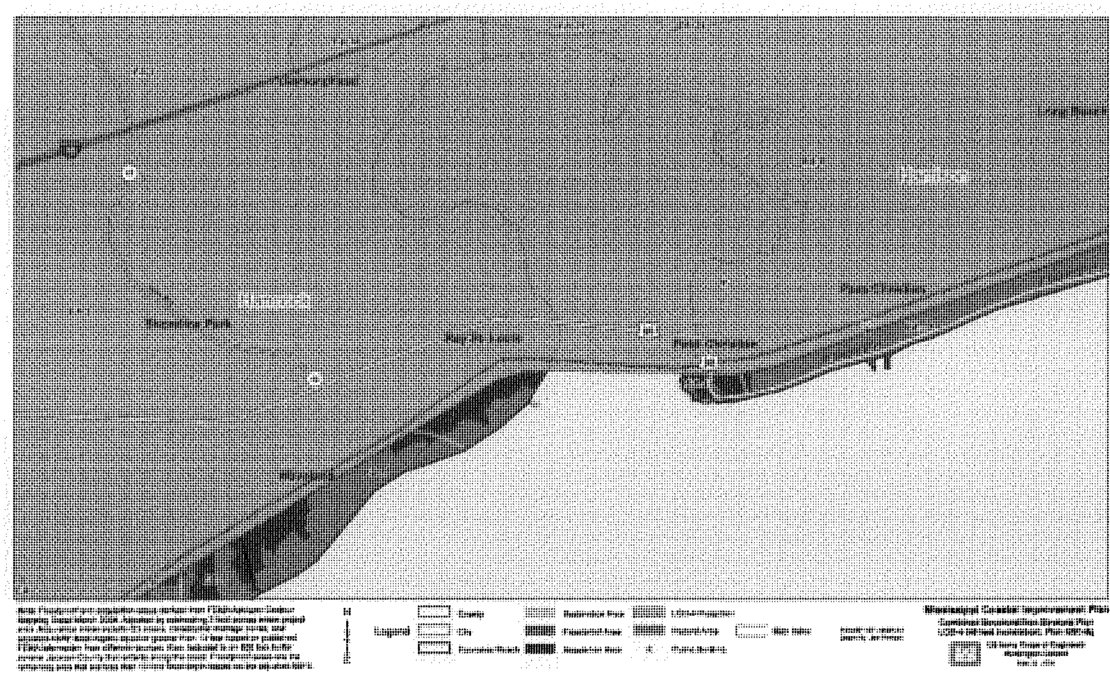


Figure 136 - Plan NSC-6g Combined Nonstructural and Structural Plan (A4)

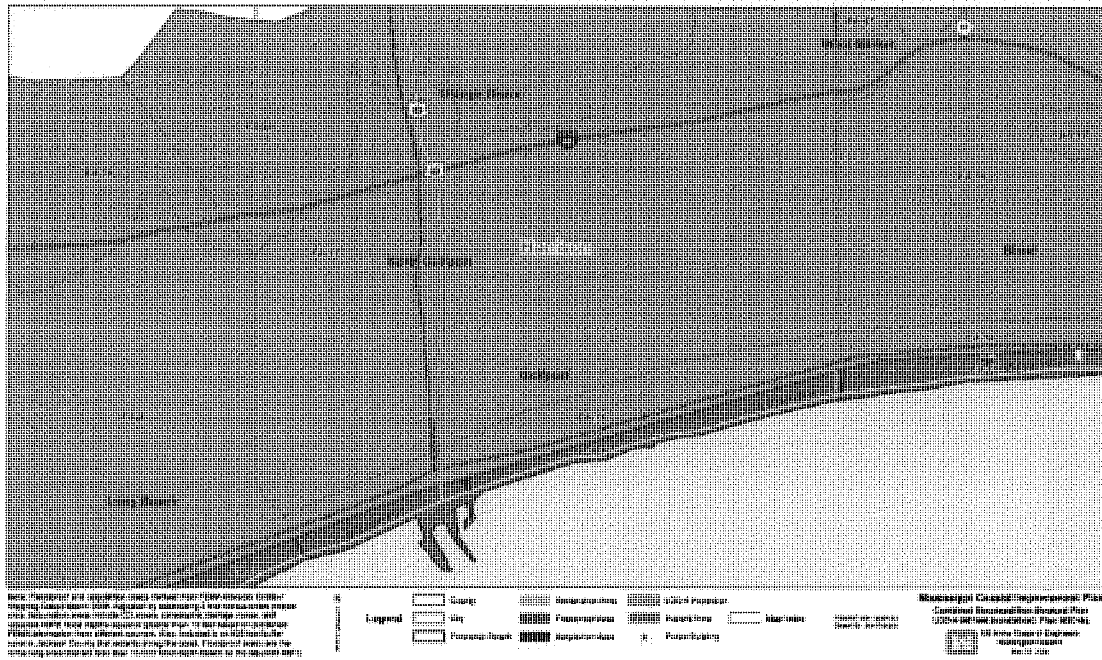


Figure 137 - Plan NSC-6g Combined Nonstructural and Structural Plan (A5)

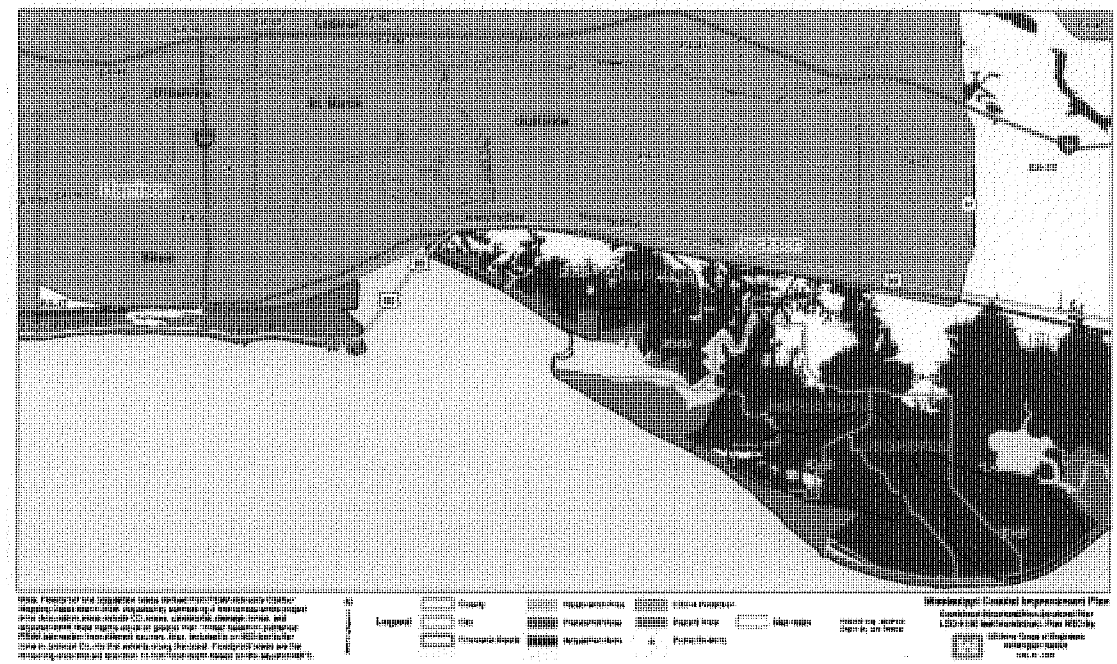
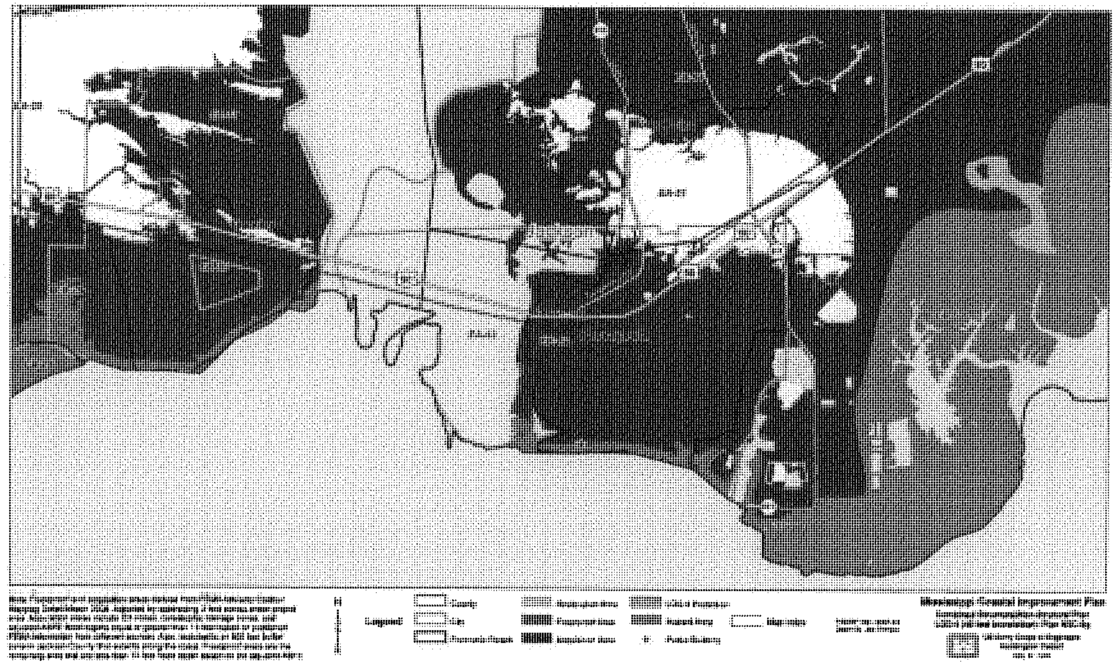


Figure 138 - Plan NSC-6g Combined Nonstructural and Structural Plan (A6)



CHAPTER 7. EVALUATION OF NONSTRUCTURAL PLANS

7.1 General

In Section 4.0 of this Appendix, several nonstructural measures were dropped from further consideration for one or more reasons related to either implementation cost; inability of the measure to meet one or more of the planning objectives, considered to be politically unpalatable, or would result in significant environmental, social or economic impacts to the coastal population. Environmental justice issues were cited several times in the determination to scrub a measure from further consideration. At that initial level of screening, an intuitive evaluation of the outputs of those dropped measures (based largely on experience of the NS PDT, lessons learned from past nonstructural project implementation and research) was sufficient to justify their closure in the process. The remaining measures, although with potential impacts, promise significant benefits or positive outputs if implemented. Having integrated those measures into several plans, identification, quantification and evaluation of their outputs must now be accomplished.

The evaluation process is composed of two steps: 1) assessment or the quantification of the plan affects (may be expressed in relative qualitative as well as quantitative terms) in monetary or numerical terms, and 2) appraisal or the judgment of the worth or significance of the output or improvement. Using these two components of evaluation, each output from each plan can be weighed in relative terms with all other outputs allowing trade-off analysis, sensitivity analysis, and best-deal determinations. At the level of planning detail conducted for the MS Coastal Comprehensive Plan many of the standard metrics used in evaluating plans at a feasibility level are unavailable due to the lack of base data for many of the proposed measures. Collecting and analyzing data for over 70,000 separate parcels of property (some with multiple tracts) requires far more effort in formulating nonstructural measures and plans than time or financial resources allowed in the study. Therefore much more qualitative evaluation is used in the appendix than would normally be used in a standard feasibility study.

In addition, since time and funding constraints did not allow a full economic analysis of each of the several nonstructural plans, only the average annual damages reduced for acquisitions and floodproofing in Plan NSC-1 at the ABFE level were generated in HEC-FDA. This Appendix only identifies, evaluates and compares various nonstructural plans and should not be used as the only document for recommending implementation of any of the plans described herein. Therefore, allowances with the average annual damages figures were taken for comparison of the plans at the ABFE level of inundation. For plans that had either more or less amounts of acquisitions or floodproofing at the ABFE level, the average annual damages were proportionately applied to the various plans (by parcel protected) to compare their outputs.

Subsequent to completion of this evaluation process, the structural alternative labeled "LOD 4" was screened from the list of alternatives due to unsustainable annual O&M costs for the surge gates. Therefore all evaluations involving the structural measure LOD 4 and nonstructural measures shown in plans NSC-6d through NSC-6g are provided for reference only. The combined alternatives that include ringwalls and ring-levees and nonstructural measures (NSC-6 through NSC-6c) are still valid plans for consideration.

The assessment process begins with quantifying and describing the outputs from each formulated plan that would be anticipated to occur in the future with one of the plans (projects) in place. This "future-with project condition" is described below.

7.2 Future With-Project Conditions

7.2.1. General:

The evaluation of nonstructural plans begins with a description of the anticipated future with-project conditions that would emerge if one of the nonstructural plans were to be implemented. The reviewer must remember that the performance of each nonstructural plan is predicated only upon protection to the minimum inundation level of the Advisory Base Flood Elevation. Each of the formulated plans will produce a different future for the project area than would have occurred in the absence of any one of the plans (the future without-project conditions).

The descriptions of these conditions are based upon the stated objectives of the planning process and the metrics determined by the team. Metrics such as reduced flood damages, reduced threats to loss of life, increased wetland acres, reduced emergency costs, and residual damages are all used to define the anticipated future with-project condition. Other benefits of the plans that were not anticipated are likewise noted for each plan. The descriptions of these conditions in whatever metrics may be applicable (monetary flood damage reduction benefits, acres of ecosystem, lives at less risk, improvements to current housing stock, or reductions in emergency costs) are compared with the conditions of the without-project future for the same area to determine whether a plan is worthy of implementation when compared to other alternative plans.

To simplify this process, the various plans are displayed in Table 34 showing the anticipated future with-project conditions in the project area that may occur as a result of their implementation. As the matrix shows, many of the plans generate measurable (quantifiable) outputs such as the reduction of damages, plan and per unit costs for protection and numbers of parcels offered protection to some degree. Several of the plans demonstrate an ability to reduce the potential threats to life and safety due to inundation drowning and still others generate substantial numbers of relocations to flood-safe living units. In many cases, the outputs of each plan are measurable in monetary units, acres protected, structures protected or acres of potential ecosystem restoration land evacuated. In other cases, the plan outputs are either difficult to measure quantitatively or time/funding constraints limited the team's ability to collect the necessary data to support the measurement of the plan outputs and therefore the output is described in qualitative terms.

7.2.2 Plan Outputs:

7.2.2.1 Plan NS-PAHHZ:

This plan provides substantial protection for beachfront structures and their occupants that are at highest risk of severe structural and content damages and loss of life. Field investigations revealed that a substantial number of parcels were made vacant (total structure loss) by Katrina in this zone. Post-Katrina estimates were that at least 30,000 residential structures were destroyed by Katrina and considering the high incidence of structure and content flood related damages in this zone (nearly 90% total loss), reducing damages to residential structures is considered a significant affect.

Composed of one measure, permanent acquisition, this plan affects 14,997 parcels (approximately 7,500 structures) within the three counties. Using a proportionate share of the average annual damages calculated for the ABFE (Plan NSC-1), this plan reduces the without-project average annual damages by approximately $92.0M.

Table 34.
Future With-Project Conditions

PLANS / Parameters/Measures	Plan NS-PAHHZ	Plan NS-PA100	Plan NSC-1 – Federal Agencies Action Plan	Plan NSC-2 – Wet and Dry Floodproofing W/FWEE Upgrades	Plan NSC-3 – Joint Federal and Non-Federal Jurisdiction Plan	Plan NSC-4 – Non-Federal Jurisdiction Plan	Plan NSC-5 – Loss of Life Reduction Plan	Plan NSC-6 – Combined *Structural and Nonstructural* Plan
Flood Damages Reduced Units Protected	14,997 Total Parcels Removed from Future Development $92.0M AAD Prevented	33,191 Total Parcels Removed from Future Development. $210.0M AAD Prevented	58,617 Total Parcels Protected $315.0M AAD Prevented	25,419 Total Units Protected $105.0M AAD Prevented	At least 58,617 Total Parcels Protected , At least $315.0M AAD Prevented	95,000 Total Units Protected 1) AAD reduced are undetermined at this time	14,997 parcels removed from Future Development $92.0M AAD Prevented	Reductions in AAD have not been computed for the scaled plans greater than the ABFE. ABFE reductions are in Plan NSC-1
Total Plan Cost Cost per Unit Protected	$6.1B $404K/parcel	$8.2B $248K/parcel	$18.7B $323K/parcel	$10.8B $425K/parcel	$19.1B $325K/parcel	$5.5M Cost per unit is undetermined at this time.	$6.1B $404K/parcel	Plan costs range from $8.7B to $25.3B with cost per unit of $288K/parcel to $296K/parcel
Permanent Acquisition (including HARP)	14,997 Parcels Removed from Future Development $92.0M AAD Prevented	33,191 Parcels Protected $210.0M AAD Prevented	33,191 Parcels Protected $210.0M AAD Prevented	Although this plan is purely floodproofing, there could be some acquisitions as an option, but the numbers are unknown at this level of planning.	33,191 Parcels Protected $210.0M AAD Prevented	No permanent acquisitions. A TDR or PDR program could purchase development rights at 80% of the total property value for over 27,000 vacant lots	14,997 parcels removed from future redevelopment $92.0M AAD Prevented	Units Protected range from 44,088 to 85,447 Damages prevented are not available.
Total Permanent Acquisition Cost Cost per Unit Protected	$6.1B $404K/parcel	$8.2B $248K/parcel	$7.9B $323K/parcel	Although this plan is purely floodproofing, there could be some acquisitions as an option, but the numbers are unknown at this level of planning.	$7.9B $323K/parcel	No permanent acquisitions. A TDR or PDR program could purchase development rights at 80% of the total property value for over 27,000 vacant lots	$6.1B $404/parcel	Acquisitions costs range from $4.5B to $23.9B with per parcels costs ranging from $225K/parcel to $281K/parcel
Wet and Dry Floodproofing	No Floodproofing	No Floodproofing	25,419 Total Parcels Protected $105.0M Damages Prevented	25,412 Total Parcels Protected $105.0M Damages Prevented	25,419 Total Units Protected $105.0M AAD Prevented	No Floodproofing	No Floodproofing	Ranges from 0 parcels to 40,964 parcels in Floodproofing
Total Floodproofing Costs Cost per unit Protected	No Floodproofing	No Floodproofing	$10.8B $425K/parcel	$10.8B $425K/parcel	$10.8B $425k/parcel	No Floodproofing	No Floodproofing	Ranges from $0.00 to $11.4B and $0/parcel to $278/parcel
By **Elevation**	No Floodproofing	No Floodproofing	$10.8B $425K/parcel	$10.8B $425K/parcel	25,419 Units Protected $210.0M AAD Prevented	No Floodproofing	No Floodproofing	Ranges from 0 parcels to 40,964 parcels in Floodproofing
Total Elevation Costs Cost per unit elevated	No Floodpronfing	No Floodproofing	$10.8B $425K/parcel	$10.0B $425K/parcel	$10.8B $425/parcel	No Floodproofing	No Floodproofing	Ranges from $0.00 to $11.4B and $0/parcel to $278/parcel
Other Floodproofing	No Floodproofing	No Floodproofing	Undetermined at this time.	Undetermined at this time	Undetermined at this time	No Floodproofing	No Floodproofing	Undetermined at this time
Total Other Floodproofing Costs Cost per unit floodproofed	No Floodproofing	No Floodproofing	Undetermined at this time	Undetermined at this time	Undetermined at this time	No Floodproofing	No Floodproofing	Undetermined at this time
Replacements of Public Buildings	No Replacements	No Replacements	7 Total Units Protected	No Replacements	7 Total Units Protected	No replacements	7 Total Units Protected	Undetermined at this time
Total Relocations Costs Cost per unit relocated	No Replacements	No Replacements	$51.8M $7.4M per parcel	No Replacements	$51.8M $7.4M per parcel	No Replacements	$51.8M $7.4M	Undetermined at this time.
Reduced Threat to Loss of Life (based upon 2.6 persons per household)	14,997 potential households protected from flooding 38,900 lives protected	33,191 potential households protected from flooding 86,000 lives protected	42,300 Households protected from flooding 152,000 Potential Lives	25,419 Households protected from flooding 66,000 lives protected	58,617 Households protected from flooding 152,000 Potential Lives	Plan affects over 90,000 parcels .Potential for 234,000 lives to be offered some level of protection.	14,997 potential households protected from flooding 38,900 lives protected	Protected Parcels ranges from 30,508 to 85,447 with potential for 79,300 to 222,000 lives to be protected

Table 34.
Future With-Project Conditions

PLANS / Parameters/Measures	Plan NS-PAHHZ	Plan NS-PA100	Plan NSC-1 – Federal Agencies Action Plan	Plan NSC-2 – Wet and Dry Floodproofing W/FWEE Upgrades	Plan NSC-3 – Joint Federal and Non-Federal Jurisdiction Plan	Plan NSC-4 – Non-Federal Jurisdiction Plan	Plan NSC-5 – Loss of Life Reduction Plan	Plan NSC-6 – Combined Structural and Nonstructural Plan
Flood Preparedness (Storm Warning and Emergency Evacuation) and Public Education	No FWEE Upgrades	No FWEE Upgrades	95,000 Parcels Covered 247,000 Population Informed	95,000 Structures Covered 247,000 Population Informed	95,000 Parcels Covered 247,000 Population Informed	95,000 Parcels Covered 247,000 Population Informed	95,000 Parcels Covered 247,000 Population Informed	95,000 Parcels Covered 247,000 Population Informed
Floodplain Management Improvements	No NFIP Upgrades	Nn NFIP Upgrades	No NFIP Upgrades	No NFIP Upgrades	95,000 Parcels Covered by Updated Floodplain Management Ordinances	95,000 Parcels Covered by Updated Floodplain Management Ordinances	No NFIP upgrades	95,000 Parcels Covered by Updated Floodplain Management Ordinances
Building Codes Upgrades	No Building Code Upgrades	No Building Code Upgrades	No Building Code Upgrades	No Building Code Upgrades	95,000 parcels Covered by Updated Codes	95,000 parcels Covered by Updated Codes	No Building Code Upgrades	No Building Code Upgrades
Development **Impact Fees**	No Development Impact Fees	No Development Impact Fees	No Development Impact Fees	No Development Impact Fees	At least 6,000 New Subdivided Lots Covered by Impact Fees and 27,000 vacant lots	At least 27,000 vacant lots Covered by Impact Fees	No Development Impact Fees	No Development Impact Fees
TDR/PDR	May be used to supplement acquisitions of interspersed vacant properties in high-hazard zones.	May be used to supplement acquisitions of vacant properties in high-hazard zones and areas deeper than 13 feet of water depth.	May be used to supplement acquisitions of interspersed vacant properties in high-hazard zones and areas deeper than 13 feet of water depth.	No TDR or PDR programs	At least 27,000 Interspersed Vacant Properties Development Rights Transferred or Purchased	At least 27,000 Interspersed Vacant Properties Development Rights Transferred or Purchased	No TDR or PDR programs	No TDR or PDR programs
Land Use Zoning and Regulations	No changes in land use zoning	No changes in land use zoning	No changes in land use zoning	No changes in zoning or land use regulations	At least 14,997 Parcels with Changed Zoning Designation to Reduce Flood Damages	At least 14,997 Parcels with Changed Zoning Designation to Reduce Flood Damages	No changes in zoning or land use regulations	No changes in zoning or land use regulations
Development Redirection	Approximately 3000 lots would be constructed out of the inundation zones	Approximately 6000 lots would be constructed out of the inundation zones	6,000 New Residential and Commercial lots developed out of the BFE limits	No redirection of development	6,000 New Residential and Commercial lots developed out of the BFE limits	Some redirection by local jurisdiction but numbers of lots undetermined at this time	Approximately 3000 lots would be constructed out of the inundation zones	Between 6,800 lots and 29,900 lots may be developed out of the BFE limits
Residual Damages	Residual damages to units not participating plus utilities and transportation facilities. Numerous unmovable facilities	Residual damages to units not participating plus utilities and transportation facilities. Numerous unmovable facilities	Residual damages to units not participating plus utilities and transportation facilities. Numerous unmovable facilities	Residual damages to units not participating plus utilities and transportation facilities. Numerous unmovable facilities	Residual damages to units not participating plus utilities and transportation facilities. Numerous unmovable facilities	Residual damages to units not participating plus utilities and transportation facilities. Numerous unmovable facilities	Residual damages to units not participating plus utilities and transportation facilities. Numerous unmovable facilities	Residual damages to units not participating plus utilities and transportation facilities. Numerous unmovable facilities
Risks and Uncertainty	Risks associated with the acquisition program plus H&H level of protection. Uncertainties center on credibility of the base data supporting acquisition costs.	Risks associated with the acquisition program plus H&H level of protection. Uncertainties center on credibility of the base data supporting acquisition costs.	Risks associated with the acquisition program plus H&H level of protection for floodproofing. Uncertainties center on credibility of the base data supporting acquisition costs.	Risks associated with H&H level of protection for floodproofing.	Risks associated with the acquisition program plus H&H level of protection for floodproofing. Uncertainties center on credibility of the base data supporting acquisition costs.	Uncertainty associated with political willingness to apply nonstructural measures and the TDR or PDR programs.	Risks associated with the acquisition program plus H&H level of protection. Uncertainties center on credibility of the base data supporting acquisition costs.	Risks associated with the acquisition program plus H&H level of protection. Uncertainties center on credibility of the base data supporting acquisition costs.
Potential Upgraded Housing Units	Potential for 7,500 new or upgraded Housing Units	Potential for 17,144 new or upgraded Housing Units	Potential for 17,144 new or upgraded Housing Units. A percentage of floodproofed structures will be upgraded while being elevated.	A percentage of floodproofed structures will be upgraded while being elevated.	Potential for 17,144 new or upgraded Housing Units. A percentage of floodproofed structures will be upgraded while being elevated.	No upgrading of housing expected as a result of project implementation other than through new IBC application.	Potential for 7,500 new or upgraded Housing Units	Potential for a range of 6,800 to 29,900 new housing units to be constructed plus upgrades to over 40,000 floodproofed structures.
Evacuated Acres Available for **Wetlands Restoration**	4,000 Acres	9,300 Acres	9,300 Acres	Undetermined at this time	9,300 Acres	0 acres available for restoration.	4,000 acres	Undetermined at this time

Were the plan to be implemented in a mandatory fashion, all 14,997 identified parcels would be acquired and the remaining residents relocated to suitable replacement DSS housing. This massive relocation project may trigger the need for one or more replacement housing sites within the project area to accommodate so many displaced landowners into an anemic housing market. The residential redevelopment sites would be located above the 0.2% annual chance flood elevation either by location or by design and the influx of new DSS housing resources would substantially increase the volume and quality of the region's housing stock from its current state.

Using the average per household size provided in the 2000 US Census figures for this area (2.6 persons per household); approximately 38,900 persons could be removed from these high-hazard zones permanently. Considering that over 250 people lost their lives in MS during Katrina, this reduction in the threat to life and increased safety is a significant affect of the plan. The effectiveness of this plan in reducing the threats to life would be dependent upon the attitudes of the landowners and their perception of the risks of redevelopment in the high-hazard zone.

In addition to the reduction of structural and content damages and reduced threat to life and safety, this plan provides approximately 4,000 acres of land found to be suitable for ecosystem restoration of wetlands many of which are directly connected to the Gulf waters. Considering the importance of estuarine wetland habitats that are directly connected to the Gulf in terms of promoting aquatic diversity, seafood production and shorebird productivity, this product of the plan is considered to be significant.

The cost of implementing Plan NS-PAHHZ is estimated to be $6.1B which translates into $404,000 per unit protected. In addition to the land acquisition, relocations assistance and structure demolition costs reflected in the total cost, the construction of at least 3,000 new housing lots would also be included in that total cost at an average cost of $45,000 per lot.

On the environmental impact side of the ledger, Plan NS-PAHHZ would result in significant migrations of population from the near-shore zone into less flood-prone and less developed areas where good quality habitat may be impacted by new home development (housing redevelopment/subdivision sites). Emphasis on in-fill development in the more urban areas and smaller communities located north of I-10 could reduce those impacts, but the magnitude of the relocations (at least 3,000 new lots) suggests some impacts to natural resources. Suitable redevelopment sites could encompass agricultural land as well as upland forest and grasslands. Wetland areas would be avoided during the redevelopment process.

In addition to the impact on natural resources by this migration, there may be impacts to public services (schools, wastewater collection and treatment systems, police and fire services and water supply systems) as additional users are added to the system. Also, there could be social and economic impacts by the loss of social connections in the affected communities. These impacts would surely be less than the impacts from Katrina itself, but would persist for several years as the program progressed. On the positive side, the Plan would evacuate many acres of high-quality beachfront habitat that would revert to a more natural state in addition to many acres of restored wetland habitat across the region.

Although one-dimensional, Plan NS-PAHHZ does attack the most critical storm damage needs and could significantly reduce threats to loss of life by inundation drowning. Public reaction to this plan would be mixed. Many of those landowners whose homes were destroyed by Katrina and did not have flood insurance would favor an opportunity to be relocated into a new more flood-safe replacement structure with limited personal financial investment. More opposition may be generated by local governments whose loss in tax revenues (already reduced by Katrina) from the relocation of acquired landowners would be hard to replace and whose remaining residents would have to bear the higher costs of remaining public services in those damaged areas.

7.2.2.2 Plan NS-PA100

This plan concentrates on the permanent acquisition of land and structures located in the high-hazard zones (see Plan NS-PAHHZ) and those structures within the FEMA-identified 1% annual chance flood area (as amended by the ABFE) where flood depths from the ABFE are greater than 13 feet above the ground surface. Under a mandatory implementation scheme, this plan would result in the permanent acquisition of an estimated 33,191 parcels of land with attendant structures (estimated 17,144) and families. The reduction in average annual damages due to these acquisitions would be approximately $210.0M. Given the high incidence of total destruction in the high-hazard zone (as much as 90%) and the reduction in annual damages provided by this measure, this would be a significant affect.

Approximately 95,000 acres of land could be acquired through this plan under a mandatory acquisition scheme. The actual number of parcels acquired would be dependent upon the individual landowners' perception of the flood risks and the opportunities for relocation to a flood-safe site. Participation rates could vary substantially depending upon the extent of damages to individuals homes incurred during Katrina and the individual prospects for redevelopment in the current location given higher construction costs and increased FEMA elevation requirements.

As in Plan NS-PAHHZ described above, estimates are that numerous interspersed parcels within the boundaries of Plan NS-PA100 were made vacant by Katrina. Early acquisition of a portion of those vacated lots through the initial HARP would potentially save an estimated $270.0 million dollars in structure acquisition and relocations payments. Also like the previous plan, Plan NS-PA100 potentially generates substantial housing relocations (as many as 17,144 at full participation) which would have to be accommodated in a severely under-stocked housing market. Several residential redevelopment sites holding at least 6,000 new residential lots may have to be constructed above the 0.2% annual chance flood limits to accommodate the displaced homeowners.

Using the average per household size provided in the 2000 US Census figures for this area (2.6 persons per household); approximately 44,600 persons could be permanently removed from the combined high-hazard zones and areas of water depth greater than 13 feet. Being relocated to more flood-safe locations, the threats to loss of life due to inundation drowning would be reduced substantially by this plan. This affect would be considered significant.

In addition to the reduction of structural and content damages and reduced threat to life and safety, this plan provides approximately 9,300 acres of land found to be suitable for ecosystem restoration of wetlands many of which are directly connected to the Gulf waters. This acreage is substantially greater (132% greater) than that generated by Plan NS-PAHHZ since many of the original wetland areas located away from the near-shore high-hazard zones and filled for residential development would be purchased as parcels where water depths at the ABFE would exceed 13 feet. This plan affect would be considered significant.

The cost of implementing Plan NS-PA100 is estimated to be $8.2B which translates into $248,000 per unit protected. In addition to the land acquisition, relocations assistance and structure demolition costs reflected in the total cost, the construction of at least 6,000 new housing lots would also be included in that total cost at an average development cost of $45,000 per lot.

Considering the environmental impacts of the plan, Plan NS-PA100 would result in significant migrations of population from the near-shore zone into less flood-prone and less developed areas where good quality habitat may be impacted by new home development (housing redevelopment/subdivision sites). Needing as many as 6,000 new lots to accommodate displaced landowners could impact over 2,000 acres of heretofore undeveloped land above the 0.2% annual chance flood limits. At these higher elevations there are fewer chances that wetland areas would be impacted by redevelopment and efforts would be made during the planning process to delineate all wetlands and purposefully avoid them during development. Upland forest and grasslands as well as agricultural lands may be most impacted by these redevelopment sites. Emphasis on in-fill development in the more urban areas and smaller communities located north of I-10 could reduce redevelopment impacts, but the magnitude of the relocations suggests some impacts to natural resources.

In addition to the impact on natural resources by this large migration, there could be impacts to public services (schools, wastewater collection and treatment systems, police and fire services and water supply systems) because of lack of capacity as well as social and economic impacts by the loss of social connections in the affected communities. These impacts would surely be less than the impacts from Katrina itself, but the impacts would persist for several years as the programmed acquisition process progressed. Even at a modest rate of participation in the program, many receiving communities would be hard-pressed to accommodate so many new households without substantial investments in new infrastructure and social/public services.

On a more positive environmental side, the permanent acquisition of both the high-hazard zones and areas where water depths at the ABFE exceeded 13 feet would encompass most of the near-shore areas as well as many of the original wetland areas within the inlets where placement of fill over the years had allowed residential and commercial development to occur. Once cleared, this estimated 9,300 acres could be restored to wetland habitat and use for a multitude of public uses including recreation.

As in the case of Plan NS-PAHHZ, Plan NS-PA100 is one dimensional using only permanent acquisition as a method of reducing structure and content damages and risks to life and increasing public safety. This plan does address most directly the highest risk properties that are damaged more frequently due to surge and wave action and does reduce the potential threats to life and public safety in the project area.

The social and economic impacts of this plan would make it unpopular with the local governments and communities unless some form of revenue sharing could be arranged between those communities being evacuated and those receiving new displaced homeowners (read as increased property tax receipts). It is possible that the magnitude of this acquisition program could result in the abandonment of substantial miles of access roads and utilities within heretofore heavily populated neighborhoods thus reducing future damages to these categories of infrastructure as well.

7.2.2.3 Plan NSC-1 Federal Agencies Plan

This plan relies primarily on those actions that could be undertaken by assorted Federal agencies including the Corps of Engineers, FEMA, and NOAA. This plan would feature permanent acquisition of a maximum of 33,191 eligible parcels (approximately 17,100 structures) within the high-hazard zones and areas where water depths would exceed 13 feet at the ABFE (similar to Plan NS-PA100) level. This plan would also feature floodproofing at 25,419 eligible parcels by elevation (meeting current local NFIP requirements) and other means, replacement of 7 public structures to more flood-safe locations and the upgrading of the existing components of the existing flood warning and emergency evacuation system.

This multi-dimensional plan would address several of the planning objectives (reducing flood damages, reducing threats to loss of life and providing opportunities for ecosystem restoration). The plan would provide complete protection through the acquisition of an estimated 33,191 parcels and relocation of at least 17,144 households and businesses and provide a minimum level of protection to the structures of as many as 25,419 landowners through floodproofing in the project area. The total reduction in average annual damages would be approximately $315.0M ($210.0 in acquisitions and $105.0M in floodproofing).

In addition to flood damage reduction, the estimated 33,191 parcel acquisitions represent as many as 86,300 persons residing on those high-risk parcels whose lives would be made safer by relocation to more flood-safe residences through the relocations assistance program. Although the plan would not condone residents remaining in elevated structures during a hurricane event, structures raised above the ABFE would provide protection from drowning due to surge conditions for as many as 63,000 persons. Both of these affects would be considered significant.

As in the case of Plan NS-PA100, this plan could result in the acquisition of up to approximately 95,000 acres of land of which approximately 9,300 acres would be suitable for restoration as wetland ecosystem habitat. This positive affect on the region's ecosystem would be considered significant. The total acres acquired and those suitable for restoration would be contingent upon program participation rates.

By incorporating a multitude of measures, this plan provides a variety of flood damage reduction and public safety measures not found in other plans. The replacement of 7 public structures (some of which are schools) allows not only continuance of essential public services to the population but can provide needed evacuation centers for those fleeing future flooding events. These affects are considered significant as well.

From an environmental standpoint this plan has both positive and negative affects. The potential clearing of over 93,000 acres of residential and commercial land in flood-prone areas that can be converted to wetlands or other quality habitat as well as used for passive recreation uses is a significant positive affect on the region's ecosystems. From a negative viewpoint, relocating all of those households would result in some land and vegetation disturbance either through planned redevelopment sites or through the housing market construction process to meet the new housing needs. Needing at least 6,000 new residential and commercial lots would require an estimated 2,000 acres of subdivision development above the 0.2% annual chance floodplain. In-fill within already disturbed urban areas would siphon off a portion of this needed new development, but some land development disturbance is anticipated. Although identified wetlands could be avoided, agricultural lands and forest and grassland habitat may be impacted by this new development. New private market housing may be more dispersed and potentially less concerned about site development impacts while planned redevelopment sites would be evaluated through the NEPA process.

7.2.2.4 Plan NSC-2 Wet and Dry Floodproofing with FWEE Upgrades

This plan relies primarily on floodproofing, by various methods (wet and dry), structures on at least 25,419 eligible parcels within the ABFE footprint and the implementation of upgrades to the existing flood warning and emergency evacuation (FWEE) system. The upgrades to the existing FWEE would be spearheaded by other Federal (FEMA and NOAA), state and local agencies with support by the Corps of Engineers. Given the potential for thousands of families to be perched in elevated structures along the coast following the implementation of this plan, being able to issue credible and timely storm/flood warnings and efficiently and safely evacuate those people to safe storm shelters would be paramount in assuring that those in elevated residences would wisely choose to evacuate to high-ground.

The level of protection for elevated structures in this plan was based upon the ABFE minus 2 feet which was used as an approximation of the anticipated new FEMA-issued Base Flood Elevations following Katrina. The ABFE elevations or increased freeboard requirements (4 feet of additional freeboard) were adopted by each of the municipal and county governments following Katrina (see Table 8). Average annual flood damages for structures and their contents located on the 25,419 eligible parcels would be reduced by an estimated $105.0M as a result of implementation of this plan at that level of protection. This amount of flood damage reduction would be a significant affect produced by this plan.

[The new BFE elevations were being issued in draft form by FEMA as this Appendix was being completed, but no attempt was made to recalculate the numbers of eligible parcels for floodproofing or to recalculate floodproofing costs based upon the new revised BFE. Once the new BFE elevations have been reviewed by the 11 municipal areas and 3 counties and have been adopted into the existing floodplain management ordinances, those elevations would form the basis of any subsequent detailed planning and engineering documentation by the Corps of Engineers prior to implementation of an authorized and funded nonstructural project.]

Although people living within the elevated structures would be strongly encouraged to evacuate their floodproofed homes during a storm surge event, past experience indicates that many would choose to remain sheltered in place. Based upon a household size of 2.6 persons, as many as 65,000 people might be protected by this plan during a storm event that did not exceed the ABFE level. Providing some level of safety to people sheltering in place would be a significant affect. Conversely, promoting elevation of homes in high-hazard zones (potential consequences of other Federal programs) may place many families in extreme peril should hurricane surge and waves exceed the design height of the home's elevation (FEMA BFE).

The floodproofing program would affect approximately 136,000 acres of land within the project area. Of those acres approximately 3,800 acres would be suitable for ecosystem restoration as wetlands. Although the floodproofing program wouldn't be directly involved in purchasing those lands, it is possible that a number of structures would be found to be either structurally unsound and therefore unfit for elevation under the guidelines or that the cost of floodproofing the structure would exceed the appraised value of the structure. In these two cases, the owner may be given the option to sell the property to the Federal government (or project sponsor) for the appraised value, opt for a replacement home on-site at a lesser cost than floodproofing or to buy-up to the floodproofing cost with private funds. In the event that the owner would sell the property to the Federal government, they would be relocated under the provisions of the Uniform Relocations Act and the vacated land could be used for ecosystem restoration as wetlands. This determination would be made at the time of implementation of the floodproofing program on a case-by-case basis.

From an environmental perspective, Plan NSC-2 has very minimal impacts since all of the construction work occurs within the confines of an already disturbed residential, commercial or institutional building lot. In most cases, construction would be confined largely to the existing footprint of the structure foundation and all construction (including storage of building materials) would be confined to the owner's property. Since floodproofing construction is hand-labor intensive, there would be minimal use of heavy construction equipment on site (limited engine exhaust, petroleum or hydraulic fluid leakage, or waste water). Operation and maintenance of the structure elevation by the landowner also is environmentally friendly.

7.2.2.5 Plan NSC-3 Combined Federal and Non-Federal Jurisdiction Plan

This plan combines the best measures and attributes of Plans 1 and 4 into a suite of effective components aimed at all parcels affected by Katrina surge inundation within the ABFE footprint. In addition to the permanent acquisition of up to 33,191 parcels (an estimated 17,144 structures), the floodproofing of up to 25,419 structures and replacements of at least 7 public buildings, this plan includes application of numerous local jurisdiction actions that would affect every parcel (approximately 95,000 parcels) in the project area. Reductions in the average annual damages are estimated to be $315.0M based solely upon the affects of acquisitions of at-risk structures and floodproofing by elevation.

Additional reductions in annual damages would be generated by the application of nonstructural measures by the local jurisdictions such as upgraded floodplain management ordinances (application of the revised FEMA BFE), upgraded building codes, revised land use zoning ordinances, implementation of either a TDR or PDR program to address interspersed vacant properties, and the institution of development impact fees. Although incrementally small in comparison to the damage reductions provided by Federally-funded acquisitions and floodproofing, these local measures, when taken in aggregate, would have a significant affect on future damages.

In addition to flood damage reduction, the 33,191 parcel acquisitions (an estimated 17,144 structures) represent as many as 86,300 persons residing on those high-risk parcels whose lives would be made safer by relocation to more flood-safe residences through the relocations assistance program. Although the plan would not condone residents remaining in elevated structures during a hurricane event, structures raised above the ABFE would provide protection from drowning due to surge conditions for as many as 63,000 persons. Both of these affects would be considered significant.

As in the case of Plans NS-PA100 and Plan NSC-1, this plan could result in the acquisition of up to approximately 95,000 acres of land of which approximately 9,300 acres would be suitable for restoration as wetland ecosystem habitat. This positive affect on the region's ecosystem would be considered significant. The total acres acquired and those suitable for restoration would be contingent upon program participation rates.

From an environmental standpoint this plan has both positive and negative affects. The potential clearing of over 93,000 acres of residential and commercial land in flood-prone areas that can be converted to wetlands or other quality habitat as well as used for passive recreation uses is a significant positive affect on the region's ecosystems. Clearing the beachfront properties of residential and commercial development and the pavements and weekly maintenance of lawns and ornamentals (as well as extracting invasive plant species) would release the indigenous vegetation communities to flourish and provide additional storm protection (primarily wave and wind) through dense tree and shrub growth.

From a negative viewpoint, relocating all of those households would result in some land and vegetation disturbance either through planned redevelopment sites or through the housing market construction process to meet the new housing needs. Needing at least 6,000 new residential and commercial lots would require an estimated 2,000 acres of subdivision development above the 0.2% annual chance floodplain. In-fill within already disturbed urban areas would siphon off a portion of this needed new development, but some land development disturbance above the 0.2% annual chance elevation is probable. Planned development sites would avoid identified wetlands, but agricultural lands (especially vacated agricultural lands) and forest and grasslands may be impacted by new housing development. New private market housing may be more dispersed and potentially less concerned about site development impacts while planned redevelopment sites would be evaluated through the NEPA process.

In addition to the impact on natural resources by this large migration, there could be impacts to public services (schools, wastewater collection and treatment systems, police and fire services and water supply systems) because of lack of capacity as well as social and economic impacts by the loss of social connections in the affected communities. These impacts would surely be less than the impacts from Katrina itself, but the impacts would endure for several years as the programmed acquisition process progressed. Even at a modest rate of participation in the program, many receiving communities would be hard-pressed to accommodate so many new households without substantial investments in new infrastructure and social/public services.

The social and economic impacts of this plan would make it unpopular with the local governments and communities unless some form of revenue sharing could be arranged between those communities being evacuated (taxable property lost) and those receiving new displaced homeowners (read as increased property tax receipts). It is also possible that the magnitude of this acquisition program could result in the abandonment of substantial miles of access roads and utilities within heretofore heavily populated neighborhoods thus reducing future damages to these categories of infrastructure as well.

7.2.2.6 Plan NSC-4 Non-Federal Jurisdiction Plan

This plan contains the full palette of flood damage reduction measures that can be implemented through the local jurisdictions' (counties and municipalities). These individual measures affect essentially each and every parcel and structure located with the footprint of the Katrina surgeplain. Most of the measures are regulatory in nature (upgrading and enforcement of building codes, NFIP, and land use zoning), but a few are more proactive in their application such as a TDR/PDR program that would actively acquire or transfer development rights from at-risk properties or the development impact fees that would increase the costs of development in the at-risk zones (hopefully discouraging further development in high-risk zones) as well as generating funds for emergency management purposes.

Unlike the measures listed under Plan NSC-1 Federal Agencies Plan, the measures contained in NSC-4 do not lend themselves to easily quantifying benefits in terms of flood damages reduced or reductions in threats to loss of life. In addition, the application of these regulatory and land use measures do not directly generate additional lands for ecosystem restoration although the TDR/PDR programs could both be used to accomplish the same objectives in that regard as does permanent acquisition and relocations. In most cases, the counties and municipalities have the regulatory measures (land use zoning, NFIP, and building codes) in place to some degree and the incremental differences in reduced damages and loss of life to be gained by upgrading these components would be largely unnoticeable on an individual parcel basis. Only at the aggregate level would the differences be evident following a hurricane event. Intuitively, positive changes in the building codes and increases in the level of the Base Flood Elevation (should that be adopted by the communities) should reduce damages from future events. The presence of such a large number of vacated parcels (developed under previous codes/regulations) following Katrina indicates that updated regulatory codes and floodplain ordinances should generate positive benefits when the rebuilding occurs.

In the absence of a Federal program for storm protection in the project area (known as the No Federal Action Plan in NEPA terminology), these measures could be instituted at the local level to reduce future damages to those types of land uses contemplated in the future without-project condition described in the comprehensive plan and below. With the institution of these local measures and enforcement of upgraded building codes, floodplain management ordinances and land use zoning, future storm-related damages could be significantly reduced. The initiation of a TDR or PDR program that would transfer or purchase development rights on high-risk parcels (up to 33,191 parcels within the 100-year surge inundation footprint) would generate significant damage reduction benefits while potentially increasing development in less flood-prone areas north of I-10. Such limitations on development rights negotiated through the market system or by direct purchase would allow continued maintenance of the coastline properties by private landowners while maintaining some proportion of the original tax revenues to local jurisdictions.

7.2.2.7 Plan NSC-5 Loss of Life Reduction Plan

This plan relies primarily on permanent acquisitions in the high-hazard zone, replacements of public structures and upgrades to the flood warning and emergency evacuation (FWEE) systems. The permanent acquisitions would address 14,997 parcels located in the most dangerous coastal properties where the potential for loss of life due to drowning would be greatest in many categories of hurricanes and tropical storms. This area is subject to surge inundation and high waves, both factors in drowning deaths. The reduction in average annual damages amounts to approximately

$92.0M. The potential reduction in threats to life by surge inundation drowning is approximately 39,000 persons. Considering that over 200 people lost their lives in MS during Katrina, this reduction in the threat to life and safety is a significant affect of the plan. The effectiveness of this plan in reducing the threats to life would be dependent upon the attitudes of the landowners and their perception of the risks of redevelopment in the high-hazard zone.

Were the plan to be implemented in a mandatory fashion, all 14,997 identified properties would be acquired and the remaining residents relocated to suitable replacement DSS housing. This massive relocation project may trigger the need for one or more replacement housing sites within the project area to accommodate so many displaced landowners in an anemic housing market. The residential redevelopment sites would be located above the 0.2% annual chance flood elevation either by location or by design and the influx of new DSS housing resources would substantially increase the volume and quality of the region's housing stock from its current state.

In addition to the reduction of structural and content damages and reduced threat to life and safety, this plan provides approximately 4,000 acres of land found to be suitable for ecosystem restoration of wetlands many of which are directly connected to the Gulf waters. Considering the importance of estuarine wetland habitats that are directly connected to the Gulf in terms of promoting aquatic diversity, seafood production and shorebird productivity, this product of the plan is considered to be significant.

On the environmental impact side of the ledger, Plan NS-PAHHZ would result in significant migrations of population from the near-shore zone into less flood-prone and less developed areas where good quality habitat may be impacted by new home development (housing redevelopment sites). Emphasis on in-fill development in the more urban areas could reduce those impacts, but the magnitude of the relocation effort suggests some impacts to natural resources.

In addition to the impact on natural resources by this migration, there could be impacts to public services (schools, wastewater collection and treatment systems, police and fire services and water supply systems) because of lack of capacity as well as social and economic impacts by the loss of social connections in the affected communities. These impacts would surely be less than the impacts from Katrina itself, but would persist for several years as the program progressed. On the positive side, the Plan would evacuate many acres of high-quality near-shore habitat that would revert to a more natural state in addition to many acres of restored wetland habitat across the region.

In addition, this plan address replacement of public structures including 7 identified public buildings including schools and fire stations. These structures would contain children (one of the segments of the population more susceptible to drowning in surge situations) and first responders during and immediately following a storm event. Their replacement would reduce the potential for loss of life and would provide flood-safe emergency shelters for evacuees.

Upgrades to the flood warning and emergency evacuation system would assure that credible and timely warnings could be issued to a larger segment of the at-risk population so that evacuations could be conducted in a safe and orderly manner encouraging more people to participate in both voluntary and mandatory evacuations. The upgrades to signage and highway routing and emphasis on an ongoing education and awareness program would assure that both residents and visitors would be knowledgeable about evacuation routes and locations for emergency shelters.

7.2.2.8 Plan NSC-6 Combined Structural/Nonstructural Plan

Plan NSC-6 envisions combining several structural projects that either protect individual municipal areas with ring-levees or, as in the case of LOD-4, protect all of those parcels located roughly north of the CSX railway line with a levee and surge gates with nonstructural measures that would address all of those parcels not protected by these projects. Protecting large municipal areas in place with structural projects does eliminate many of the social and economic impacts of full-scale relocations or the visual and access impacts of elevating so vast a number of tightly confined structures. The benefits of LOD-4 when combined with nonstructural measures (primarily permanent acquisitions) is the generation of many acres of land suitable for ecosystem restoration as wetlands between the levee alignment and the Gulf.

This basic NSC-6 plan (combinations of nonstructural measures and structural projects) and its several scales (ABFE, 20 foot, 30 foot and 40 foot inundation) were formulated using just the measures described in Plan NSC-1 set in combination with various ring-levees and the Line of Defense 4 (LOD-4). Other measures described in the local jurisdiction plan (Plan NSC-4) could be applied in the nonstructural areas in NSC-6, but issues of combinability would emerge as shown in Plan NSC-3. Specific data on the numbers and costs of replacements of public buildings was eliminated for the 20 foot, 30 foot and 40 foot levels of inundation since data on the specific locations of these critical facilities at these increased flooding depths was not available from local, Corps or FEMA sources.

In addition, since only the annual flood damage reductions were calculated for the nonstructural measures at the ABFE level, specific reductions in average annual damages for the higher level of inundation were not available for this Appendix. What is known are the numbers of structures that would be included in the various scales of the nonstructural plan and estimates of the plan cost shown in Tables 25 through 33. Also, based upon the structures being afforded protection by each scale of the alternative, the approximate number of persons afforded protection from loss of life by nonstructural measures in the several scales of this plan can be estimated. These figures are shown in Table 25.

In addition to the numbers of parcels that would be eligible for acquisitions and floodproofing in the scales of NSC-6, there may be a need for several redevelopment sites located above the 0.2% annual chance floodplain (north of I-10). Numbers of needed relocation lots range from 6,800 to 29,000 to accommodate the numbers of structures that would be displaced by the nonstructural acquisitions in inundation depths from the ABFE to the 40 foot level. This need would require between 2,200 acres and 9,600 acres of land to address this number of displaced persons. Careful planning of these new subdivision sites could reduce significant environmental impacts normally associated with land development on this scale, but impacts to upland grasslands and forested sites may be unavoidable.

Specific data on the number of acres that would be acquired by permanent acquisition in the 20 foot, 30 foot and 40 foot levels of inundation was not available for this appendix, but in the options that involved the ring-levee alignments, the number of acres that would be purchased and suitable for ecosystem restoration would approximate those displayed for the single-measure permanent acquisition plans NS-PAHHZ and NS-PA100.

In comparison with the nonstructural plans, the combined structural nonstructural plan would open up the potential for more in-fill redevelopment in protected urban areas so that the relocation of displaced households could occur in areas with in-place infrastructure and public services rather than more rural areas without infrastructure. The combined plan featuring LOD-4 with nonstructural measures would accomplish the objective of moving most development away from the beachfront north towards the I-10 corridor. This movement, part of the "tiering" concept, would accomplish significant reductions in flood damages while spurring significant growth along that highway corridor.

7.3 Comparison with Future Without-Project Conditions

7.3.1. General

Following the description and display of the future with project outputs from each of the plans, those plan outputs are then compared to the anticipated future without-project conditions to determine to what extent the plans affect or improve the anticipated future condition. The MsCIP PDT formulated a series of future without-project scenarios based upon different mixes of land uses re-occupying the high-hazard zones and the possible effects of various sea-level rise amounts that may occur along the project area during the planning period (100 years). The two primary land use types were residential (single-family homes) and a mixed-use redevelopment featuring residential and commercial uses. Sea-level rise was divided into no relative rise, an expected relative sea level rise and a high relative sea level rise. In all, six scenarios were developed by the team including:

1) Residential redevelopment with no relative sea-level rise,

2) Residential redevelopment with an expected relative sea-level rise,

3) Residential redevelopment with a high relative sea-level rise,

4) Mixed use (residential/commercial) with no relative sea-level rise,

5) Mixed use (residential/commercial) with an expected relative sea-level rise, and

6) Mixed use (residential/commercial) with a high relative sea-level rise.

In each case the rate of redevelopment demonstrates an expected vigorous rebuilding program that would result in most of the previous development being back in place within 10 years. This growth rate is not unusual given the rates of growth that were common within the project area prior to Katrina. The combination of revised FEMA floodplain mapping and ordinances to guide redevelopment and the resurgence of various sectors of the economy in the region, rebuilding of the coast, barring a recurrence of Katrina-like events, could be swift and sustained.

In this re-building environment, the nonstructural plans would produce, in varying amounts, an array of storm damage reduction benefits, reductions in potential losses of life and opportunities for substantially increasing the acres of high-quality wetland and other ecosystem habitats in the region. The affects of the various amounts of anticipated relative sea level rise could be compensated for in the nonstructural measures by adjusting the geographical limits of permanent acquisition (to account for greater depths of inundation or expansions of the V-zone) and floodproofing by elevation. Since both of these nonstructural measures are applied on a structure-by-structure basis, program adjustments accounting for changes in inundation depths are relatively simple and incrementally inexpensive on a per structure basis. The performance of each nonstructural plan with respect to the various future without-project condition scenarios is discussed below.

7.3.2. Comparisons with Future Without-Project Conditions

7.3.2.1. Plan NS-PAHHZ

This plan addresses a geographic area of the coast (approximately 57,000 acres) that is defined not by elevation above the gulf, but by lateral extent from the waterline based on the presence of velocity waters (V-zone) and the damages observed after Katrina. In this regard, all of the changes in sea level contemplated by the scenarios have little affect on the effectiveness of this plan unless the changes in sea level were to translate into a regulatory modification of the V-zone and other damage zones that comprise this area in the Plan.

This plan addresses those parcels (14,997) and attendant structures (7,510) residing in the high-hazard zones of the project area. Since a number of structures were totally destroyed during Katrina, this plan is particularly effective in reducing damages and threats to life and public safety since all of the scenarios described above would see this area completely repopulated with new structures within 4 years. Even elevated to the revised BFE's published by FEMA and adopted by the local jurisdictions, the new structures may still be highly susceptible to massive damages by any storm surge level and waves that would exceed the revised BFE level in this zone.

Residential construction was observed to be highly susceptible to the battering affects of surge and waves in this zone. Therefore, the scenarios featuring residential growth (scenarios 1-3) in this high-hazard zone would be most susceptible to heavy damages which would be completely eliminated by mandatory application of this Plan. The eventual effectiveness of this plan would be contingent upon a high rate of participation in a non-mandatory plan. Plan NS-PAHHZ would also be effective under scenarios 4-6 featuring a mix of residential and commercial growth. It is anticipated that any land use development including commercial that is rebuilt in this zone to the revised BFE's would remain susceptible to heavy damages by storm surge and waves that exceeded the BFE elevation. Given the risks that commercial uses (especially retail uses) would assume in rebuilding in this high-hazard zone, their flood insurance burden may demand greater elevation of first floors and greater use of building materials and construction practices that would reduce damages. In any case, this plan would significantly reduce those damages through permanent acquisition and relocation of commercial uses as well as residential uses.

Continued threats to life and public safety under any of the 6 scenarios would be significantly reduced by this plan through permanent acquisition and relocation of the at-risk households. Were the high-hazard zone to be rebuilt within a 10 year period under any of the scenarios, the potential losses of life by surge inundation may be substantial and potentially greater than that experienced in Katrina. New development in the high-hazard zone under revised NFIP guidelines may encourage elevation of homes and businesses thus instilling a false sense of security and tendency for homeowners to seek shelter in elevated structures during larger storms. Permanent acquisition and relocation of these at-risk properties removes the risk to life and public safety.

More importantly, the proposed initial High Hazard Area Risk Reduction (HARP) would be most effective in reducing future damages and loss of life in this zone under any of the 6 scenarios of redevelopment. By purchasing interspersed vacant properties in the high-hazard zone prior to the initiation of any of the 6 scenarios of the future without-project condition, the potential damages that could occur with new growth would be eliminated.

7.3.2.2. Plan NS-PA100

This plan addresses only permanent acquisitions in the high-hazard zone and the area affected by the 1% annual chance flood event where water depths would exceed 13 feet at the ABFE. As such, the effectiveness of this plan in the high-hazard zone under each of the 6 scenarios is the same as described above in Plan NS-PAHHZ. According to field observations and the structure databases, the incidence of structure loss in the area inundated by the 1% annual chance flood where water depths would exceed 13 feet at the ABFE was much less than observed in the high-hazard zone. Although there are interspersed vacant acres of land in this deep water zone that could be affected by any one of the 6 scenarios of the future without-project condition, the anticipated increase in placement of damageable property is much less than would be expected in the largely decimated high-hazard zone. There are approximately 95,000 acres of land included within this plan area (an additional 37,000 more than Plan NS-PAHHZ).

Conversely, there remain a significant number of structures still susceptible to flood damages in this deep-water zone that would continue to suffer future damages in spite of any substantial redevelopment in the zones covered by this plan. Permanent acquisition of these remaining structures would significantly reduce damages under any of the 6 scenarios and especially in the scenarios that contemplate rises in sea level (scenarios 2, 3, 5 & 6) for those remaining structures. As such, Plan NS-PA100 would show incremental storm damage reduction benefits in excess of Plan NS-PAHHZ just based upon the substantial number of additional parcels (structures) included in this plan (approximately 10,000 additional parcels affected) over Plan NS-PAHHZ.

Threats to loss of life would be substantially lessened by this plan through at least 4 of the 6 scenarios since any sea level rise would result in an increase in the numbers of structures that would be acquired in lieu of elevation in place (floodproofing) in the deep water area. Although this area is not subject to the wave action encountered in the high-hazard zone, inundation of homes by deeper water would place more persons in jeopardy of drowning before evacuation would be possible. Acquisition of these structures through this plan would remove this threat.

7.3.2.3. Plan NSC-1

This plan not only addresses both permanent acquisition of the high-hazard zone and areas where water depths would be in excess of 13 feet at the ABFE but also elevates additional structures and their contents above the ABFE. This plan generates substantial storm damage benefits under any of the 6 scenarios as described in the above two plans (Plan NS-PAHHZ and Plan NS-PA100) and additionally generates storm damage benefits through elevation of structures on an additional 25,419 parcels. Compared to the zones described in the two plans above where wave action and deep water may have resulted in substantial numbers of destroyed structures, the geographic area comprising the 25,419 parcels eligible for floodproofing by elevation (about 136,000 acres) is mainly susceptible to inundation damages with substantially fewer losses of structures.

This plan is effective under any of the 6 scenarios since the elements of the plan associated with permanent acquisitions eliminate many of the potential future damages that would occur by either residential or mixed-use redevelopment of the high-hazard zone and areas where water depths would exceed 13 feet. The balance of structures covered by this plan through floodproofing and any additional vacated acres of land within the total 136,000 acres of this zone that may be redeveloped under one of the 6 scenarios would be protected by elevating the first floor of new structures above the design flood elevation. Since the plan is implemented on a structure-by-structure basis, adjustments to the design flood height (0-3 feet) to account for any anticipated sea level rise would not increase costs substantially on an individual structure. Storm damage reduction benefits and reduced threats to loss of life could be maintained by slight adjustments in design criteria for elevating structures or increasing the number of acquired structures.

An added feature of this plan is the replacements of public buildings to flood-safe areas. Under any of the 6 future without-project scenarios, replacements will be effective in both reducing damages to these critical facilities as well as maintaining essential services both during and immediately after a storm event. Given the increased regulatory requirements for locating critical facilities (usually above the 0.2% annual chance flood zone) under the NFIP, it is improbable that many of these types of structures would populate the high-hazard zones in future redevelopment scenarios. Since the flood frequency elevations that govern location of these structures would be sensitive to sea level rise, the replacements component of Plan NSC-1 could be easily adjusted during implementation to account for anticipated sea level rise at either an expected relative level or relative high level.

Threats to life and public safety under this plan are substantially reduced under any of the 6 scenarios. With permanent acquisition of the high-hazard zone and areas where water depths exceed 13 feet, most of the threat is substantially reduced. Since the program does not recommend that people remain in elevated structures during a storm surge event and would be evacuated to high-ground, the threats to that population would be substantially reduced under all of the scenarios.

7.3.2.4. Plan NSC-2

This plan relies mainly on floodproofing by elevation and upgrades to the flood warning and emergency evacuation system (FWEE) to reduce storm surge related damages and threats to life and public safety. The upgrades to the FWEE will be spearheaded by NOAA and FEMA in cooperation with state and local emergency management offices with support and coordination from the Corps.

Since this plan does not include permanent acquisition of the high-hazard zone or areas where water depths at the ABFE would exceed 13 feet, its ability to reduce damages as a result of the 6 redevelopment scenarios is substantially less that other plans. This plan can be effective in reducing damages despite sea level rise for structures on the 25,419 parcels included in the floodproofing component because the heights of elevation can be easily adjusted during implementation of the program at minimal cost per structure lifted. The only impact that sea level rise anticipated in 4 of the 6 scenarios would have on this plan is the transfer of some structures to the permanent acquisition component of the project due to water depths in excess of 13 feet at the structure. The mix of new development considered in the 6 scenarios would not impact the effectiveness of this plan since either residential or commercial structures can be elevated to reduce flood damages.

However, since most of the redevelopment would occur in those areas where the majority of interspersed vacant land is now located (notably the high-hazard zone), this plan is largely ineffective in reducing storm surge damages or threats to life and public safety for upwards of 33,191 parcels and attendant structures (an estimated 17,144). Given an average of 2.6 persons per household in the region, this leaves potentially 86,300 persons unprotected by this plan under the 6 redevelopment scenarios.

7.3.2.5. Plan NSC-3

This plan combines the best nonstructural measures (9 total measures) that can be jointly implemented by Federal agencies and local jurisdictions to reduce storm-related damages, reduce threats to life and public safety and increase the acreage of wetland ecosystems in the project area. With such a broad array of effective measures available, this plan can be adjusted on a parcel-by-parcel basis to meet any of the new conditions or threats that would be generated by the 6 future without project condition scenarios.

In addition to the nonstructural components included in Plan NS-PA100 and Plan NSC-2 above that would address future damages in the high-hazard zones by acquisition, this plan features the application of local jurisdictional measures such as upgraded NFIP requirements, upgraded building codes, a TDR or PDR program for acquiring development rights on at-risk parcels, development impact fees, and modifications of existing land use zoning codes. In terms of the redevelopment scenarios that feature either residential or a mix of residential and commercial land uses, the application of a voluntary TDR or PDR program would significantly limit redevelopment of these damageable structures in the high-risk areas of the coast by securing the development rights of each parcel in perpetuity. In addition, development rights could be purchased on parcels that possessed existing wetland thereby restricting further development of these sensitive ecosystems in the future scenarios.

Upgrading the existing floodplain management ordinances according to new FEMA floodplain mapping and the FEMA 550 guidelines would significantly reduce damages to the redeveloped land uses anticipated in the 6 scenarios. As these ordinances can be easily adjusted to account for any sea level rise, storm-related damages to new development would be reduced through enforcement of the floodplain management ordinances and revised building codes. Upgrading and enforcing the existing International Building Codes and International Residential Codes in each county and municipal jurisdiction would assure that any new construction anticipated in the 6 scenarios would be able to withstand hurricane force wind loads as well as wind-driven rain penetration and the corrosive effects of a saltwater environment.

This plan performs very well under any of the future without-project conditions described in the 6 scenarios through reduction of storm-related damages, reduced threats to life and public safety and opportunities for increasing the acres of ecosystem restoration for wetlands and other sensitive habitat types.

7.3.2.6. Plan NSC-4

This plan emphasizes those nonstructural measures that can be implemented by local jurisdictions such as the 3 counties and 11 municipalities in the project area. These measures are primarily regulatory in nature and would be easily applied to all of the parcels that were affected by Katrina's surge floodplain. Any redevelopment of the project area under the 6 scenarios would be subject to the upgraded floodplain management ordinances, building codes, land use zoning ordinances and development impact fees all capable of reducing storm-related damages and threats to loss of life and public safety through application and enforcement. Generally these regulatory measures are mandatory in nature and therefore do not depend upon individual parcel owner's voluntary participation to be effective. Changes in sea level could be accommodated by the various regulations through modification of the ordinances.

Of the local jurisdictional measures, the application of either a voluntary TDR or PDR program in the project area could have the most impact under all 6 scenarios of redevelopment. By securing the development rights of a substantial number of high-risk parcels, the anticipated placement of damageable assets under the scenarios would not take place thereby significantly reducing storm-related damages and threats to life and public safety for the occupants. Although the development rights would be secured in perpetuity, the landowner would still retain the property and be able to enjoy whatever use of the property the purchase agreements allowed. In addition to maintaining the property according to municipal or county requirements, the landowner would still be paying property taxes (a minimal amount) that would support a minimal level of public services to interspersed vacated land).

Despite the ability of the local jurisdictional measures in this plan to have an effect on the redevelopment of the coast anticipated in the 6 scenarios, these measures do little to reduce further damages to existing structures that survived Katrina. Structures remaining in the high-hazard zone and those that could be elevated or purchased and relocated in other risk zones would not be addressed by this plan.

7.3.2.7. Plan NSC-5

This plan emphasizes reductions in loss of life and treats to public safety through permanent acquisitions of parcels in the high-hazard zone, replacements of critical public facilities in flood-hazard areas and upgrades to the FWEE. Upgrades to the FWEE would be led by NOAA, FEMA and state and local emergency management departments with support and cooperation from the Corps. These upgrades to the existing system would make early warning of approaching storms and hurricanes more credible and timely allowing the at-risk population more time to safely evacuate the potential surge inundation areas and seek shelter in safe evacuation centers. Under any of the 6 scenarios the upgraded FWEE would be able to provide credible and timely warnings to the anticipated additional occupants of the high-risk parcels.

The permanent acquisition component of the plan would purchase (on a volunteer basis) parcels within the high-hazard zone where much of the development anticipated in the 6 scenarios would occur. Therefore under any scenario, this plan removes a portion of the future damages that may occur in future storm events. The effectiveness of the plan under any of the scenarios would be based upon the participation rate of the individual landowners in the high-hazard zone. Potential sea level rises would not affect this component of the plan since the delineation of the high-hazard zone for permanent acquisition is not sensitive to elevation, but lateral extent of the V-zone and post-Katrina damage documentation by FEMA. This component would also reduce threats to life and public safety by removing potential occupants from the high-hazard parcels.

The replacement of public structures from hazard areas would significantly reduce storm-related damages and threats to life and public safety by relocating these critical facilities to higher elevations and away from hazard areas. During replacements planning, the affects of potential future placement of either residential or mixed use development back into the hazard zones (minus those parcels acquired through this plan) that could affect the service areas of relocated structures would be taken into account. Only the effects of sea level rise in the scenarios would affect the replacements portion of this plan. However, under any of the sea level rise scenarios, the locations or construction of the relocated structures (elevated first floors) could be modified to accommodate the anticipated rises in sea level described in the 4 scenarios.

7.3.2.8. Plan NSC-6

This nonstructural plan is a modification of Plan NSC-1 with three scales of surge inundation above the base ABFE level of protection that would be applied to all of those areas not protected by either a series of ring-levees or by LOD-4. Since the ring-levee alignments protect most of the high-density urban development, the nonstructural measures would address the less densely developed areas and some displaced households or businesses through the permanent acquisition component may relocate into the urban areas protected by structural projects. This "in-fill" opportunity for displaced households and businesses would reduce program costs and impacts to the tax base.

As described above for Plan NSC-1, this plan features permanent acquisition in the high-hazard zones and non-floodproofing areas where water depths would exceed 13 feet. This plan also uses floodproofing by elevation as a means of reducing storm inundation damages to structures and their contents and the replacements of critical public facilities to further reduce storm-related damages and threats to life and public safety.

As described in Plan NSC-1 above, the use of permanent acquisition in the high-hazard zone, where much of the redevelopment contemplated in the 6 scenarios could occur, would reduce future damages by a significant amount (the percent reduction would be contingent upon the program participation rate). This reduction in damages would also hold true for any sea level rise scenario since the high-hazard zone is not sensitive to water elevation but lateral extent of the V-zone and the damage zone observed in Katrina.

The floodproofing component of the plan, depending upon the determination of the final level of protection for each structure would be sensitive to sea level rise although being implemented on a structure-by- structure basis, this measure can be easily adjusted to account for changes in the Gulf's water level and the freeboard included in the floodproofing design gives some increment of protection against future rises in the Gulf levels. Under any of the redevelopment scenarios, floodproofing by elevation would be applicable through the current NFIP requirements by setting first floors above the BFE. Since this regulatory requirement is mandatory in the flood hazard areas defined in the local ordinances, each new building constructed would be subject to this requirement in order to obtain a building permit.

The replacement of public structures from hazard areas would significantly reduce storm-related damages and threats to life and public safety by relocating these critical facilities to higher elevations and away from hazard areas. During replacements planning, the affects of potential future placement of either residential or mixed use development back into the hazard zones (minus those parcels acquired through this plan) that could affect the service areas of relocated structures would be taken into account. Only the effects of sea level rise in the scenarios would affect the replacements portion of this plan. However, under any of the sea level rise scenarios, the locations or construction of the relocated structures (elevated first floors) could be modified to accommodate the anticipated rises in sea level described in the 4 scenarios.

7.4 Plan Comparisons with Planning Objectives

7.4.1 Planning Objectives

The MsCIP team developed a series of planning objectives for the Comprehensive Study in concert with project stakeholders and cooperating agencies. In total, 29 separate and distinct planning objectives were formulated for the study. Among those objectives were 10 objectives that could be specifically addressed through nonstructural measures. Other objectives being pursued by the study such as protection against saltwater intrusion and restoration of the barrier islands are not consistent with the nonstructural measures identified and evaluated in this appendix. The plans are also evaluated with the 4 primary civil works project objectives prescribed in the P&G. Those planning objectives that can be addressed by nonstructural measures are:

1) Reduction of the potential for future storm created flood damages,

2) Reduction of the potential for future storm related threats to life and safety,

3) Reduce costs for storm related emergency services,

4) Provide environmental justice in recommended solutions,

5) Provide complete solutions (in accordance with the P&G),

6) Provide solutions "acceptable" to communities & resource agencies,

7) Provide environmentally sound solutions,

8) Provide solutions that fit within existing laws, policies, regulations, and the general plans of local governments and communities,

9) Minimize impacts to the environment, and

10) Generate opportunities for ecosystem restoration of wetland habitat.

7.4.2. Comparisons with Planning Objectives

It is against this abridged listing of planning objectives, objectives that can be reasonably addressed by nonstructural measures, that the various plans have been evaluated. Table 35 shows the comparisons of the various plans with respect to the planning objectives and indicates whether or not and to what extent the plans accomplish one or more of the stated objectives.

Table 35
Comparison of Plans with Study and Principles and Guidelines (P&G) Objectives

Plans	NS-PAHHZ	NS-PA100	NSC-1	NSC-2	NSC-3	NSC-4	NSC-5	NSC-6
Objectives								
Reduce Storm Damages	Partially meets objective - $92.0M in AAD prevented	Partially meets objective - $210.0M in AAD prevented	Meets objective - $315.0M in AAD prevented	Partially meets objective - $105.0M in AAD prevented	Meets objective - $315.0M in AAD prevented	Partially meets objective - but AAD prevented would be minimal	Partially meets objective - $92.0M in AAD prevented	Meets objective – AAD prevented is undetermined
Reduce threats to life and public safety	Partially meets objective – 38,900 lives potentially given protection	Partially meets objective – 86,300 lives potentially given protection	Meets objective – 152,000 lives potentially given protection	Partially meets objective – 65,900 lives potentially given protection	Meets objective – 152,000 lives potentially given protection	Partially meets objective - lives given protection is undetermined	Partially meets objective – 38,900 lives potentially given protection	Meets objective – 222,000 lives potentially given protection
Reduce storm related emergency costs	Partially meets objective – reduces emergency costs for at least 14,997 parcels	Partially meets objective - reduces emergency costs for at least 33,100 parcels	Meets objective - reduces emergency costs for at least 42,513 parcels	Partially meets objective - reduces emergency costs for at least 25,419 parcels	Meets objective - reduces emergency costs for at least 42,513 parcels	Partially meets objective - potentially reduces emergency costs for at least 27,000 parcels	Partially meets objective – reduces emergency costs for at least 14,997 parcels	Meets objective - reduces emergency costs for at least 42,513 parcels
Provide environmental justice in recommended solutions	Plan impacts do not disproportionately affect impact minority or low income sectors of the population	Plan impacts do not disproportionately affect impact minority or low income sectors of the population	Plan impacts do not disproportionately affect impact minority or low income sectors of the population	Plan impacts do not disproportionately affect impact minority or low income sectors of the population	Plan impacts do not disproportionately affect impact minority or low income sectors of the population	Plan impacts do not disproportionately affect impact minority or low income sectors of the population	Plan impacts do not disproportionately affect impact minority or low income sectors of the population	Plan impacts do not disproportionately affect impact minority or low income sectors of the population
Provide complete solutions (in accordance with the P&G	Provides complete solution for specific geographic zone of the project area	Provides complete solution for specific geographic zones of the project area.	Provides complete solution for the project area.	Provides complete solution for specific geographic zones of the project area.	Provides complete solution for the project area.	Does not meet the objective for the project area – is incomplete	Provides complete solution for specific geographic zone of the project area	Provides complete solution for the project area.
Provide solutions "acceptable" to communities & resource agencies	Does not meet objective with respect to community acceptance in target area. Meets the objective from resources agencies viewpoint.	Does not meet objective with respect to community acceptance in target area. Meets the objective from resources agencies viewpoint	Does not meet objective with respect to community acceptance in target areas. Meets the objective from resources agencies viewpoint.	Does meet objective with respect to community acceptance in target area. Meets the objective from resources agencies viewpoint.	Does not meet objective with respect to community acceptance in target areas. Meets the objective from resources agencies viewpoint.	Does meet objective with respect to community acceptance in target areas. Meets the objective from resources agencies viewpoint.	Does not meet objective with respect to community acceptance in target areas. Meets the objective from resources agencies viewpoint	Does meet objective with respect to community acceptance in target areas. Partially meets the objective from resourcas agencies viewpoint
Provide environmentally sound solutions	Meets the objective	Meets the objective	Meets the objective	Meets the objective	Meets the objective	Meets the objective	Meets the objective	Partially meets the objective
Provide solutions that fit within existing laws, policies, regulations, and the general plans of local governments and communities	Partially meets objective – relocation of structures from the HHZ may not meet current community plans	Partially meets objective – significant relocation of structures may not meet current community plans	Partially meets objective – significant relocation of structures may not meet current community plans	Meets objective	Partially meets objective – significant relocation of structures may not meet current community plans	Meets objective	Partially meets objective – significant relocation of structures may not meet current community plans	Meets objective
Minimize impacts to the environment	Meets the objective – only impacts are through redevelopment sites	Meets the objective – only impacts are through redevelopment sites	Meets the objective – only impacts are through redevelopment sites	Meets the objective	Meets the objective – only impacts are through redevelopment sites	Meets the objective	Meets the objective – only impacts are through redevelopment sites	Partially meets the objective

Plans	NS-PAHHZ	NS-PA100	NSC-1	NSC-2	NSC-3	NSC-4	NSC-5	NSC-6
Objectives								
Generate opportunities for ecosystem restoration of wetland habitat	Meets the objective – 4,000 acres made available for ER	Meets the objective – 9,200 acres made available for ER	Meets the objective – 9,200 acres made available for ER	Does not meet the objective – no acres would be available for ER	Meets the objective – 9,200 acres made available for ER	Does not meet the objective – no acres would be available for ER	Meets the objective – 4,000 acres made available for ER	Meets the objective – 9,200 acres made available for ER
Completeness	Partially meets the objective – complete for the identified zone being targeted	Partially meets the objective – complete for the identified zone being targeted	Meets the objective	Partially meets the objective – complete for the identified zone being targeted	Meets the objective	Does not meet the objective	Partially meets the objective – complete for the identified zone being targeted	
Effectiveness	Effectiveness is contingent upon landowner participation rates; thus meeting the objective is uncertain at this time.	Effectiveness is contingent upon landowner participation rates; thus meeting the objective is uncertain at this time.	Effectiveness is contingent upon landowner participation rates; thus meeting the objective is uncertain at this time.	Partially meets the objective	Effectiveness is contingent upon landowner participation rates; thus meeting the objective is uncertain at this time.	Partially meets the objective	Partially meets the objective	Effectiveness is contingent upon landowner participation rates; thus meeting the objective is uncertain at this time.
Efficiency	Does not meet the objective with respect to other plans	Does not meet the objective with respect to other plans	Meets the objective with respect to other plans	Does not meet the objective with respect to other plans	Meets the objective with respect to other plans	Meets the objective with respect to other plans	Does not meet the objective with respect to other plans	Meets the objective with respect to other plans
Acceptability	Meets the objective from the standpoint of feasibility of implementation, but would not be acceptable to local communities affected.	Meets the objective from the standpoint of feasibility of implementation, but would not be acceptable to local communities affected.	Meets the objective from the standpoint of feasibility of implementation, but would not be acceptable to local communities affected.	Meets the objective from the standpoint of feasibility of implementation and acceptability to local communities affected.	Meets the objective from the standpoint of feasibility of implementation, but would not be acceptable to local communities affected.	Meets the objective from the standpoint of feasibility of implementation and acceptability to local communities affected.	Meets the objective from the standpoint of feasibility of implementation, but would not be acceptable to local communities affected.	Meets the objective from the standpoint of feasibility of implementation and acceptability to local communities affected.
Sustainability	Meets the objective since acquired lands would have minimal O&M requirements	Meets the objective since acquired lands would have minimal O&M requirements	Meets the objective since acquired lands would have minimal O&M requirements	Meets the objective since floodproofed structures would have minimal O&M requirements	Meets the objective since acquired lands and floodproofed structures would have minimal O&M requirements	Meets the objectives since local measures are sustainable with local revenues	Meets the objective since acquired lands would have minimal O&M requirements	Meets the objective since acquired lands and floodproofed structures would have minimal O&M requirements

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As the table shows, several of the plans perform very well with respect to the planning objectives and 4 primary civil works project objectives in the P&G. In general, those plans including significant amounts of permanent acquisitions meet the objectives of storm damage reduction and reduced threats to life and public safety while providing substantial amounts of land for ecosystem restoration as wetlands and other sensitive habitat. Generally speaking these plans also are environmentally friendly having only minimal impacts (construction impacts at redevelopment sites) that can be mitigated and do not disproportionately affect low income or minority populations. Conversely, plans featuring substantial displacement of households may not be well accepted by the communities or local governments due to potential social and economic impacts (lost tax revenues).

Although effective in reducing damages throughout the project area (approximately $105M AAD) and reducing threats to loss of life and public safety for numerous parcels (25,419), Plan NSC-2 – Floodproofing with FWEE upgrades does not produce significant acres of land for ER and does not address those high-hazard parcels so susceptible to destruction and loss of life.

The Non-Federal Jurisdiction Plan (Plan NSC-4) does address several of the planning objectives and because of its mandatory regulatory nature, can assure compliance with upgraded ordinances and codes that would reduce damages for new growth in the future without-project conditions. However, the plan with the exception of a possible TDR or PDR program in place does little to address objectives for reducing damages to existing structures and providing acres for ecosystem restoration.

Plans NS-PAHHZ and NS-PA100 meet the objectives regarding reduction of damages and threats to life and public safety as well as providing lands suitable for ER and are environmentally friendly, but they are confined to smaller geographic zones and would not be well received by local governments or communities due to their potential social and economic impacts.

Plan NSC-6 which combines the nonstructural measures in Plan NSDC-1 with structural components at several communities or a single line of defense (LOD-4) meets or partially meets several objectives while having few instances where the nonstructural plan portion of the combined project would not meet an objective. Among the plans, Plan NSC-6 (with ring-levees) at the ABFE level of protection would meet most objectives while partially meeting many others.

Plan NSC-1 meets several of the objectives (damage reduction, loss of life and ER opportunities) but like the other plans including permanent acquisitions as a component of the plan, the plan may not be popular and perhaps unacceptable to local governments and communities due to the number of displaced landowners.

Plan NSC-3 provides the widest array of measures that can be applied to the various planning objectives and generally fully meets or partially meets most of the planning objectives with the one exception of the issue of local acceptability. The large number of permanent acquisitions that would result in displaced landowners would be a concern for the local governments and communities. The anticipated social and economic impacts that could accompany this plan when implemented make this plan less popular than some of the other plans that do not include large numbers of displaced landowners. There are a number of mitigative actions that be taken that would lessen the anticipated social and economic impacts of large migrations away from the coast to safer areas, all of which are discussed in this Appendix.

CHAPTER 8. COMPARISON OF ALTERNATIVE PLANS

8.1 General

Having displayed and discussed the various outputs of the plans and evaluated the plans with respect to the future without-project conditions and with respect to the planning objectives and P&G objectives, the plans can now be compared against one another for the purpose of indentifying major differences between them and ranking the plans based upon their attributes. Table 36 displays the plans and compares them through their contributions to 9 individual output categories.

Although this Appendix does not conclude with selection of a best or optimal nonstructural plan, this comparison does show which plans perform the best with respect to one another in certain categories of relative outputs and impacts. An objective ranking of the plans would depend upon a consensus agreement by the stakeholders of what constituted the most important category of plan outputs or most insidious impacts.

Since the MsCIP Main Report addresses many other alternatives (i.e. structural plans) in addition to the nonstructural plans, the identification of an optimal or best plan is relegated to that document. Regrettably, not all of the output categories discussed below involve metrics expressed in dollars or numbers of structures protected, lives protected or acres of ecosystem restoration land provided. Many comparison categories are not commensurable or the plan outputs are not measurable at this level of study. Where possible, comparisons are provided in like units of measurement.

8.2 Plan Comparisons

8.2.1. Plan NSC-3

Among the various plans being compared, Plan NSC-3 provides the widest array of nonstructural measures available. There are 9 measures provided that include the best practices for reducing storm-related damages in a joint effort by Federal agencies and state and local governments. Although the complete metrics that would show the full benefits of this plan are not available at this level of study, the nonstructural measures included are proven in other Corps projects to be cost effective compared to other alternatives and can be modified to adjust to a multitude of changing conditions as have been anticipated in the future without-project conditions. The local jurisdiction measures have been proven to reduce flood damages in other coastal areas and would be largely regulatory and administrative in nature.

This plan is the most expensive plan of those considered ($19.1B) since it includes administrative costs necessary to accomplish the non-Federal jurisdiction actions as well and its cost per parcel protected is relatively high at $325K per parcel. In most respects, this plan is very similar to Plan NSC-1 from a Federal perspective with similar damage reduction and reductions to loss of life (reducing the threat to as many as 152,000 people) characteristics. Plan NSC-3 at least partially addresses many of the planning objectives and performs well through all of the 6 future without project scenarios. The only concern for this plan is the potentially large number of displaced households (33,191) which would be a concern for the local communities. Those choosing not to participate could continue to carry flood insurance in accordance with the NFIP. Other mitigative actions through the Uniform Relocations Act and various revenue sharing processes could address these relocation and public revenue concerns.

From an environmental standpoint, Plan NSC-3 could provide over 9,200 acres of land suitable for restoration as wetlands through the acquisition program. Additional land for wetland restoration could be provided through the floodproofing program as well during implementation. The only environmental impacts generated by this plan are those associated with construction of redevelopment sites for displaced households and businesses. If constructed through a Corps program under the last report housing provisions of the Uniform Relocations Act, these sites would be subject to scrutiny through an EA or EIS process and the impacts mitigated in collaboration with Federal and state resource agencies.

8.2.2. Plan NSC-1.

Similar to Plan NSC-3 is Plan NSC-1 which provides substantial AAD reductions ($315.0M) and reduces threats to loss of life for at least 152,000 people living in the storm surge zones through a combination of acquisitions and floodproofing. Compared to the other plans for which AAD figures are available this plan produces the most FDR benefits and has a low per parcel cost ($323K/parcel) compared to other nonstructural plans evaluated. Plan NSC-1 is expensive at $18.7B, but it is effective in reducing damages and does reduce the threat of massive property damage and possible loss of life in another hurricane event.

NSC-1 does not include the array of local jurisdiction measures that could be applied (in particular the TDR and PDR programs) to the many parcels within the ABFE footprint, but even without additional upgrades to existing regulations and ordinances, the ability of local jurisdictions to police coastal development and redevelopment activities is potent and effective. When new FEMA BFE mapping is adopted by the counties and municipalities, any development activities that occur within the defined flood hazard areas will be provided some level of protection through existing ordinances.

As with Plan NSC-3 this plan could provide a substantial number of acres of land (9,200 acres) suitable for wetlands restoration and with the exception of potential impacts caused by the redevelopment sites, is environmentally friendly to natural resources. Like plan NSC-3 this plan does acquire a large number of parcels voluntarily and that potential displacement of households and businesses is a concern for local governments and communities regarding social and public services and property tax revenue issues. Were a local TDR or PDR program to be established in conjunction with Plan NSC-1, the costs of securing the vacated parcels in the high-hazard zone would be reduced by 20-30 percent as only the development rights of the property would be purchased.

8.2.3. Plan NSC-6

Plan NSC-6 includes all of the nonstructural measures of Plan NSC-1 and when combined with LOD 4 at the 20 feet inundation level has the lowest per parcel protected cost of $210K for all nonstructural plans. With costs between $8.0B and $25.0B, these plans are more expensive that several other plans (Plan NS-PAHHZ, Plan NS-PA100 and Plan NSC-5) considered. Other variants of Plan NSC-6 that combine nonstructural measures with structural components at varying levels of inundation may provide substantial reductions in AAD (not determined at this phase of the study) and may provide protection for many people located outside of the lines of protection. Estimates of the numbers of people whose threat of drowning by surge inundation would be lessened by Plan NSC-6 variants range from 79,000 to 222,000. Combined with those protected by the structural measures, the variants of Plan NSC-6 are very effective in protecting at-risk residents.

Each of the scaled plans developed as a part of Plan NSC-6 will produce substantial acres of ecosystem restoration for wetlands (specific acreages not yet determined) and other sensitive habitat. Like Plan NSC-1 the permanent acquisition component of the NSC-6 variants will result in displacement of many thousands of households and businesses. The acquisitions range from

19,556 to 85,447 parcels across the 8 variants and required redevelopment lots range from 6,800 to 29,900 lots. This large number of displaced persons would be a concern for local governments and communities. These numbers clearly exceed anything found in the other plans and would have devastating effects on the social and economic systems of the project area.

The one benefit that Plan NSC-6, in its several scales, provides that is slightly different than other plans is its ability to protect, by use of structural means, the major commercial centers within the project area thus reducing the social and economic impacts associated with acquisitions within the urban centers that power the coastal economy. Either by means of the several ring-levees or the LOD 4 protection system, many of the major centers could be protected from surge flooding without resorting to high levels of population relocation.

8.2.4. Plan NS-PA100

This plan compares favorably with other plans at the ABFE level of protection in damages reduced ($210.0M) and lives protected (86,000) from surge inundation drowning. The plan has a lower per parcel protected cost at $248K/parcel and does produce 9,200 acres of land suitable for ecosystem restoration as wetlands. Among the plans considered this plan is very efficient on a per parcel protected basis, but is geographically limited to the 100-year surge floodplain in its effect and may not be acceptable to local governments and communities due to the displacement issues.

8.2.5. Plan NSC-2

This plan has a high project cost at $10.8B and is not efficient (compared to other alternatives) at $425K/parcel protected. The plan would reduce average annual flood damages by $105.0M. This plan does not provide many acres of land suitable for ecosystem restoration as wetlands and although it provides some potential increment of protection for as many as 69,900 lives, the inhabitants of floodproofed structures would be encouraged to seek shelter outside of the elevated structure.

This plan would be technically feasible and probably acceptable to the local communities and local governments compared to other plans that have large permanent acquisition components. The plan would have limited environmental impacts except perhaps for historic structures that may not be able to be elevated in place and maintain their significance. The plan would be applicable at several levels of protection although due to the depth restrictions for elevating structures at higher level of inundation (30 feet and 40 feet) floodproofing is not an option for most of the parcels in the project area.

8.2.6. Plan NS-PAHHZ

This plan in comparison to other nonstructural plans is relatively efficient at $404K/parcel protected. Its project cost is relatively high given the limited geographical extent of its coverage (high-hazard zone) and the number of displacements although lower than other plans still would be a concern for local governments and communities. The plan offers the least amount of reduction in average annual damages ($92.0M) but is relatively effective in reducing threats to life and public safety (38,900 lives) compared to the other plans.

The plan does provide 4,000 acres of land suitable for ecosystem restoration as wetlands and its environmental impacts would be relatively insignificant compared to the other plans since it has a limited geographical impact.

8.2.7. Plan NSC-5

This plan is dedicated to reducing loss of life and increasing public safety. At a cost comparable to Plan NS-PAHHZ ($6.1B) the plan is relatively inexpensive compared to other plans but at a per parcel cost of $404/parcel) this plan is relatively inefficient compared to all the other plans (i.e. NS-PA100 and NSC-1). The plan is comparable to Plan NS-PAHHZ in geographic extent and community impacts and therefore may not the best nonstructural plan.

The plan does create 4,000 acres of land suitable for ecosystem restoration as wetlands and its public buildings replacement component would enable these critical facilities to be relocated to higher ground, but its per parcel cost is much higher than other plans also featuring relocations as well.

8.2.8. Plan NSC-4

This plan is unique in that all of the measures within it are non-Federal and implemented by local jurisdictions. It has a relatively low cost (estimated to be $5.5M) compared to the other more robust plans since the majority of the costs are administrative and enforcement related and some like building codes are actually reimbursed through the building construction permit process. Although the plan is simple in its delivery and its effectiveness is not contingent upon a participation rate since the regulatory ordinances are mandatory in nature, the plan does not address damages for existing structures and is contingent upon the political will of the local leadership to upgrade and enforce the necessary ordinances and codes to control new development.

Since the plan is locally based and does not have a permanent acquisition component that would generate opposition, this plan can be effective in reducing future damages. Since there are so many vacated parcels in the project area that would be rebuilt upon (all 6 scenarios suggest a rebuilt environment in 10-12 years) and since the ordinances and codes that control such redevelopment rest in the hands of the local jurisdictions, this plan has merit.

In order to address the future damages on the vacated parcels and protect sensitive environmental areas, the initiation of either a TDR or PDR program by the three counties would allow securing the development rights of many parcels and accomplishing the same flood damage reduction objectives as can be met by the permanent acquisition components of several of the plans. At a much reduced cost for acquisition (just the development rights) or in the case of a TDR program where all transactions are within the land market, using these programs to forestall redevelopment and new development in perpetuity would increase the completeness of the plans and make them more efficient on a per parcel cost basis.

Table 36
Comparison of Plans

Metrics \ Plans	Plan NS-PAHHZ	Plan NS-PA100	Plan NSC-1	Plan NSC-2	Plan NSC-3	Plan NSC-4	Plan NSC-5	Plan NSC-6
Reduction of Average Annual Damages and Parcels protected	$92.0M in AAD prevented and 14,997 parcels removed from future development	$210.0M in AAD prevented and 33,191 parcels removed from future development	$315.0M in AAD prevented and 58,617 parcels protected.	$105.0M in AAD prevented and 25,419 parcels protected – some additional protection offered by the FWEE.	$315.0M in AAD prevented and 58,617 parcels protected	AAD prevented have not been determined for this Plan at this time.	$92.0M in AAD prevented and 14,997 parcels removed from future development	AAD have not been determined for this plan at this time.
Plan Costs and Cost per parcel protected	$6.1B $404K/parcel	$8.2B $248K/parcel	$18.7B $323K/parcel	$10.8B $425K/parcel	$19.1B $325K/parcel	$5.5M No per parcel cost has been determined at this time	$6.1B $404K/parcel	Costs range from $8.8B to $25.3B and per parcel cost range from $221K/parcel to $306K/parcel
Completeness	Plan complete in addressing damages in geographical target area.	Plan complete in addressing damages in geographical target area.	Plan complete in addressing damages	Plan not complete in addressing damages in project area	Plan Complete in addressing damages	Plan not complete in addressing damages to existing structures	Plan complete in addressing loss of life issues in project area.	Various plan variants complete for those areas located outside lines of structural protection.
Efficiency	Less efficient plan based upon per parcel cost to protect $404K/parcel	Very high efficiency at $248K/parcel protected	Medium level of efficiency compared to other plans at $323K/parcel protected	Very low efficiency at $425K/parcel protected	Medium level of efficiency at $325K/parcel protected	Efficiency yet to be determined based upon application of local regulatory codes and ordinances	Less efficient plan based upon per parcel cost to protect - $404/parcel	Plan NSC-6 at 20 feet inundation with LOD-4 is most cost efficient plan at $221K/parcel protected
Effectiveness	Plan is effective in addressing damages in geographic target area. Effectiveness will be contingent upon participation rate	Plan is effective in addressing damages in geographic target area. Effectiveness will be contingent upon participation rate	Plan is effective in addressing damages and threats to life in project area.	Plan not effective in addressing damages in geographic target area. Effectiveness will be contingent upon participation rate.	Plan is effective in addressing damages and threats to life in project area.	Plan is not effective in reducing damages to existing structures but would reduce damages for structures built upon approx. 27,000 vacant acres in flood zones.	Plan is effective in addressing damages in geographic target area. Effectiveness will be contingent upon participation rate	Plan is effective in addressing damages and threats to life in project areas located outside of structural protection.
Acceptability	Plan is technically feasible but may be unacceptable to local communities	Plan is technically feasible but may be unacceptable to local communities	Plan is technically feasible but permanent acquisitions may be unacceptable to local communities	Plan is technically feasible and may be acceptable to local communities	Plan is technically feasible but permanent acquisitions may be unacceptable to local communities	Plan is technically feasible and may be acceptable to local communities	Plan is technically feasible but permanent acquisitions may be unacceptable to local communities	Plan is technically feasible but permanent acquisitions may be unacceptable to local communities
Sustainability	Plan is sustainable in long term since evacuated parcels have minimal O&M requirements	Plan is sustainable in long term since evacuated parcels have minimal O&M requirements	Plan is sustainable in long term since evacuated parcels and floodproofed structures have minimal O&M requirements	Plan is sustainable in long term since floodproofed structures have minimal O&M requirements	Plan is sustainable in long term since evacuated parcels and floodproofed structures have minimal O&M requirements	Plan is sustainable since costs are primarily administrative in nature and supported by existing taxes and assessments which are anticipated to grow.	Plan is sustainable in long term since evacuated parcels have minimal O&M requirements	Plan is sustainable in long term since evacuated parcels and floodproofed structures have minimal O&M requirements
Public Safety	Plan potentially protects at least 38,900 lives	Plan potentially protects at least 86,000 lives	Plan potentially protects at least 152,000 lives	Plan potentially protects at least 60,000 lives	Plan potentially protects at least 152,000 lives	Plan potentially protects at least 220,000 lives	Plan potentially protects at least 38,900 lives	Plan potentially protects between 69,000 and 220,000 lives depending upon the level of protection selected.

Plans / Metrics	Plan NS-PAHHZ	Plan NS-PA100	Plan NSC-1	Plan NSC-2	Plan NSC-3	Plan NSC-4	Plan NSC-5	Plan NSC-6
Environmental Impacts	Plan is environmentally acceptable and creates 4,000 acres of potential wetlands creation. Potential impacts to social and economic systems that can be mitigated.	Plan is environmentally acceptable and creates 9,200 acres of potential wetlands creation. Potential impacts to social and economic systems that can be mitigated.	Plan is environmentally acceptable and creates 9,200 acres of potential wetlands creation. Potential impacts to social and economic systems that can be mitigated.	Plan is environmentally acceptable but does not create many acres of potential wetlands creation. No significant displacements of landowners through acquisition.	Plan is environmentally acceptable and creates 9,200 acres of potential wetlands creation. Potential impacts to social and economic systems that can be mitigated.	Plan is environmentally acceptable but does create any acres potential wetlands creation	Plan is environmentally acceptable and creates 4,000 acres of potential wetlands creation. Potential impacts to social and economic systems that can be mitigated.	Plan is environmentally acceptable but acres of potential wetlands created are unknown at this time. Potential impacts to social and economic systems that can be mitigated.

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Table 37.
National Register of Historic Buildings and Sites

	City	Date
Hancock County		
Beach Blvd. Historic District (Bay St. Louis MRA)	Bay St. Louis	25 Nov 1980
Building at 242 St. Charles (Bay St. Louis MRA)	Bay St. Louis	25 Nov 1980
Claiborne Site (22-Ha-501) (A)	Pearlington	12 Nov 1982
Glen Oaks/Kimbrough House (Bay St. Louis MRA Amdmt)	Bay St. Louis	21 Nov 1986
Jackson Landing Site (22-Ha-504) (A)	Pearlington Vicinity	27 Jul 1973
Main St. Historic District (Bay St. Louis MRA)	Bay St. Louis	25 Nov 1980
Nugent Site (22-Ha-592) (A)	Kiln Vicinity	13 Apr 1988
Onward Oaks	Bay St. Louis	1 Nov 1996
Rocket Propulsion Test Complex (NHL)(F)	Bay St. Louis	3 Oct 1985
SJ Mound (22-Ha-594) (A)	Pearlington Vicinity	13 Apr 1988
Sycamore St. Historic District (Bay St. Louis MRA)	Bay St. Louis	25 Nov 1980
Taylor House (Bay St. Louis MRA Amdmt)	Bay St. Louis	21 Nov 1986
Taylor School (Bay St. Louis MRA Amdmt)	Bay St. Louis	15 Jan 1987
Three Sisters Shell Midden (22-Ha-596) (A)	Pearlington Vicinity	28 Jul 1988
Up the Tree Shell Midden (22-Ha-595) (A)	Pearlington Vicinity	13 Apr 1988
Washington St. Historic District (Bay St. Louis MRA)	Bay St. Louis	25 Nov 1980
Webb School (Bay St. Louis MRA Amdmt)	Bay St. Louis	21 Nov 1986
Williams Site (22-Ha-585) (A)	Pearlington Vicinity	28 Jul 1988
Harrison County		
Bailey House (Holy Angels Nursery) (Biloxi MRA)	Biloxi	18 May 1984
Barq, E., Pop Factory (Biloxi MRA)	Biloxi	18 May 1984
Bass, Raymond Site (22-Hr-636) (A)	Biloxi	26 Feb 1987
Beauvoir (NHL)	Biloxi	3 Sep 1971
Benton, Thomas & Melinda, House	Gulfport	9 Aug 2002
Biloxi Downtown Historic District	Biloxi	3 Sep 1998
Biloxi Garden Center (see Old Brick House)		
Biloxi Lighthouse	Biloxi	3 Oct 1973
Biloxi's Tivoli Hotel (Trade Winds) (Biloxi MRA)	Biloxi	18 May 1984
Biloxi Veterans Administration Medical Center (F)	Biloxi	14 Feb 2002
Bond House (Biloxi MRA)	Biloxi	18 May 1984
Brielmaier House (Biloxi MRA)	Biloxi	18 May 1984
Brunet-Fourchy House (Mary Mahoney's) (Biloxi MRA)	Biloxi	18 May 1984
Church of the Redeemer (Biloxi MRA)	Biloxi	18 May 1984
Clemens House (Biloxi MRA)	Biloxi	18 May 1984
Dantzler, G.B., House	Gulfport	1 Dec 1989
Fisherman's Cottage (Biloxi MRA)	Biloxi	9 Mar 1990
Fort Massachusetts (Ship Island) (F)	Gulfport Vicinity	21 Jun 1971
French Warehouse (Gulf Islands NTL SS) (22-Hr-638) (A) (F)	Biloxi	13 Dec 1991
Gillis House [Relisted – 1978]	Biloxi	7 Jul 1978
Grass Lawn (see Milner House)		
Gulf Coast Ctr for the Arts (Old Library) (Biloxi MRA)	Biloxi	8 May 1984
Harbor Square Historic District	Gulfport	13 Aug 1985
Hermann House (Biloxi MRA)	Biloxi	18 May 1984

	City	Date
Hewes Building	Gulfport	7 Oct 1982
Hewes, Finley B., House	Gulfport	15 Aug 2002
Holy Angels Nursery (see Bailey House)		
House at 121 West Water Street (Biloxi MRA)	Biloxi	18 May 1984
House at 407 E. Howard Ave	Biloxi	17 Jul 1986
Josephine (shipwreck) (22-Hr-843)	Biloxi Vicinity	22 Nov 2000
Magnolia Hotel	Biloxi	14 Mar 1973
Harrison County		
Bailey House (Holy Angels Nursery) (Biloxi MRA)	Biloxi	18 May 1984
Barq, E., Pop Factory (Biloxi MRA)	Biloxi	18 May 1984
Bass, Raymond Site (22-Hr-636) (A)	Biloxi	26 Feb 1987
Beauvoir (NHL)	Biloxi	3 Sep 1971
Benton, Thomas & Melinda, House	Gulfport	9 Aug 2002
Biloxi Downtown Historic District	Biloxi	3 Sep 1998
***Margaret Emillie (schooner) (Delisted 1989)*	*Biloxi*	*1973*
Mary Mahoney's (see Brunet-Fourchey House)		
Milner House (Grass Lawn)	Gulfport	31 Jul 1972
Nativity B. V. M. Cathedral (Biloxi MRA)	Biloxi	18 May 1984
Old Brick House (Biloxi Garden Center)	Biloxi	3 Oct 1973
Peoples Bank of Biloxi (Biloxi MRA)	Biloxi	18 May 1984
Quarles, W. J., House	Long Beach	16 Oct 1980
Redding House (Biloxi MRA)	Biloxi	18 May 1984
Reed, Pleasant, House (Reed House)	Biloxi	11 Jan 1979
Saenger Theater (Biloxi MRA)	Biloxi	18 May 1984
Scenic Drive Historic District	Pass Christian	7 May 1979
Scherer House (Spanish House) (Biloxi MRA)	Biloxi	18 May 1984
Seashore Campground School (Biloxi MRA)	Biloxi	18 May 1984
Spanish House (see Scherer House)		
Suter House (Biloxi MRA)	Biloxi	18 May 1984
Swetman, Glenn, House (Biloxi MRA)	Biloxi	18 May 1984
Tivoli Hotel (see Biloxi's Tivoli Hotel)		
Toledano/Philbrick/Tullis House	Biloxi	5 Nov 1976
Trade Winds (see Biloxi's Tivoli Hotel)		
U.S. Post Office & Customhouse (F)	Gulfport	19 Mar 1984
U.S. Post Office, Courthouse/Customhouse/Biloxi City Hall	Biloxi	30 Jan 1978
West Beach Historic District (Biloxi MRA)	Biloxi	18 May 1984
West Central Historic District (Biloxi MRA)	Biloxi	18 May 1984
West Central Historic District (Addl Documentation)		1997
Jackson County		
Applestreet Site (22-Ja-530) (A)	Gautier Vicinity	12 Sep 1985
Back Bay of Biloxi Shipwreck Site (22-Ja-542)	Ocean Springs Vic	22 Apr 1999
"Bellevue" ("Longfellow House")	Pascagoula	12 Dec 2002
Bertuccine House & Barbershop (Ocean Springs MRA)	Ocean Springs	9 Jun 1987
Bodden, Capt. Willie, House (Pascagoula MPS)	Pascagoula	20 Dec 1991
Brash, Anna C., House (Pascagoula MPS)	Pascagoula	20 Dec 1991
Carter-Callaway House (Ocean Springs MRA)	Ocean Springs	20 Apr 1987
Clark, Clare T., House (Pascagoula MPS)	Pascagoula	20 Dec 1991

	City	Date
Clinton, Capt. F. L., House	Pascagoula	20 Dec 1991
Cochran-Cassanova House (Ocean Springs MRA)	Ocean Springs	20 Apr 1987
Colle Company Housing (Pascagoula MPS)	Pascagoula	20 Dec 1991
Colle, Capt. Herman H. Sr., House (Pascagoula MPS)	Pascagoula	20 Dec 1991
Cottage by the Sea Tavern (Pascagoula MPS)	Pascagoula	20 Dec 1991
Cudabac-Gantt House	Moss Point	24 Jul 1990
Dantzler, A. F., House	Moss Point	26 Mar 1987
Degroote Folk House	Hurley Vicinity	4 May 1982
Dejean House	Pascagoula	25 Feb 1993
Farnsworth R. A. Summer House (Pascagoula MPS)	Pascagoula	20 Dec 1991
Ford, Mayor EBB, House (Pascagoula MPS)	Pascagoula	20 Dec 1991
Frentz, George, House (Pascagoula MPS)	Pascagoula	20 Dec 1991
Front Street Historic District	Pascagoula	17 May 1984
Gautier, Adam, House (Pascagoula MPS)	Pascagoula	20 Dec 1991
Gautier, Eugene, House (Pascagoula MPS)	Pascagoula	20 Dec 1991
Gautier, Walter, House (Pascagoula MPS)	Pascagoula	20 Dec 1991
Graveline Mound Site (22-Ja-503) (A)	Gautier Vicinity	2 Jul 1987
Griffin House	Moss Point	7 Jul 1983
Halstead Place (Ocean Springs MRA)	Ocean Springs	20 Apr 1987
Hansen-Dickey House (Ocean Springs MRA)	Ocean Springs	20 Apr 1987
Herrick, Lemuel D., House (Pascagoula MPS)	Pascagoula	20 Dec 1991
House at 1112 Bowen Ave (Ocean Springs MRA)	Ocean Springs	20 Apr 1987
House at 1410 Bowen Ave (Ocean Springs MRA)	Ocean Springs	20 Apr 1987
Hughes, William, House (Pascagoula MPS)	Pascagoula	21 Oct 1993
Hull, Edgar W., (Pascagoula MPS)	Pascagoula	20 Dec 1991
Indian Springs Historic District (Ocean Springs MRA)	Ocean Springs	20 Apr 1987
Keys, Thomas Isaac, House (Ocean Springs MRA)	Ocean Springs	20 Apr 1987
Kinne, Georgia P., House (Pascagoula MPS)	Pascagoula	20 Dec 1991
Krebs, Agnes V., House (Pascagoula MPS)	Pascagoula	20 Dec 1991
Krebs, James, House (Pascagoula MPS)	Pascagoula	20 Dec 1991
Krebsville Historic District (Pascagoula MPS)	Pascagoula	20 Dec 1991
Levin, Leonard, House (Pascagoula MPS)	Pascagoula	20 Dec 1991
Lewis, Col. Alfred E., House (Oldfields)	Gautier	16 Oct 1980
Louisville & Nashville Railroad Depot	Pascagoula	27 Aug 1974
Louisville & Nashville Railroad Depot	Ocean Springs	31 Dec 1979
Lover's Lane Historic District (Ocean Springs MRA)	Ocean Springs	9 Jun 1987
Marble Springs Historic District (Ocean Springs MRA)	Ocean Springs	20 Apr 1987
Nelson Tenement (Pascagoula MPS)	Pascagoula	20 Dec 1991
Nelson, John C., House (Pascagoula MPS)	Pascagoula	20 Dec 1991
O'Keefe-Clark Boarding House (Ocean Springs MRA)	Ocean Springs	20 Apr 1987
Ocean Springs Comm Center (Walter Anderson thematic)	Ocean Springs	24 Aug 1989
Oldfields (see Col. Alfred E. Lewis House)		
Old Farmers & Merchants State Bank (Ocean Springs MRA)	Ocean Springs	20 Apr 1987
Old Ocean Springs Historic Dist (Ocean Springs MRA)	Ocean Springs	7 Oct 1987
Old Ocean Springs High School	Ocean Springs	2 Aug 1990
Old Spanish Fort	Pascagoula	3 Sep 1971
Olsen, Lena, House (Pascagoula MPS)	Pascagoula	20 Dec 1991

	City	Date
Orange Avenue Historic District	Pascagoula	14 Aug 2001
Pascagoula Central Fire Station #1	Pascagoula	8 Dec 1978
(Old) Pascagoula High School	Pascagoula	6 Apr 2000
Pascagoula St. Railroad & Power Co (Pascagoula MPS)	Pascagoula	20 Dec 1991
Randall's Tavern (Pascagoula MPS)	Pascagoula	20 Dec 1991
Round Island Lighthouse	Pascagoula Vicinity	9 Oct 1986
Shearwater Historic District (Walter Anderson thematic)	Ocean Springs	24 Aug 1989
St. John's Episcopal Church (Ocean Springs MRA)	Ocean Springs	20 Apr 1987
St. Mary's by the River	Moss Point	2 May 1991
Sullivan-Charnley Historic Dist (Ocean Springs MRA)	Ocean Springs	20 Apr 1987
Tabor, Dr. Joseph A., House (Pascagoula MPS)	Pascagoula	20 Dec 1991
Thompson, George, House (Pascagoula MPS)	Pascagoula	20 Dec 1991
Vancleave Cottage (Ocean Springs MRA)	Ocean Springs	20 Apr 1987
Westphal, Laura, House (Pascagoula MPS)	Pascagoula	20 Dec 1991

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Figure 139 – Land Surface Elevations of Economic Reaches w/Respect to the Gulf (A1)

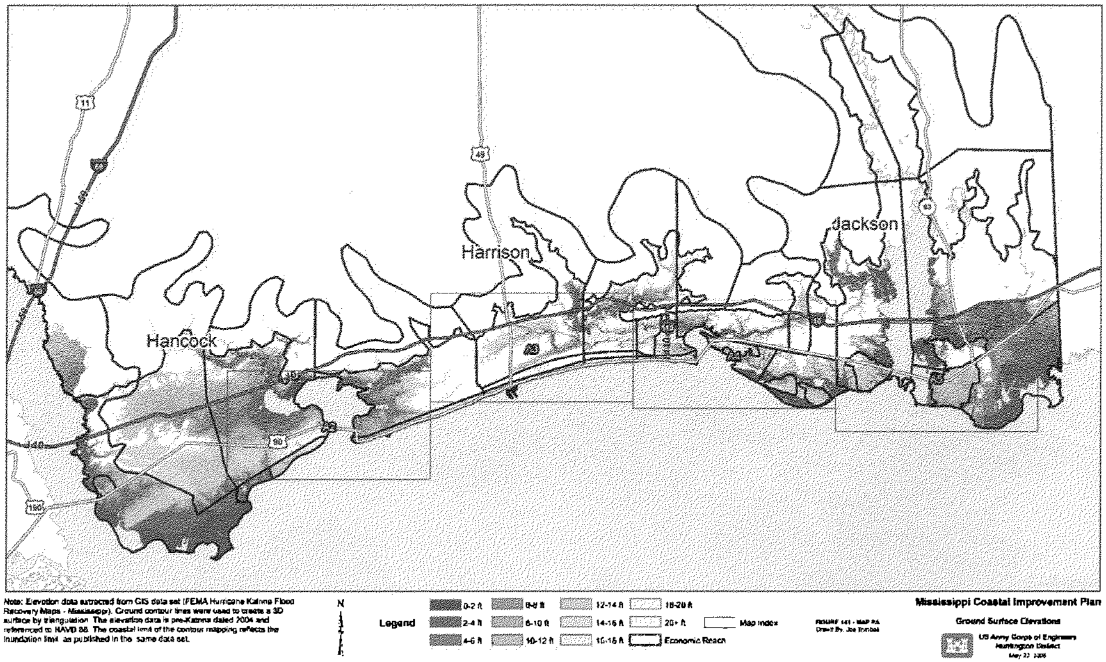


Figure 140- Land Surface Elevations of Economic Reaches w/Respect to the Gulf (A2)

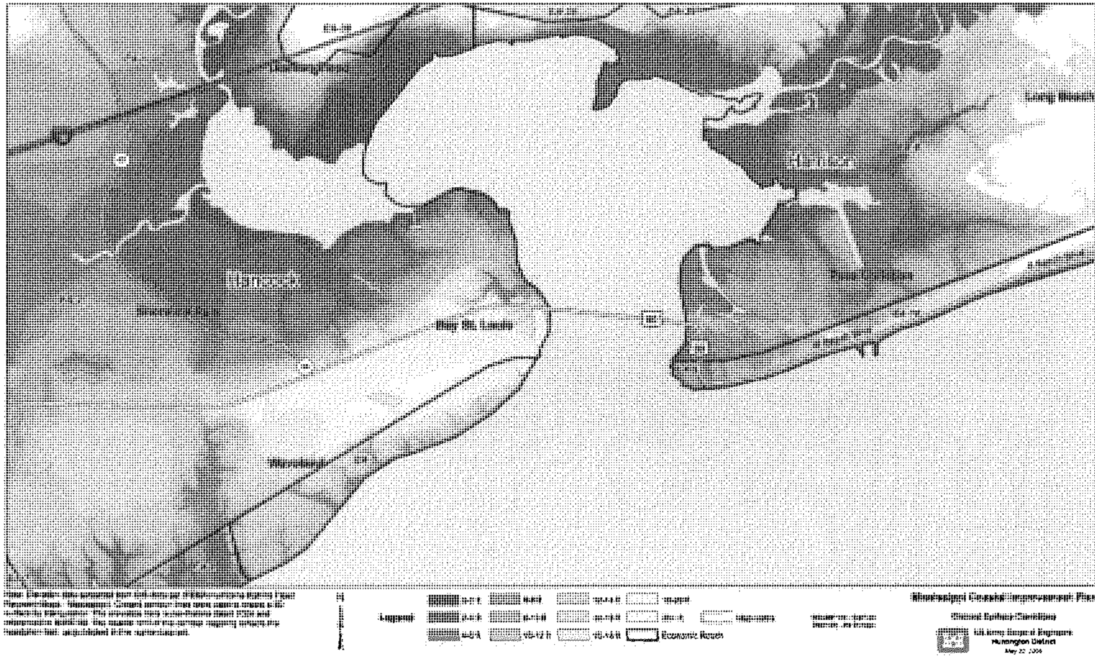


Figure 141 - Land Surface Elevations of Economic Reaches w/Respect to the Gulf (A3)

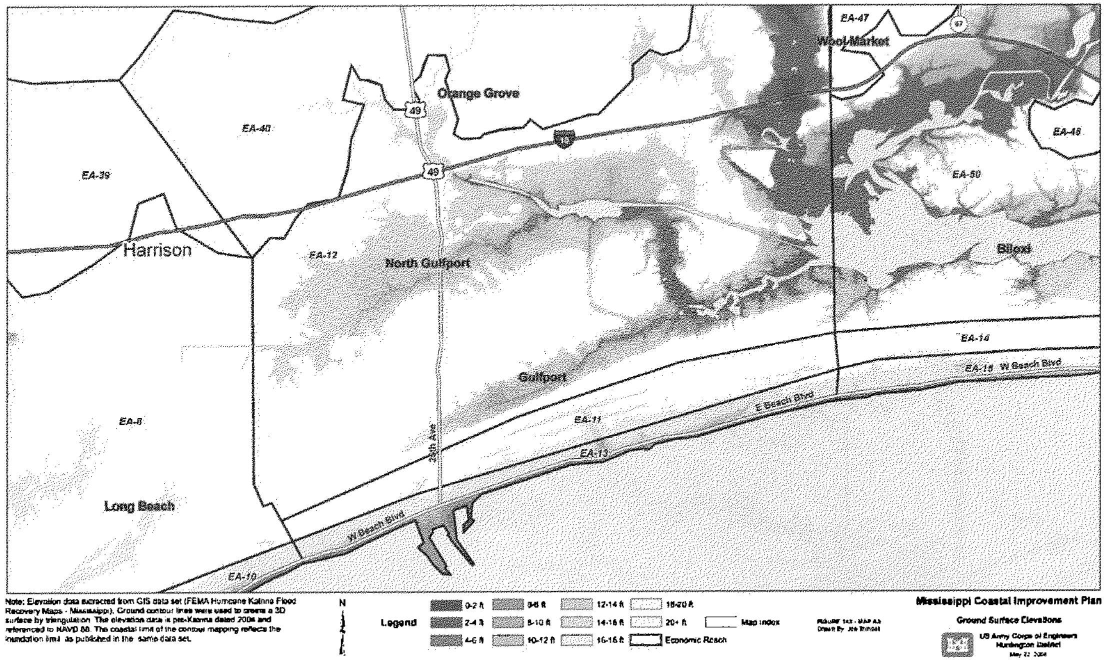


Figure 142 - Land Surface Elevations of Economic Reaches w/Respect to the Gulf (A4)

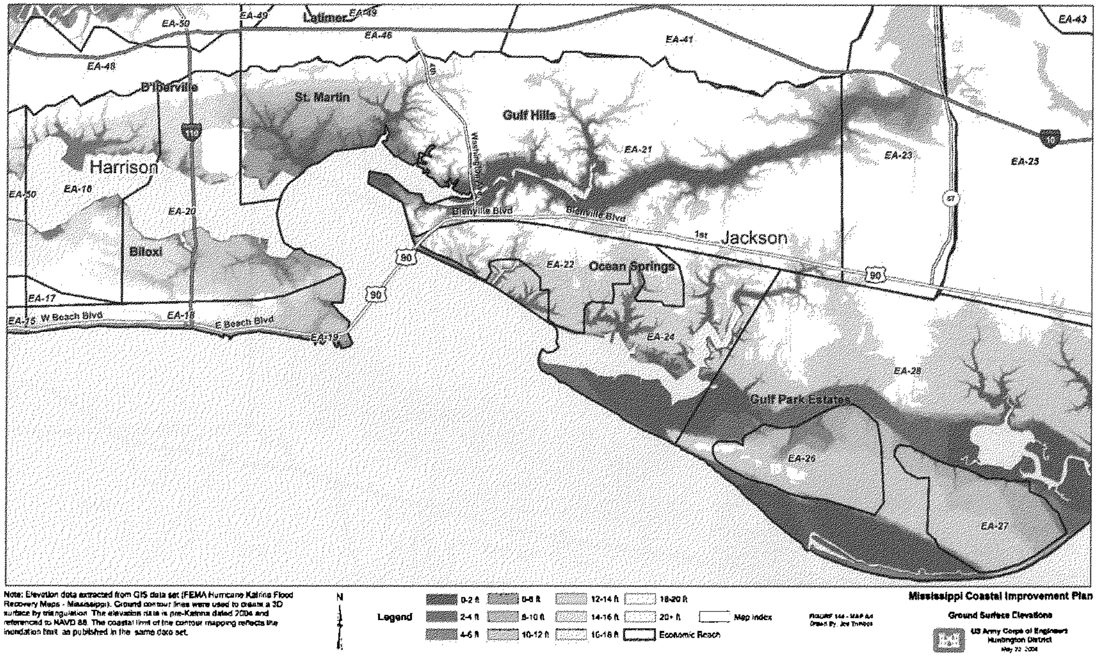
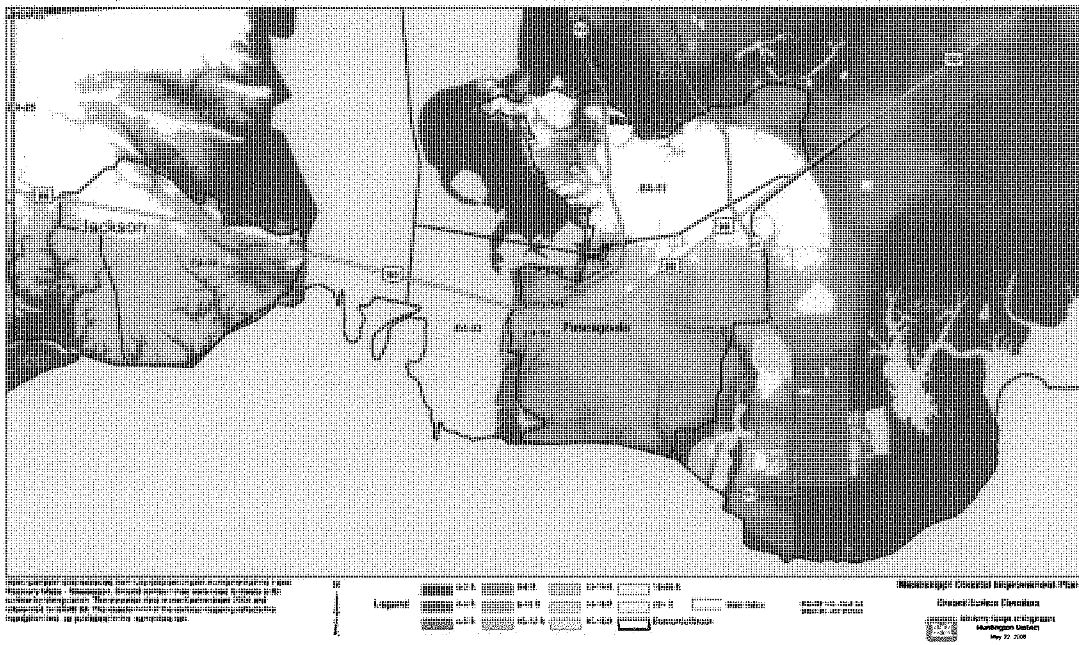


Figure 143 - Land Surface Elevations of Economic Reaches w/Respect to the Gulf (A5)



AFTERWORD

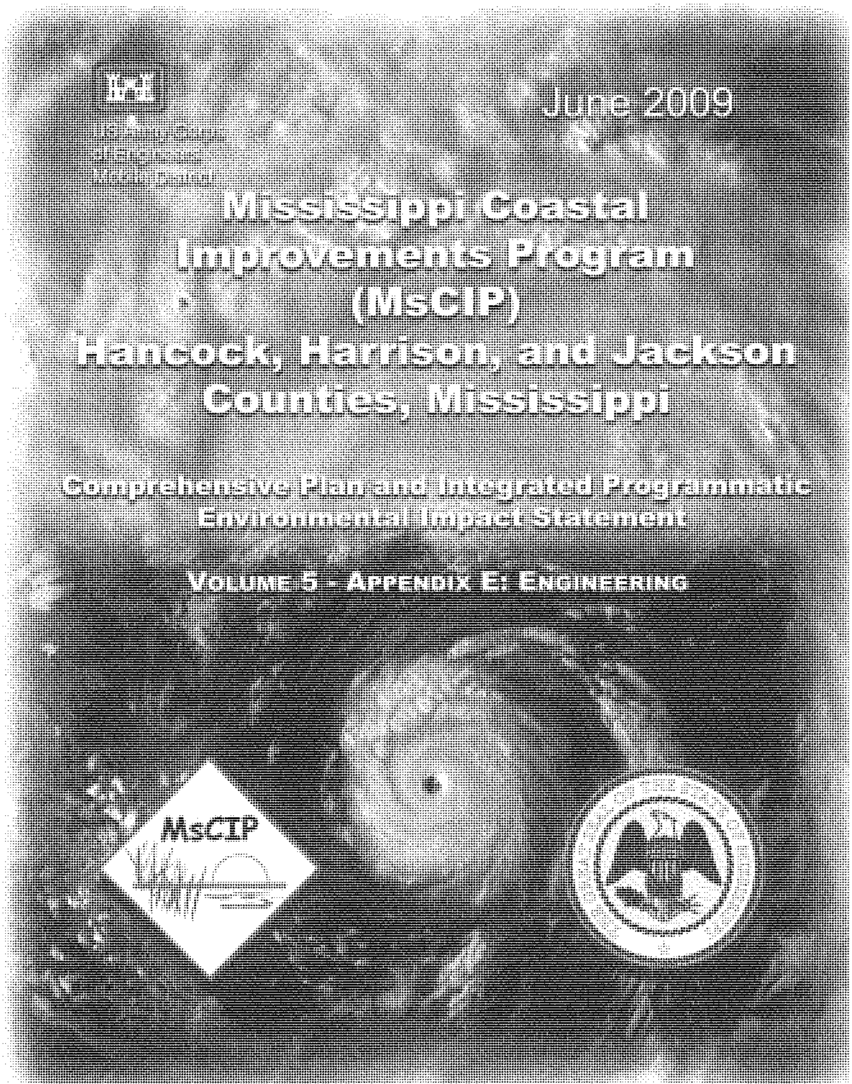
Rather than abruptly conclude this Appendix with the text in Chapter 8 on page 288, the team decided to prepare this short Afterword. Many of the concepts within this document are captured within the Main Report of the MsCIP and will hopefully be the focus of future, more detailed planning and implementation plans.

Much thought, analysis and teamwork went into the plan formulation and preparation of this document, but the plan is not the end of the process in and of itself. The proof of the pudding as many say is in the successful implementation of the plan itself. An old planning cliché states that "Action without planning can be fatal, but planning without action is futile." It would be sad indeed were this current planning effort to end in futility.

All of the thought processes that supported the formulation of the nonstructural measures and alternatives displayed in text and graphics in this document must be reaffirmed on the ground with the various neighborhood and community residents and local officials before the efficacy of the plans can be proven. As those collaborative workshops, charrettes, community meetings and small-group gatherings take place, a vision of a future disaster-resilient community needs to be formed through consensus-building – a vision that all can support to some degree and that all can participate in as citizens of the coast.

The Nonstructural PDT encourages all those who will participate in the coastal visioning efforts to be open-minded, future-oriented and committed to a coastal community that is sensitive to the diverse natural resources of the region, individual citizen rights and the rich culture and history of the Gulf Coast.

Essayons

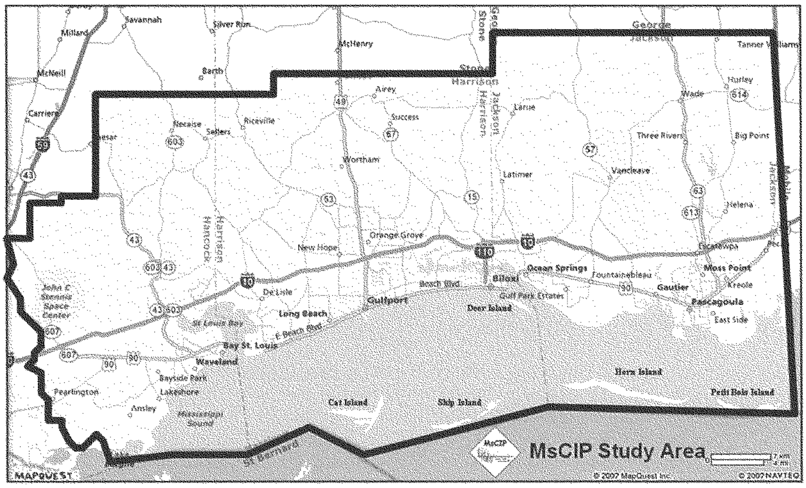

June 2009
Mississippi Coastal Improvements Program (MsCIP)
Hancock, Harrison, and Jackson Counties, Mississippi
Comprehensive Plan and Integrated Programmatic Environmental Impact Statement
Volume 5 - Appendix E: Engineering
MsCIP

(2019)

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, that 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.

This appendix, the Main Report/EIS, and all other appendices and supporting documentation, were subject to Independent Technical Review (ITR) and 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.

The report presents background on the counties that comprise the Mississippi coastline most severely impacted by the Hurricanes of 2005, their pre-hurricane conditions, a summary of the effects of the 2005 hurricane season, 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.

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, currently presented as tentatively-selected recommendations contained in the Main Report/EIS.

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.

This appendix, The Engineering Appendix, contains detailed supporting data and technical information on the many engineering options that were considered as possible measures that could be used in the Comprehensive Plan. Each option can be used as a stand-alone measure or in combination with other engineering options, environmental measures or non-structural programs in the development of alternatives for the Comprehensive Plan.

EXECUTIVE SUMMARY

Hurricanes are commonly recurring hazards for coastal Mississippi. Climatologically, the central Gulf coast region has one of the highest rates of occurrence in the United States. The Atlantic tropical cyclone database since 1886 indicates significant tropical storm impacts on the region occurring about every 2-3 years, and at least category 1 hurricane impact about every 8-9 years. Development along the Mississippi coastline with relatively low elevations in many areas has created a landscape that is highly susceptible to storm damage. Two bays that divide the coastlines 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. The area that was completely inundated due the storm surge associated with Hurricane Katrina is shown in Figure ES-1. 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 Mississippi Sound were completely destroyed in Katrina.

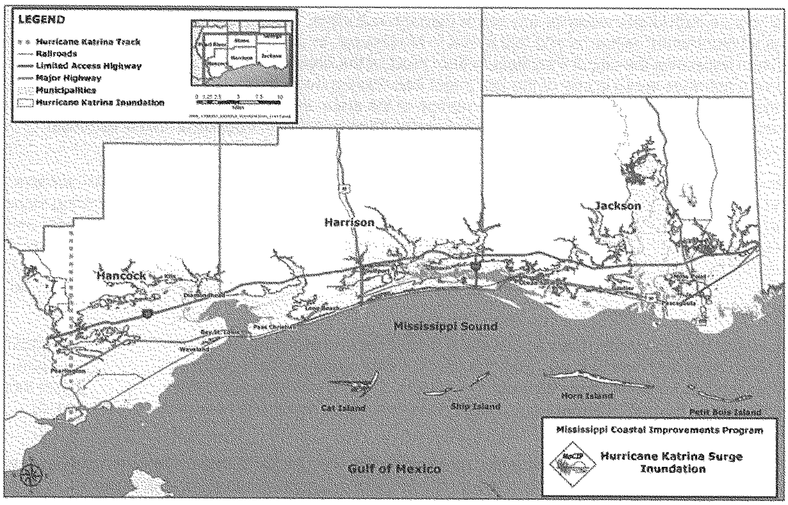


Figure ES-1. Inundated Areas of Coastal Mississippi from Hurricane Katrina Storm Surge

The Mississippi coast and its offshore chain of barrier islands is a wave-dominated coastline. Because prevailing wind in the Mississippi barrier island and mainland areas is from the eastern quadrants, most waves approach the shoreline at an angle and induce longshore currents that move sediment to the west. The islands migrate west due to littoral drift at approximately 50 ft/yr. Studies also show that all of the barrier islands are losing surface area due to erosion caused by a number of factors including the impacts of major storms.

Sea level rise and land surface subsidence have been taken into account as part of this study and is reported as "relative sea level rise" which accounts for both as a single value. The Intergovernmental Panel for Climate Change (IPCC) 'high' values were selected for evaluating project performance as the 'higher than observed rate' versus those predicted using EPA and NRC methods because the IPCC values are more recent and more widely (globally) used. In a subtle departure from USACE guidance, relative sea level rise values based on IPCC 'expected' (also referred to as 'medium' and 'central value') eustatic sea level rise predictions were adopted in lieu of rise computed using extrapolated historic rates because most experts believe that the rate of sea level rise will increase in this century and extrapolated historic rise assumes past relative sea level rise rates will persist.

With the task of developing a comprehensive hurricane damage reduction plan for the coast of Mississippi, several issues had to be considered. First, it had to be technically feasible. The storm damage reduction system must be designed such that it would be effective and at the same time not destroy what it was supposed to help protect? It had to be reliable so when needed, it would do the job it was designed for. It also needed to be cost effective. This system also had to be integrated into other storm reduction concepts such as non-structural solutions and buy-out programs. It must also include re-establishing some wetland areas as environmental components of the plan. The development along the coast had some areas that were not contiguous to highly developed areas like found in Harrison County where the entire coastline is densely developed. These outlying areas will require individual means for any storm damage reduction. Almost any project along a coastline has environmental concerns and this is true in Mississippi. 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 is home to an endangered fish species. In the western portion of the state, extensive marshes create other concerns along with the Pearl River that separates Mississippi from Louisiana. Other technical issues also made working in this river problematic.

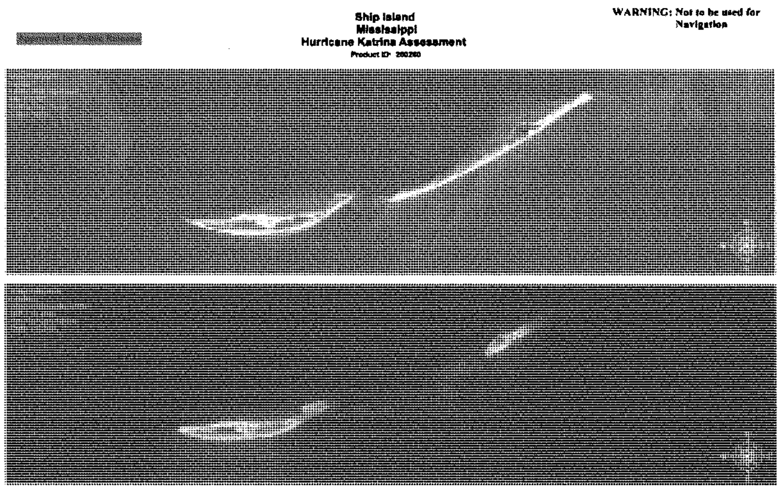
Review of the coastline in Mississippi using aerial photographs, topographic maps, LIDAR surveys, and storm inundation data revealed that natural topography could play a major role in forming storm barriers. Other features such as the offshore barrier islands, extensive beaches in many areas, and existing beach-front roadways were also realized as having a role in formulating a storm defense system. An existing railway track crosses the entire state near the coast and in the typical fashion of railways, these tracks follow high ground. This same general alignment was judged to be favorable for any type of inland barrier.

Review of the inundation maps from Katrina also revealed the extensive low-lying areas associated with two bays that extend inland from the coast. It was apparent that any storm protection systems would have to consider these as breaks in the line. Closing off rivers and bays with surge gates has been used in Europe to protect inland areas and these type structures have been considered for Mississippi.

During planning sessions with the project delivery team, a structural "Lines of Defense" concept was drafted that started with the offshore barrier islands and progressed inland to what could be considered the worst possible scenario with a extremely large hurricane, even worse than Katrina. Research identified numerous methods that have been developed to provide protection from storm surge. Along with the traditional methods of levee or structural seawall construction, many other types of protection were reviewed. These included inflatable barriers, concrete sidewalks or roadways that could be hydraulically rotated upwards to form a seawall, sliding panel gates, offshore breakwaters, and many types of surge barriers to close off the bays. The lines would also provide increasing levels of protection as you transgressed inland. It was understood that some lines would not provide protection from large storms. It was also evident that several areas of the coast could not be included in continuous line of defense and would be either placed in a ring levee system or designated to a non-structural solution.

From the planning session came five conceptual lines of defense. The general concept for this plan was made in a project team meeting that included engineers, environmentalists, planners, and geologists. Information from along the coastline was gathered that included large scale aerial photography, topographic maps, navigation maps, and a large collection of pre and post-Katrina photographs.

The first apparent feature to be considered was the offshore barrier islands that had been included in the Mississippi Governor's Hurricane Recovery Plan. Designated as Line of Defense (LOD) 1, the barrier islands have been eroded by numerous storms. In 1969, Hurricane Camille caused extensive erosion on the islands and created a large breach in Ship Island, (see Figure ES-2). 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 since Hurricane Camille. The post-Camille shoreline of Ship Island was documented by the Mississippi Department of Environmental Quality. 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. 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.



Source – United States Geological Survey

Figure ES-2. Before and After. The aerial photograph on top shows the islands in 1997 prior to Hurricane George in 1998. The bottom photograph shows the same view of the eroded condition of East and West Ship Island after Hurricane Katrina. Prior to a breach during Hurricane Camille, Ship Island was a single island, although the island has been breached prior to Camille.

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 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. A photo of the existing condition of the beaches and roads in Harrison County is shown in figure ES-3. 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.

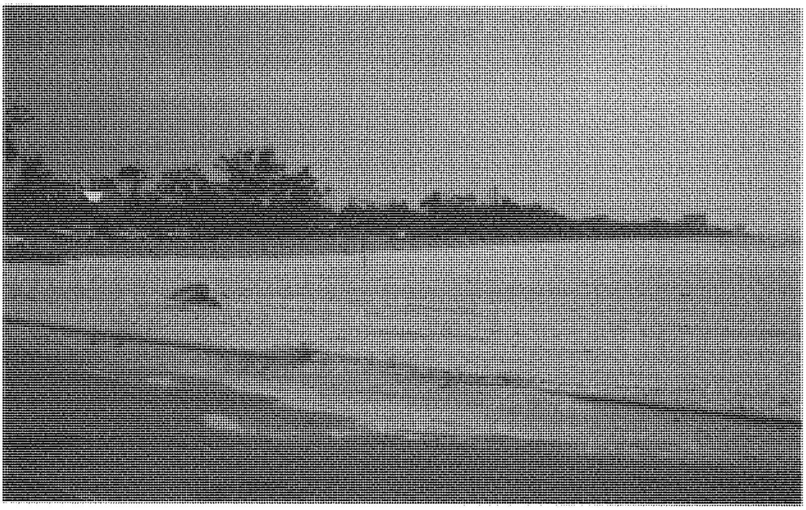


Figure ES-3. 2007 photograph of Biloxi Beach showing the existing beach berm and the adjacent seawall and roadway.

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 (NAVD88) and the general grade elevation for US 90 in Harrison County is 10.0 (NAVD88) although it varies from elevation 7.0 to 16.0 (NAVD88) depending on the exact location. With the existing road elevations, a top elevation of 11.0 (NAVD88) was selected for study in Hancock and Jackson County and a top elevation of 16.0 (NAVD88) 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.

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 one 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 (NAVD88). 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, (see Figure ES-4). 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 (NAVD88). Possible options for LOD-4 include omitting the surge barrier across St. Louis Bay. This would require that LOD-4 be terminated o 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.

Figure ES-4. The CSX Railway parallels the coast and its embankment acted as a low levee-like storm surge barrier in some areas.

As maximum protection from the largest storm surge event, the limits of surge predicted from the MPI event was transposed to maps. This location of this line was shifted as refinements were made in the storm surge modeling. 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 to local governments for location of critical infrastructure such as hospitals and emergency facilities.

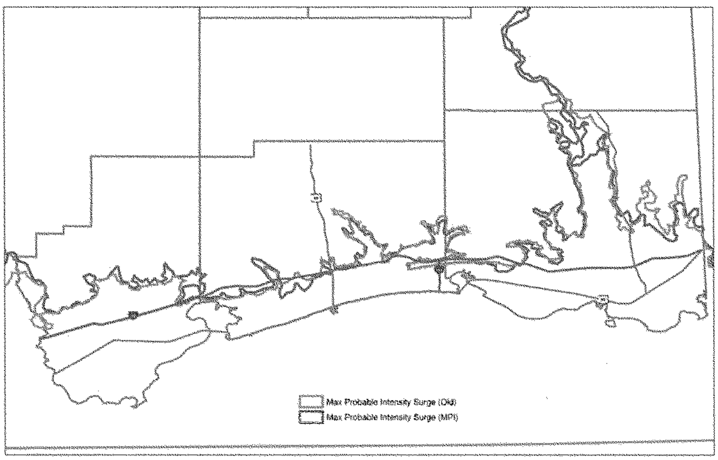


Figure ES-5. The surge limits of a computer simulated Maximum Possible Intensity hurricane based on early data and later refined modeling efforts

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 sea level rise.

At this phase of the plan formulation process, there were no assessments made for HTRW investigations nor remediation costs based on the vast number of properties potentially involved and the uncertainties associated with project footprints. Also, the cost of escalation will be addressed as projects are selected to proceed to feasibility level of design. The identification of a major HTRW site within a project footprint could certainly have a cost impact, but none are known to exist at this time. Likewise, depending on the time that a project is funded for further study to feasibility level, the effects of escalation could be a major factor based on fuel costs or other items that can change drastically outside the usual inflation rate.

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Figures

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PART 1. GENERAL

1.1 Guidance

1.1.1 Engineer Regulations

- ER 1105-2-101, "Planning - Risk Analysis for Flood Damage Reduction", 3 January 2006
- ER 1110-1-12, "Engineering and Design - Quality Management", 1 June 1993
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- ETL 1110-2-569, "Engineering and Design: Design Guidance for Levee Underseepage", 01 May 2005

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- EM 1110-1-1004, "Engineering and Design - Geodetic and Control Surveying", 01 June 2002
- EM 1110-1-1005, "Engineering and Design - Topographic Surveying", 31 August 1994
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1.2 History of Tropical Cyclones

1.2.1 Introduction

Tropical cyclones are commonly recurring hazards in coastal Mississippi. Climatologically, the central Gulf coast region has one of the highest rates of occurrence in the United States. The Atlantic tropical cyclone database since 1886 indicates significant tropical storm impacts on the region occurring about every 2-3 years, and at least category 1 hurricane impact about every 8-9 years. However, the record since 1886 has severe limitations in assessing a longer temporal perspective on tropical cyclone activity. Historical records enable reconstruction of tropical cyclones that extend back to the eighteenth century. Meteorological records afford a detailed and continuous reconstruction at yearly resolution back to the mid 1800's.

1.2.2 Historical Data

All available historical data has been utilized in the present study. First, tropical cyclone occurrences were compiled for each year from the HURDAT database from 1851-2005, counting each storm believed to be of hurricane intensity when it was centered within 75 miles of the Mississippi Coast. Similarly, a compilation of early nineteenth century hurricanes (1800-1850) was utilized (Bossak, 2003). This database relied primarily upon the landmark work of Ludlum (1963). All storms prior to 1800 were compiled from Ludlum (1963). For the period 1800-1870, only minor adjustments were made from a detailed examination of early instrumental records, diaries, and newspapers.

1.2.3 Results

A chronological listing of all known Hurricanes to affect Mississippi from 1711 to 2005 is given in Table 1.2-1. The resultant time series is shown in Figure 1.2-1. For the period of record, 66 tropical cyclones were identified as being of hurricane intensity Examination of the series reveals an obvious discontinuity in storm frequency circa 1840. This is simply a statistical artifact, as many tropical cyclone events prior to this time must have been unreported due to sparse population and lack of communication. Not until daily Meteorological observations were initiated by U.S. Army Post Surgeons at New Orleans in 1838, and near Mobile in 1840, can we be certain that all hurricanes were accounted for.

Temporal analysis of the tropical cyclone record, smoothed by 9-year running frequencies, indicate decadal variability in the historical past exceeding that of modern times. In particular, the 1850-1880 period was extraordinarily active. It was followed by another active period from 1910-1930. Much of the twentieth century...1930-1990...was conspicuous for relative inactivity. Indeed, it was this era that is the most anomalous period in the entire record.

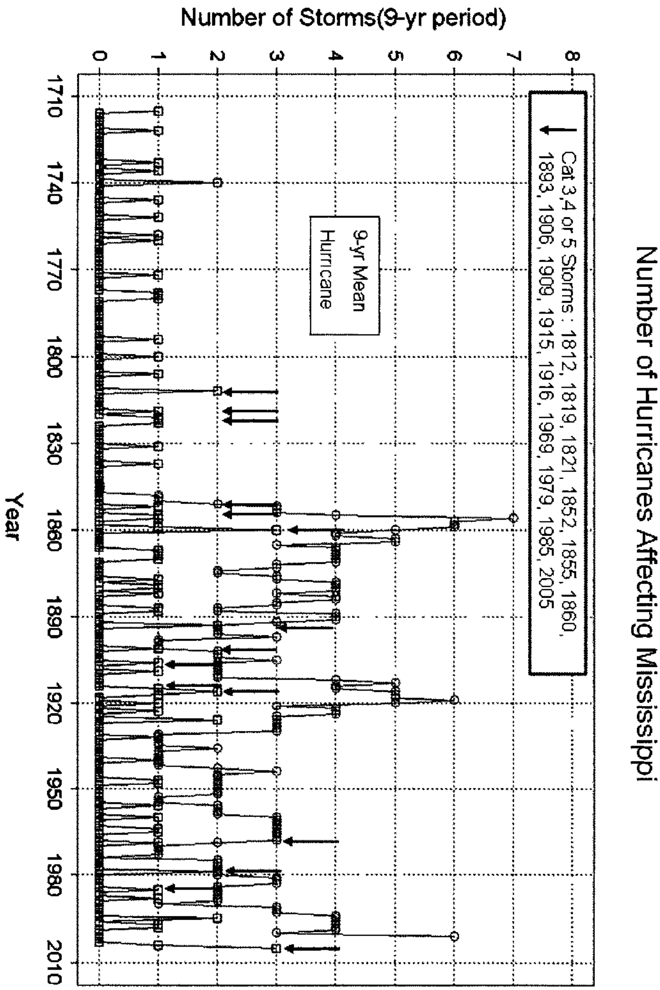

Figure 1.2-1. Hurricanes that Have Affected Mississippi

Table 1.2-1.
Hurricanes Affecting Mississippi Coast (1715-2005)

Year	Landfall	Estimated Storm Category at Landfall
1715 n.d.	Dauphin Island	(1)/Unknown
1722 Sept. 22-23	New Orleans	(1)
1733	Mobile	(1)
1736	Pensacola	(1)
1740 Sept. 22	Mobile	(1) The Twin Mobile Hurricanes of 1740
1740 Sept. 29	Mobile	(1) Second Mobile Hurricane
1746 n.d.	Ala.-Miss.-La.	(1)
1752 Nov. 3	Pensacola	(1)
1758 n.d.	N.W. Florida	(1)
1760 Aug. 12	Pensacola	(1)
1772 Aug. 30-Sept. 3	Fla.-La.	(1)
1778 Oct. 7-10	Fla.-La.	(1)
1779 Aug. 18	New Orleans	(1)
1780 Aug. 24	New Orleans	(1)
1794 Aug. 31?	Louisiana	(1)
1800 Aug	New Orleans	1
1806 Sept. 17	New Orleans	1
1812 June 11-12	Louisiana	1
1812 Aug 19	New Orleans	3
1819 July 27-28	Bay St. Louis	3/4
1821 Sept. 15-17	Bay St. Louis	3
1822 July 7-8	Biloxi	1
1823 Sept. 12-14	La.-Ala.	1
1831 Aug. 17-18	New Orleans	3/4
1837 Oct. 3-7	La.-Fla.	2
1852 Aug. 25	Pascagoula	3
1855 Sept. 15-16	Bay St. Louis	3
1856 Aug. 10-11	New Orleans	4
1859 Sept. 15	Mobile	1
1860 Aug. 11	Biloxi	3
1860 Sept. 14-15	Biloxi	2
1860 Oct. 2-3	Houma, La.	2
1867 Oct. 4-5	La.-Fla.	2
1868 Oct. 3-4	La.-Fla.	1
1869 Sept. 5	New Orleans	1
1870 July 30	Mobile	1
1877 Sept. 21	La.-Fla	1
1879 Aug. 31-Sept.1	New Orleans	2/3
1880 Aug. 26-30	Pensacola	1
1882 Sept. 10	Pensacola	3
1887 Oct. 19	Port Eads, La.	1
1888 Aug. 19-20	New Orleans	1/2
1893 Sept. 7-8	Grand Isle, La	1/2
1893 Oct. 2	Pascagoula	3
1901 Aug. 15	Gulfport	1
1906 Sept. 27	Pascagoula	3
1909 Sept. 20	New Orleans	3

Table 1.2-1.
Hurricanes Affecting Mississippi Coast (1715-2005) (continued)

Year	Landfall	Estimated Storm Category at Landfall
1915 Sept. 29	New Orleans	2/3
1916 July 5	Pascagoula	3
1916 Oct. 18	Perdido Key	3
1917 Sept. 28	Pensacola	2
1920 Sept. 21	Houma, La.	2
1923 Oct. 15	Houma, La	1/2
1926 Aug, 26	Houma, La	2
1926 Sept. 21	Perdido Key	1/2
1932 Sept. 1	Mobile	1
1940 Aug.6	La.-Tx.	1
1947 Sept. 19	New Orleans	2
1948 Sept. 4	New Orleans	1
1956 Sept. 24	Port Eads/ Ft. Walton	1
1960 Sept. 15	Gulfport	1
1964 Oct. 3	Franklin, La	1
1965 Sept. 10	New Orleans	3
1969 Aug. 17	Bay St. Louis	5
1979 July 5	Grand Isle	1
1979 Sept. 12	Mobile/Pascagoula	3
1985 Sept. 2	Biloxi	3
1988 Sept. 9	New Orleans	1
1995 Aug. 3	Pensacola	3
1995 Oct. 4	Navaree, Fla.	3
1997 July 19	Mobile	1
1998 Sept. 28	Biloxi	2
2004 Sept. 16	Pensacola	3
2005 July 6	Grand Isle, La.	1
2005 July 10	Navarre, Fla.	2
2005 Aug. 29	Bay St. Louis	3

The most active hurricane years were 1860 and 2005, with three hurricanes each. Since 1800, major Hurricane impact (category 3 or greater) is clearly evident in 1812, 1819, 1852, 1855, 1860, 1893, 1906, 1909, 1915, 1916, 1947, 1969, 1985, and 2005.

The small but extremely intense Bay St. Louis Hurricane of July 27-28, 1819 and the nearly identical Category 5 Hurricane Camille of August 17-18, 1969 were the most intense storms of record. Hurricanes Camille (1969) and Katrina (2005) produced the largest known tidal surge.

1.2.4 Conclusion

Tropical cyclones affecting coastal Mississippi appear to have been somewhat more frequent in the historical past than during the present human lifetime. Only during the last decade have we seen a significant upswing in the frequency of occurrence. Six major hurricanes struck the Mississippi coast during the 1800's with seven major storms in the 1900's. Only hurricane Katrina of 2005 has made landfall as a major hurricane during the 21st Century. Thus, there is no evidence that land falling hurricanes in Mississippi are becoming more intense.

1.2.5 References

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1.3 Tide Gage Stage-Frequency Analysis

The annual percent chance exceedance stage relationship, referred to as the 'stage-frequency curve,' is the single most important descriptor of a community's flood risk. The relationship describes the annual probability, expressed in percent, of a given stage (i.e. water surface elevation) being equaled or exceeded and is relied heavily upon for purposes of the National Flood Insurance Program, for the development and evaluation of flood damage reduction measures, for understanding and communicating annual and long-term risk, amongst others.

Historically, tide gage data have been used almost exclusively to describe the entirety of a given stage-frequency curve in a given coastal area. The shortcoming of this approach is that it tends to mask the true risk in the vicinity of the gage. The reasons for this are many, but perhaps the most important is related to the observation that, while the occurrence of strong hurricanes in a given coastal region is not probabilistically rare, the probability of a particular gage site taking a direct hit from one of those strong hurricanes is more rare. A more accurate representation of the true risk for severe hurricanes then can only be obtained over a long period of meteorological and water level observations (a century is not long enough) or through refined statistical analysis of storms and effects modeling efforts.

Present needs have required that a great deal of effort be placed on developing statistical methods and modeling approaches to improve our present understanding of severe hurricane risk. A Risk Assessment Group, led by scientists at the Engineer Research and Development Center (ERDC) in Vicksburg, MS, was assembled in the aftermath of Hurricane Katrina to develop such statistical and modeling methods (Ref. 1) for the Gulf of Mexico region, and those methods have been used for this program (ERDC modeling efforts are described in Chapter 2). Those efforts were focused on what might be called an extreme storm subset of the tropical storm/hurricane population. While their products and findings are many, one of their most important products was the development of 4% (1 in 25), 2% (1 in 50), 1% (1 in 100), 0.2% (1 in 500), and 0.1% (1 in 1000) annual chance stage exceedance estimates for numerous locations in the vicinity of coastal Mississippi. These estimates, combined with probabilistic analysis results of historic observed tide levels, were joined to create composite (i.e. consisting of both observed data and hydrodynamic modeling results) stage-frequency curves for planning subunits in coastal Mississippi. These in turn were used for a host of MsCIP design and evaluation efforts.

This chapter describes the available historic tide stage data and the development of that data into stage-frequency curves. The curves were compared to an historic stage-frequency curve and to ERDC model data at the location of the gage sites are displayed.

1.3.1 Background

The US Army Corps of Engineers Mobile District (CESAM) maintains a network of tide gages along the Gulf Coast from Gulfport, MS eastward to Carrabelle, FL. Gage locations are shown in Figure 1.3-1. Hurricane Katrina made landfall at the Louisiana-Mississippi State line August 29, 2005 and generated record storm surge along the Mississippi and Alabama coast. Preliminary high water mark (HWM) data values from FEMA indicate surge ranging from 28 ft at Bay St. Louis to 11.5 ft at

Mobile, AL. The following are Mobile District tide gages along the Mississippi and Alabama coast with long term records; Gulfport, MS (42 years), Biloxi, MS (123 years) Pascagoula, MS (65 years), Dauphin Island (42 years) and State Docks (65years). A graphical frequency analysis was performed on the observed historical annual peak water (tide) levels to estimate the still water storm surge return interval.

Water levels recorded at the gage sites are collected in a stilling well to minimize effects from wave height and wave run-up. In cases where the tide gage was destroyed or malfunctioned, the maximum water level was obtained from a high water mark measured in a nearby enclosed structured.

Each tide gage is installed to support our navigation coastal dredging program. Consequently the gages are installed near the navigation projects such as harbors, ports, federal docks, and shipping channels. The gages are operated and maintained by the Mobile District Engineering Division, Hydraulics & Hydrology Branch. Mobile District archives the data for legal reasons and makes it available to the public upon request. Monthly and annual reports of the tide levels are generated, archived and made available upon request. The gages are accurate to +/- 0.1 foot. There is limited quality control of the tide data.

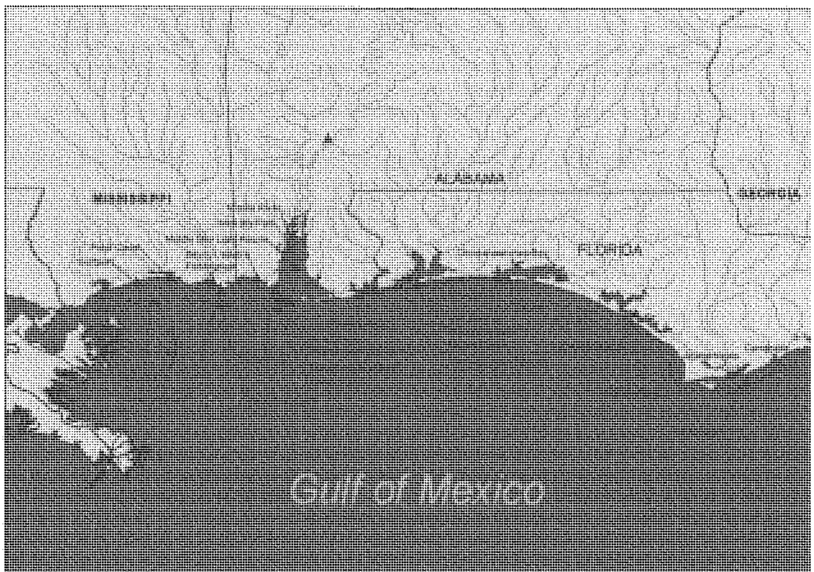


Figure 1.3-1. Mobile District Tide Gage Network

When a hurricane is forecast to strike the Gulf Coast, CESAM personnel are dispatched to remove recorded data from coastal gages and ensure that the gages are working properly. All equipment is removed from gage sites in areas of forecasted direct storm path 1-3 days before landfall. Therefore, removing the proper gage is dependent on the accuracy of the hurricane path and surge forecast.

Two gages were removed in Mississippi and one in Alabama on 28 August 2005, one day before the projected H. Katrina landfall. Water levels along the Gulf Coast for the time period during the storm are available at 16 gages and partial record from 5 gages. A total of 9 CESAM gages were destroyed and 2 gages were damaged by the hurricane. Figure 1.3-2 shows the status of the gages shortly after H. Katrina.

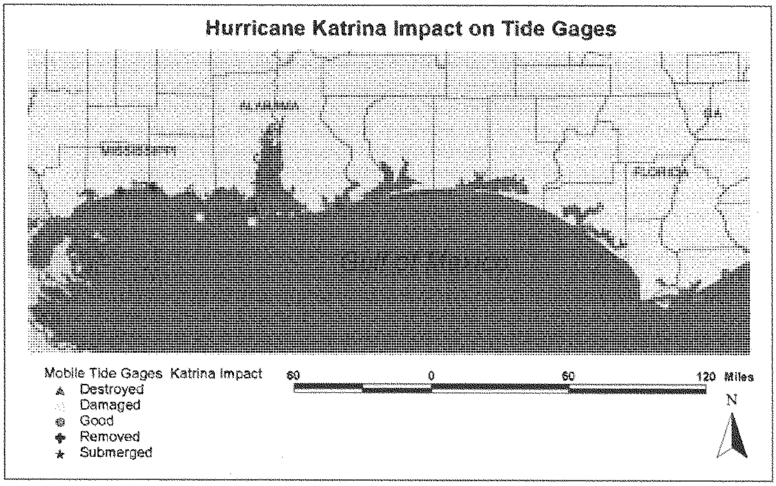


Figure 1.3-2. Hurricane Katrina Impact on Tide Gages

There are 7 active CESAM tide gages along the Mississippi Coast gages as shown in Figure 1.3-3.

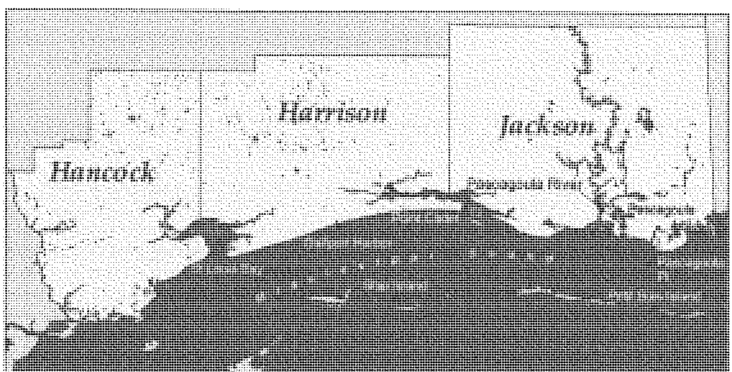


Figure 1.3-3. CESAM Mississippi Coast Tide Gages

1.3.2 Methodology

EM 1110-2-1415 (Ref. 2) recommends using graphical analysis for stage (elevation) frequency computations. The Corps of Engineers computer program Flood Frequency Analysis (FFA) was selected to compute the graphical plotting positions. Historical data was incorporated into the graphical analysis using the procedures outlined in Bulletin 17B (Ref. 3). The median plotting position formula was selected to derive probabilistic plotting positions because it corrects for the bias caused by small sample sizes.

Care was taken to select a uniform data set for the frequency analysis. Each event represents the peak water level for each January-December calendar year. There are a few years with less than 12 months of recorded data; in most cases this is due to a gage malfunction or damage from a storm event. The data set includes the effects of subsidence and sea level rise and no attempts have been made to adjust the data to account for these factors. Of these, subsidence is more important in that it affects the datum of the gage and thus the absolute water surface elevation estimate. Future analysis by this office will research the necessary adjustments. Each of the three gages has been relocated within the period of record. No adjustments were required because of the close proximity of relocations. In cases where the gage was destroyed by a severe storm, a still water high water at or near the gage used to represent the peak elevation for that storm event.

Historic data is information before the collection of systemic record. The account is often described in newspaper article, personal accounts from a witness or an investigation by some agency or entity. Historic data is very useful for locations with relative short period of record and use to extend the period of systemic record. The use of historic record can improve the frequency estimate.

The population includes annual peaks that result from storm surge and normal tidal fluctuations. There are years were multiple storms caused storm surge above normal high tide. Only the maximum recorded for each year used in the analysis. Partial duration frequency analysis was eliminated because of limited available daily data for the full period of record.

Gulfport has 43 year, 1963-2005, on continuous systematic record. Well documented historic values for the years 1915, 1926, 1947, 1948, 1955-1957, and 1960 are included in the analysis. Biloxi has 111 years, 1882-1885 and 1896-2005, of continuous systematic record. Pascagoula has 66 years, 1940-2005, of continuous systematic record. The historic record of annual maximum stages is shown in Table 1.3-1 and presented graphically in Figures 1.3-4 through 1.3-6.

1.3.2.1 Presentation of Data

Table 1.3-1.
Mississippi Coast Historic Annual Stages at Mobile District Tide Gages

		Gulfport (1963)			Pascagoula (1940)			Biloxi (1882)		
Storm	**Date**	**Gage Height, ft.**	**ft. NAVD**		**Gage Height, ft.**	**ft. NAVD**		**Gage Height, ft.**	**ft. NAVD**	
Sep 1882	9/10/1882								2.42	
27Sep1906	1906-Sep-27								6.05	
20Sep1909	1909-Sep-20							10.43	4.48	
12Aug1911	1911-Aug-12								4.49	
14Sep1912	1912-Sep-14								3.51	
29Sep1915	1915-Sep-29		9.13	1					9.05	
05Jul1916	1916-Jul-05								4.20	
28Sep1917	1917-Sep-28							8.61	2.66	
21Sep1920	1920-Sep-21								5.57	

		Gulfport (1963)			Pascagoula (1940)			Biloxi (1882)		
Storm	**Date**	**Gage Height, ft.**	**ft. NAVD**		**Gage Height, ft.**	**ft. NAVD**		**Gage Height, ft.**	**ft. NAVD**	
15Oct1923	1923-Oct-15							11.96	6.01	7
21Sep1926	1926-Sep-21		6.13	1					3.95	
Sep 1932	1932-Sep							9.16	3.21	
Oct 1932	1932-Oct							9.33	3.38	
July 1933	1933-Jul							9.16	3.21	
Sep 1933	1933-Sep							9.74	3.79	
Jun 1934	1934-Jun							8.98	3.03	
T.S. Jun 1939	1939-Jun							9.05	3.10	
26Sep1939	1939-Sep-29							9.5	3.55	
	1940-Aug-06					3.71		10.4	4.45	
12Sep1941	1941-Sep-12					3.38		9.52	3.57	
06Sep1945	1945-Sep-06						5	9.1	3.15	
	1947-Sep-08					2.68				6
19Sep1947	1947-Sep-19		14.13	1		7.48	2,6	16.88	10.93	2,6
04Sep1948	1948-Sep-04		6.13	1		4.08			5.73	
	1949-Sep-04					3.98			4.59	
Baker	1950-Aug-30					3.73			3.66	
Barbara	1954-Jul-29					2.43		9.1	3.15	
Brenda	1955-Aug-01					3.18			4.00	
26Aug1955	1955-Aug-26		6.13	1		2.83			3.67	
	1956-Jun-13					3.48		10.78	4.83	
Flossy	1956-Sep-24		4.13	1		3.18		9.39	3.44	
Audrey	1957-Jun-27					3.36			3.75	
T.S Ester	1957-Sep-18		6.63	1		2.63			4.77	
Ethel	1960-Sep-15		5.13	1		4.58			5.25	
Helda	1964-Oct-04	5.14	4.27			4.13			4.76	
Betsy	1965-Sep-09		10.83	2,7		6.48		14.64	8.69	
Debbie	1965-Sep-29	6.8	3.93			2.92				6
Camille	1969-Aug-17		19.81	2	11.37	11.33	2		15.69	2
Felice	1970-Sep-15	3.01	3.14		2.43	2.39		8.94	2.99	
Fern	1971-Sep-05	2.68	2.54		2.37	2.33				
Edith	1971-Sep-16	3.35	3.21		2.08	2.04			3.63	
Carmen	1974-Sep-08	4.95	4.81		3.98	3.94			4.60	
Babe	1977-Sep-06	3.9	3.76				5			5
Bob	1979-Jul-11		6.13			4.63			5.75	
Frederic	1979-Sep-12		3.43			5.86			4.03	
Elena	1985-Sep-02		5.56			5.58			6.16	
Juan	1985-Oct-28		6.63			5.39			5.96	
Bonnie	1986-Jun-23		2.73			2.45			2.83	
Gilbert	1988-Sep-08		4.90			3.10			4.06	
Florence	1988-Sep-10		4.67			3.11			6.39	
Chantal	1989-Jul-31		3.13			2.31			3.48	
Andrew	1992-Aug-26		4.02			3.18			3.90	
TS Dean	1995-Jul-28		3.70			2.83			3.52	
Erin	1995-Aug-04		2.68			2.84			3.04	

		Gulfport (1963)			Pascagoula (1940)			Biloxi (1882)		
Storm	**Date**	**Gage Height, ft.**	**ft. NAVD**		**Gage Height, ft.**	**ft. NAVD**		**Gage Height, ft.**	**ft. NAVD**	
Opal	1995-Oct-04		3.05			2.65				3
Josephine	1996-Oct-05		3.47			2.74			3.47	
Danny	1997-Jul-19		4.25			2.98			3.87	
Earl	1998-Sep-02		3.30			3.16		3.52	3.00	
Georges	1998-Sep-28		7.18			8.44	2		8.18	
T.S. Helen	2000-Nov-24		3.75			3.08			3.48	
T.S. Allison	2001-Jun-11		4.56			3.98				5
T.D. Edward	2002-Sep-06		4.13		4.09	3.45			3.57	
T.S. Hanna	2002-Sep-14	5.14	4.65		4.64	4.00			4.16	
Isidore	2002-Sep-26	8.26	7.77			5.83			6.99	
Lili	2002-Oct-04	3.79	3.30			3.96			4.88	
T.S. Bill	2003-Jul-10	4.6	4.11			3.41			4.12	
Ivan	2004-Sep-16	5.28	4.79			6.80	4		4.36	
T.S. Matthew	2004-Oct-10	4.88	4.39		3.66	3.02		4.32	3.80	
T.S. Cindy	2005-Jul-06	6.16	5.67			5.83			5.97	
Dennis	2005-Jul-10	3.63	3.14			3.33			2.99	
Katrina	2005-Aug-29		24.30	4		16.68	2		23.93	4
Storm Count			45			51			65	

1 Report on Hurricane Survey
2 High Water Mark at Gage Site
3 No Record gage vandalized
4 Gage Removed before landfall, HWM at gage site
5 No Record Gage Malfunctioned
6 No Record gage destroyed
7 Partial Record, gage malfunction

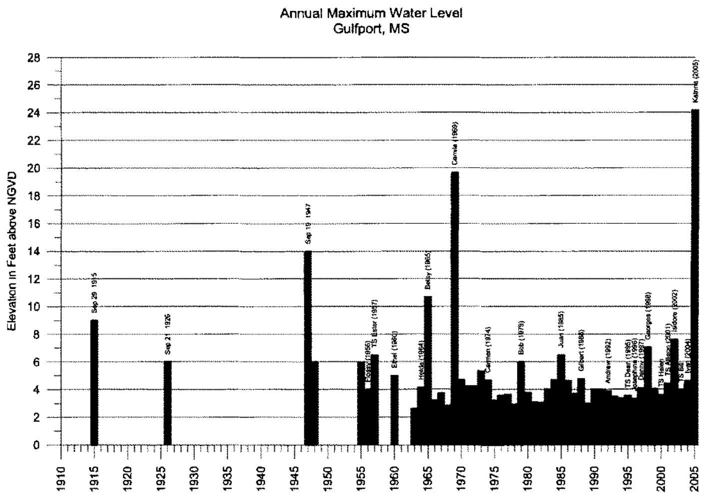


Figure 1.3-4. Gulfport, MS Annual Maximum Water Level

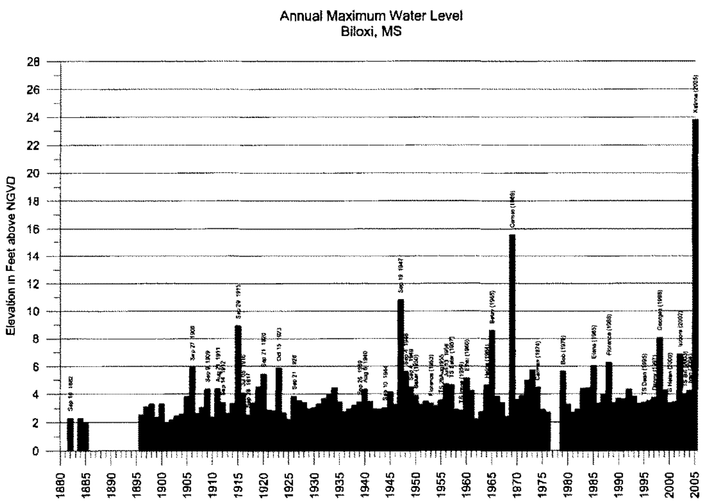


Figure 1.3-5. Biloxi, MS Annual Maximum Water Level

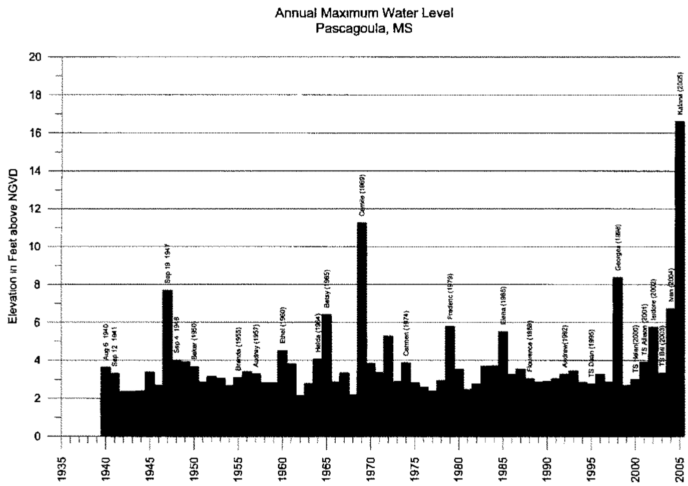


Figure 1.3-6. Pascagoula, MS Annual Maximum Water Level

1.3.3 Results

1.3.3.1 Graphical Stage-Frequency Analysis

A graphically fit (by eye) curve was drawn through the median plotting positions of the historic data for each gage site. Results for selected annual probabilities of occurrence are shown in Table 1.3-2. Comprehensive results are shown in tabular format with observed data in Tables 1.3-3 through 1.3-5. The computed Weibull plotting position is shown in those tables for reference only. Figures 1.3-7 through 1.3-9 show results presented graphically against an historic stage frequency curve. The historic curve (shown in red on the figures) was developed to represent the entire Mississippi Coast and published in a Mississippi Coast hurricane survey published by Mobile District in 1965 (Ref. 4). The hurricane survey curve was developed based on observed tidal data. That curve pre-dates some of the most intense surge-producing hurricanes to have struck the vicinity of Mississippi in the modern record: H. Betsy (1965), H. Camille (1969), H. Georges (1998), and H. Katrina (2005). The result is that, in the 40 years of record, one's impression of what the 1 in 100 chance annual stage might be according to these methods has increased dramatically, and at Gulfport that stage has nearly doubled. This observation reinforces the idea that the length of period of record is an important consideration, and that just a few historically significant events can dramatically impact the risk picture. Similarly, the tabulated results in Table 1.3-2 clearly show the influence that landfall location may impart on the stage frequency curve. While there are physical reasons why western Mississippi might register higher stages for a given hurricane than elsewhere along the Mississippi Coast, if H. Camille and H. Katrina landed more centrally there, the stage-frequency relationship would likely have been somewhat more uniform for low annual chance events at the three gages. This also demonstrates the need to combine gage data with statistical and modeling efforts to improve stage-frequency estimates.

Table 1.3-2.
Results from Graphical Frequency Analysis

Annual Percent Chance Exceedance	Pascagoula Stage	Biloxi Stage	Gulfport Stage
50	3.3	3.7	4.3
20	4.0	4.5	6.1
10	6.0	5.7	6.9
5	7.9	7.6	9.4
2	12.5	12.6	18.8
1	17.1	19.1	23.1

Period of record: Pascagoula 1916-2005, Biloxi 1882-2005, Gulfport 1941-2005.

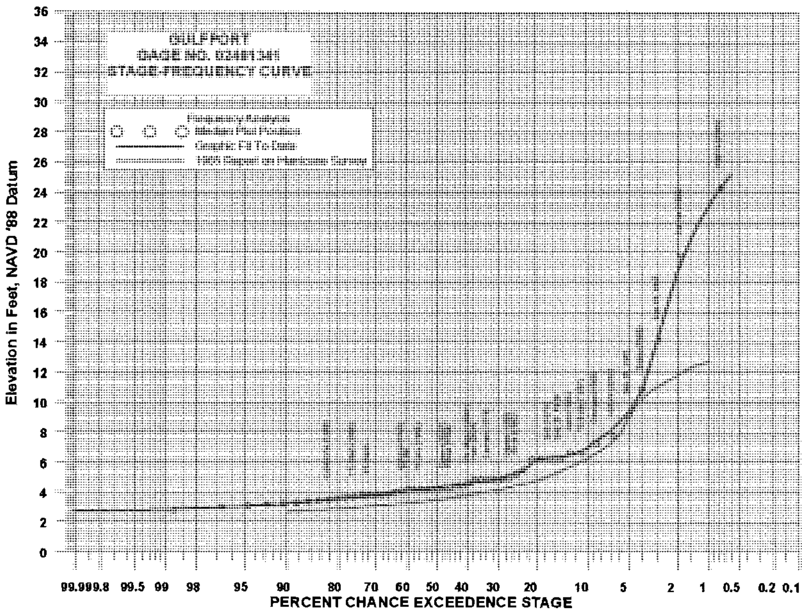


Figure 1.3-7. Gulfport, MS Frequency Curve

2080

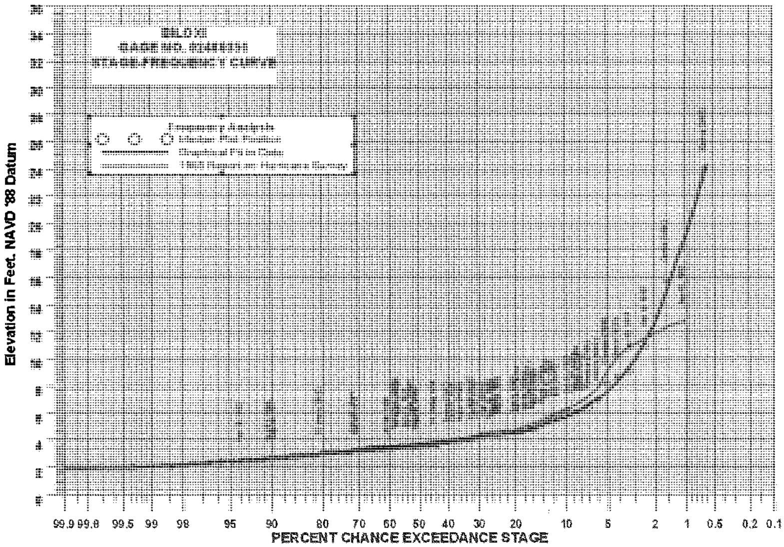


Figure 1.3-8. Biloxi, MS Frequency Curves

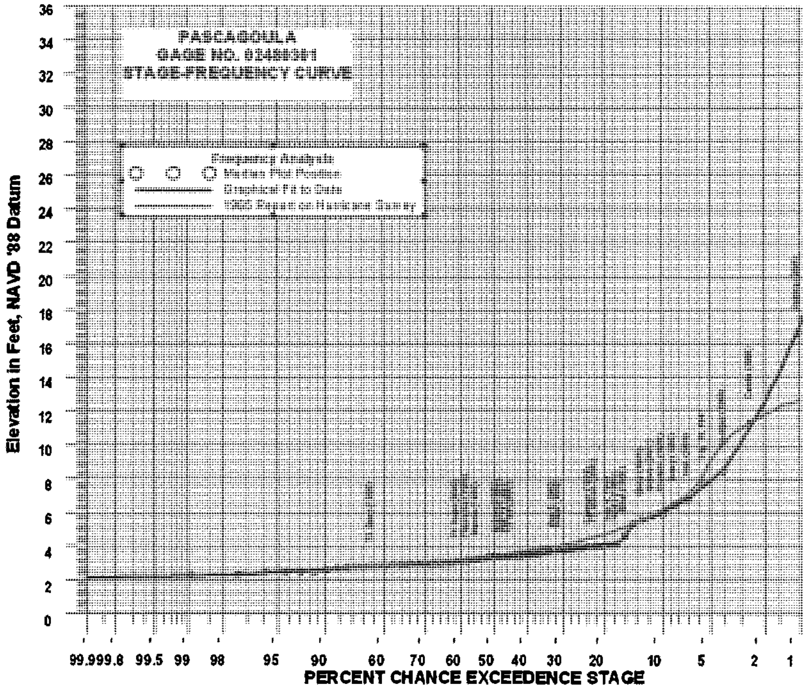


Figure 1.3-9. Pascagoula, MS Frequency Curve

Table 1.3-3.
Gulfport, MS Annual Peaks

Year	Gage Height ft. NAVD	Rank	Weibull Plotting Position (FFA)	Median Plotting Position (FFA)	Storm
2005	24.30	1	1.09	0.77	Katrina (2005)
1969	19.81	2	2.17	1.86	Camille (1969)
1947	14.13	3	3.26	2.95	Sep 19, 1947
1965	10.83	4	4.35	4.05	Betsy (1965)
1915	9.13	5	5.43	5.14	Sep 29, 1915
2002	7.74	6	6.99	6.71	Isidore (2002)
1998	7.18	7	9.03	8.76	Georges (1998)
1957	6.63	8	11.06	10.8	TS Ester (1957)
1985	6.63	9	13.09	12.85	Juan (1985)
1926	6.14	10	15.12	14.89	Sep 21, 1926
1948	6.13	12	19.19	18.98	
1979	6.13	11	17.16	16.94	Bob (1979)

Year	Gage Height ft. NAVD	Rank	Weibull Plotting Position (FFA)	Median Plotting Position (FFA)	Storm
1955	6.12	13	21.22	21.03	
1973	5.46	14	23.25	23.08	
1960	5.13	15	25.28	25.12	Ethel (1960)
1988	4.90	16	27.32	27.17	Gilbert (1988)
1970	4.85	17	29.35	29.21	
1984	4.83	18	31.38	31.26	
1974	4.81	19	33.41	33.3	Carmen (1974)
1986	4.78	20	35.44	35.35	
2004	4.76	21	37.48	37.39	Ivan (2004)
2001	4.56	22	39.51	39.44	TS Allison (2001)
1971	4.36	23	41.54	41.49	
1972	4.36	24	43.57	43.53	
1964	4.27	25	45.6	45.58	Helda (1964)
1997	4.25	26	47.64	47.62	Danny (1997)
1983	4.18	27	49.67	49.67	
1999	4.18	28	51.7	51.71	
1990	4.14	29	53.73	53.76	
1956	4.13	30	55.77	55.8	Flossy (1956)
1991	4.13	31	57.8	57.85	
2003	4.11	32	59.83	59.89	TS Bill
1992	4.02	33	61.86	61.94	Andrew (1992)
1980	3.93	34	63.89	63.99	
1967	3.87	35	65.93	66.03	
1987	3.83	36	67.96	68.08	
1977	3.76	37	69.99	70.12	
2000	3.75	38	72.02	72.17	TS Helen
1976	3.71	39	74.05	74.21	
1995	3.70	40	76.09	76.26	TS Dean (1995)
1993	3.62	41	78.12	78.3	
1994	3.49	42	80.15	80.35	
1996	3.47	43	82.18	82.39	Josephine (1996)
1975	3.36	44	84.22	84.44	
1966	3.35	45	86.25	86.49	
1981	3.23	46	88.28	88.53	
1982	3.20	47	90.31	90.58	
1989	3.13	48	92.34	92.62	
1978	3.06	49	94.38	94.67	
1968	2.96	50	96.41	96.71	
1963	2.75	51	98.44	98.76	

Table 1.3-4.
Biloxi, MS Annual Peaks

Year	Gage Height ft. NAVD	Rank	Weibull Plotting Position (FFA)	Median Plotting Position (FFA)	Storm
2005	23.93	1	0.89	0.63	Katrina (2005)
1969	15.69	2	1.79	1.53	Camille (1969)
1947	10.93	3	2.68	2.42	Sep 19, 1947
1915	9.05	4	3.57	3.32	Sep 29, 1915
1965	8.69	5	4.46	4.22	Betsy (1965)
1998	8.18	6	5.36	5.12	Georges (1998)
2002	6.99	7	6.25	6.01	Isidore (2002)
1988	6.39	8	7.14	6.91	Florence (1988)
1985	6.16	9	8.04	7.81	Elena (1985)
1906	6.05	10	8.93	8.71	Sep 27, 1906
1923	6.01	11	9.82	9.61	Oct 15, 1923
1973	5.85	12	10.71	10.50	
1979	5.75	13	11.61	11.40	Bob (1979)
1948	5.73	14	12.50	12.30	Sep 4, 1948
1920	5.57	15	13.39	13.20	Sep 21, 1920
1960	5.25	16	14.29	14.09	Ethel (1960)
1972	5.12	17	15.18	14.99	
1956	4.83	18	16.07	15.89	Jun 13, 1956
1957	4.77	19	16.96	16.79	TS Ester (1957)
1964	4.76	20	17.86	17.68	Helda (1964)
1919	4.64	21	18.75	18.58	
1974	4.60	22	19.64	19.48	Carmen (1974)
1949	4.59	23	20.54	20.38	Sep 4, 1949
1934	4.57	24	21.43	21.27	
1984	4.56	25	22.32	22.17	
1983	4.53	26	23.21	23.07	
1911	4.49	27	24.11	23.97	Aug 21, 1911
1909	4.48	28	25.00	24.87	Sep 9, 1909
1940	4.45	29	25.89	25.76	Aug 6, 1940
1992	4.45	30	26.79	26.66	
1999	4.38	31	27.68	27.56	
2004	4.36	32	28.57	28.46	Ivan (2004)
1961	4.34	33	29.46	29.35	
1945	4.26	34	30.36	30.25	
1916	4.20	35	31.25	31.15	Jul 05, 1916
2003	4.12	36	32.14	32.05	TS Bill (2003)
1987	4.10	37	33.04	32.94	
1933	4.05	38	33.93	33.84	
1971	4.03	39	34.82	34.74	
1950	4.00	40	35.71	35.64	Baker (1950)
1966	3.96	41	36.61	36.54	
1905	3.95	42	37.50	37.43	
1926	3.95	43	38.39	38.33	Sep 21, 1926

Year	Gage Height ft. NAVD	Rank	Weibull Plotting Position (FFA)	Median Plotting Position (FFA)	Storm
1993	3.93	44	39.29	39.23	
1997	3.87	45	40.18	40.13	Danny (1997)
1932	3.80	46	41.07	41.02	
1990	3.80	47	41.96	41.92	
1991	3.76	48	42.86	42.82	
1970	3.72	49	43.75	43.72	
1955	3.67	50	44.64	44.61	TS 26Aug1955
1996	3.66	51	45.54	45.51	
1927	3.65	52	46.43	46.41	
1952	3.61	53	47.32	47.31	
1941	3.58	54	48.21	48.20	
1935	3.56	55	49.11	49.10	
2001	3.56	56	50.00	50.00	
1939	3.55	57	50.89	50.90	Sep 26, 1939
1928	3.52	58	51.79	51.80	
1995	3.52	59	52.68	52.69	TS Dean (1995)
1912	3.51	61	54.46	54.49	Sep 14, 1912
1967	3.51	60	53.57	53.59	
1918	3.50	62	55.36	55.39	
1989	3.48	63	56.25	56.28	
2000	3.48	64	57.14	57.18	TS Helen (2000)
1953	3.47	65	58.04	58.08	Florence (1953)
1986	3.47	66	58.93	58.98	
1914	3.45	67	59.82	59.87	
1994	3.44	68	60.71	60.77	
1898	3.42	70	62.50	62.57	
1900	3.42	71	63.39	63.46	
1931	3.42	69	61.61	61.67	
1946	3.40	72	64.29	64.36	
1980	3.38	73	65.18	65.26	
1951	3.37	74	66.07	66.16	
1938	3.33	75	66.96	67.06	
1954	3.28	76	67.86	67.95	
1897	3.23	77	68.75	68.85	
1908	3.17	78	69.64	69.75	
1930	3.16	79	70.54	70.65	
1944	3.15	80	71.43	71.54	Sep 10, 1944
1929	3.07	81	72.32	72.44	
1937	3.07	82	73.21	73.34	
1942	3.07	83	74.11	74.24	
1943	3.05	84	75.00	75.13	
1982	3.05	85	75.89	76.03	
1921	3.02	88	78.57	78.73	
1958	3.02	86	76.79	76.93	
1975	3.02	87	77.68	77.83	
1922	2.96	89	79.46	79.62	

Year	Gage Height ft. NAVD	Rank	Weibull Plotting Position (FFA)	Median Plotting Position (FFA)	Storm
1959	2.95	90	80.36	80.52	TS Irene (1959)
1936	2.87	91	81.25	81.42	
1963	2.86	92	82.14	82.32	
1976	2.85	93	83.04	83.21	
1981	2.83	94	83.93	84.11	
1924	2.79	95	84.82	85.01	
1907	2.77	96	85.71	85.91	
1913	2.75	97	86.61	86.80	
1904	2.70	98	87.50	87.70	
1896	2.66	99	88.39	88.60	
1917	2.66	100	89.29	89.50	Sep 28, 1917
1903	2.59	101	90.18	90.39	
1968	2.54	102	91.07	91.29	
1910	2.50	103	91.96	92.19	
1899	2.48	104	92.86	93.09	
1882	2.42	105	93.75	93.99	Sep 10, 1882
1884	2.40	106	94.64	94.88	
1925	2.35	107	95.54	95.78	
1962	2.34	108	96.43	96.68	
1902	2.30	109	97.32	97.58	
1885	2.07	110	98.21	98.47	
1901	2.07	111	99.11	99.37	

Table 1.3-5.
Pascagoula, MS Annual Peaks

Year	Gage Height ft. NAVD	Rank	Weibull Plotting Position (FFA)	Median Plotting Position (FFA)	Storm
2005	16.69	1	1.49	1.05	Katrina (2005)
1969	11.33	2	2.99	2.56	Camille (1969)
1998	8.45	3	4.48	4.07	Georges (1998)
1947	7.77	4	5.97	5.57	Sep 19, 1947
2004	6.81	5	7.46	7.08	Ivan (2004)
1965	6.49	6	8.96	8.58	Betsy (1965)
1979	5.87	7	10.45	10.09	Frederic (1979)
2002	5.84	8	11.94	11.60	Isidore (2002)
1985	5.59	9	13.43	13.10	Elena (1985)
1972	5.35	10	14.93	14.61	
1960	4.59	11	16.42	16.11	Ethel (1960)
1964	4.14	12	17.91	17.62	Helda (1964)
1948	4.09	13	19.40	19.13	Sep 4, 1948
1949	3.99	14	20.90	20.63	
2001	3.99	15	22.39	22.14	TS Allison (2001)
1974	3.95	16	23.88	23.64	Carmen (1974)
1970	3.90	17	25.37	25.15	
1961	3.89	18	26.87	26.66	
1984	3.80	19	28.36	28.16	
1983	3.77	20	29.85	29.67	
1950	3.74	21	31.34	31.17	Baker (1950)
1940	3.72	22	32.84	32.68	Aug 6, 1940
1980	3.62	23	34.33	34.19	
1987	3.62	24	35.82	35.69	
1993	3.54	25	37.31	37.20	
1956	3.49	26	38.81	38.70	
1945	3.46	27	40.30	40.21	
1971	3.44	28	41.79	41.72	
1967	3.42	29	43.28	43.22	
2003	3.42	30	44.78	44.73	TS Bill (2003)
1941	3.39	31	46.27	46.23	Sep 12, 1941
1957	3.37	32	47.76	47.74	Audrey (1957)
1992	3.37	33	49.25	49.25	Andrew(1992)
1996	3.37	34	50.75	50.75	
1986	3.33	35	52.24	52.26	
1952	3.24	36	53.73	53.77	
1955	3.19	37	55.22	55.27	Brenda (1955)
1953	3.14	38	56.72	56.78	
1988	3.12	39	58.21	58.28	Florence (1988)
1991	3.12	40	59.70	59.79	
2000	3.09	41	61.19	61.30	TS Helen(2000)
1978	3.01	42	62.69	62.80	
1990	2.97	43	64.18	64.31	
1989	2.96	44	65.67	65.81	
1973	2.95	46	68.66	68.83	
1951	2.94	47	70.15	70.33	

Year	Gage Height ft. NAVD	Rank	Weibull Plotting Position (FFA)	Median Plotting Position (FFA)	Storm
1966	2.93	48	71.64	71.84	
1994	2.93	49	73.13	73.34	
1975	2.90	50	74.63	74.85	
1958	2.89	51	76.12	76.36	
1959	2.89	52	77.61	77.86	
1963	2.85	53	79.10	79.37	
1982	2.84	54	80.60	80.87	
1995	2.84	55	82.09	82.38	TS Dean (1995)
1946	2.77	56	83.58	83.89	
1999	2.77	57	85.07	85.39	
1954	2.74	58	86.57	86.90	
1976	2.66	59	88.06	88.40	
1981	2.55	60	89.55	89.91	
1944	2.47	61	91.04	91.42	
1977	2.47	62	92.54	92.92	
1954	2.74	58	86.57	86.90	
1976	2.66	59	88.06	88.40	
1981	2.55	60	89.55	89.91	
1944	2.47	61	91.04	91.42	

1.3.3.2 Composite Stage-Frequency Curves

As mentioned in Section 1.3, these probabilistic graphical analysis results were joined with hydrodynamic and statistical model results to create composite stage-frequency curves used for a host of MsCIP design and evaluation efforts as discussed throughout this report. This section presents ERDC modeling results at the location of the USACE gages with those results obtained by probabilistic analysis of gage data and shows how they were combined to form composite stage-frequency curves.

Figure 1.3-10 shows stage-frequency components obtained through probabilistic analysis of historic gage data at Gulfport with ERDC results for the same location. ERDC results were obtained from the results of hydrodynamic modeling of severe storm events and statistical analysis of hydrodynamic model output as described in Chapter 2. These results are referred to as 'synthetic,' as they were not explicitly developed from observed data, and represent the best estimate of stage for a given annual chance of occurrence. Uncertainty bands[1] for these best estimates were computed and are used in the analyses supporting the MsCIP program. Figure 1.3-11 shows the joined, or composite, stage frequency curves with uncertainty at 2 standard deviations. The curves were joined graphically. This figure was obtained from the HEC-FDA model, in which one hundred feet has been added to stage for computational purposes; the data are otherwise consistent. Similar figures are presented as Figures 1.3-12 through 1.3-15 for both the Biloxi and Pascagoula gage locations.

A more detailed discussion on the development and adaptation of composite stage-frequency information to the flood damage evaluation purpose is provided in section 2.16.

[1] Uncertainty computations are discussed in sections 2.9 and 2.16.

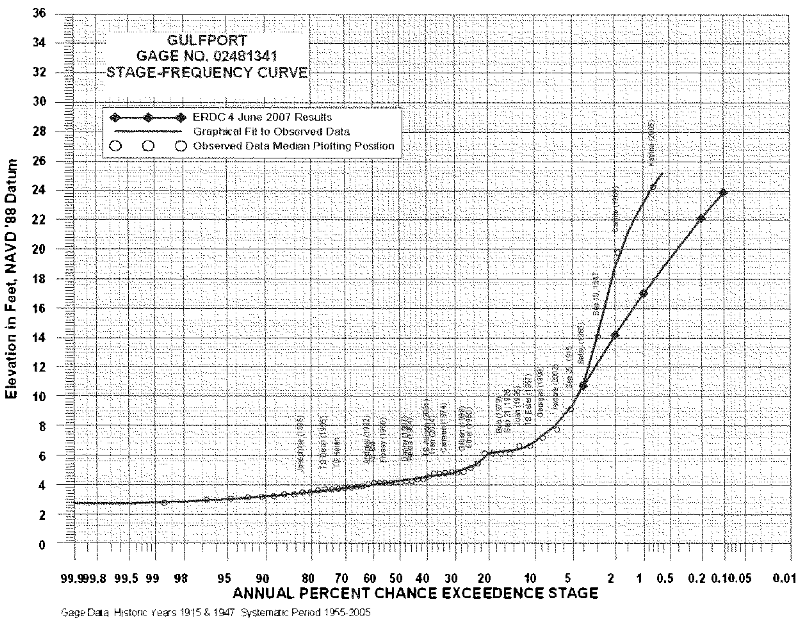
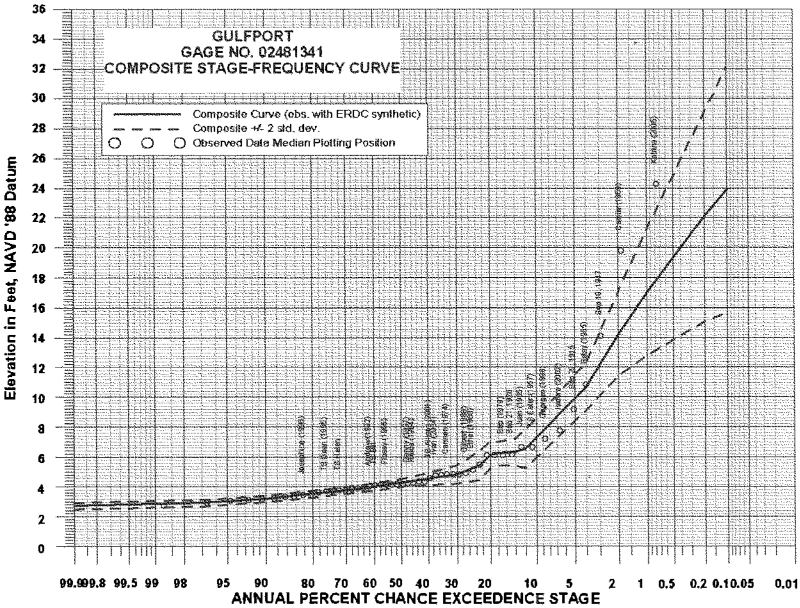
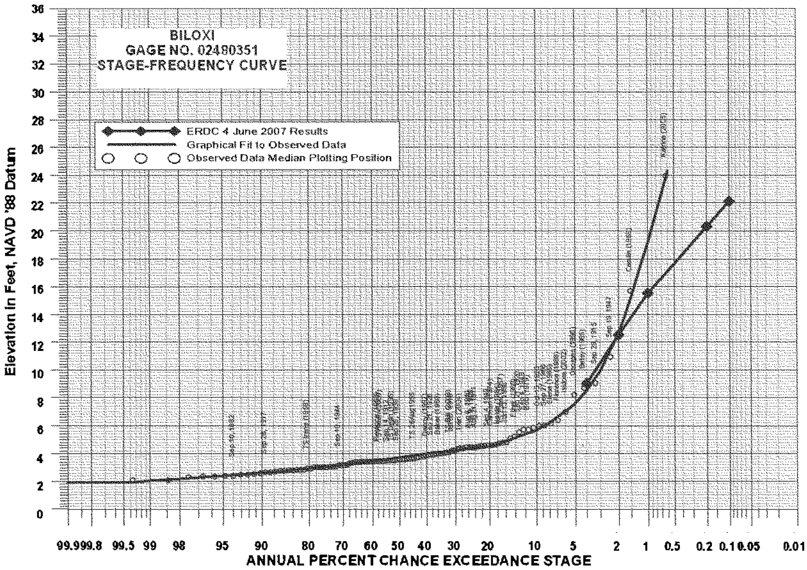


Figure 1.3-10. Graphical and Synthetic Stage-Frequency Curve Components at Gulfport



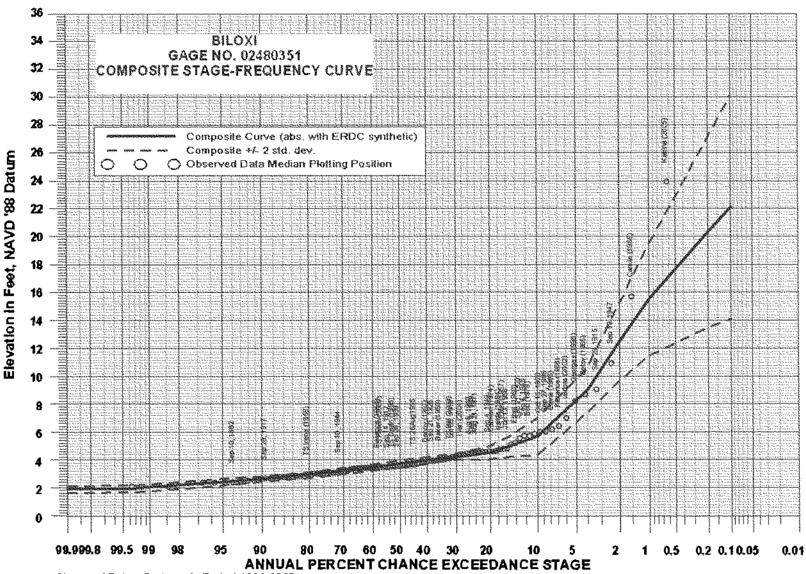
Observed Data: Historic Years 1915 & 1947, systematic period 1955-2005.

Figure 1.3-11. Composite Stage-Frequency Curve, Gulfport



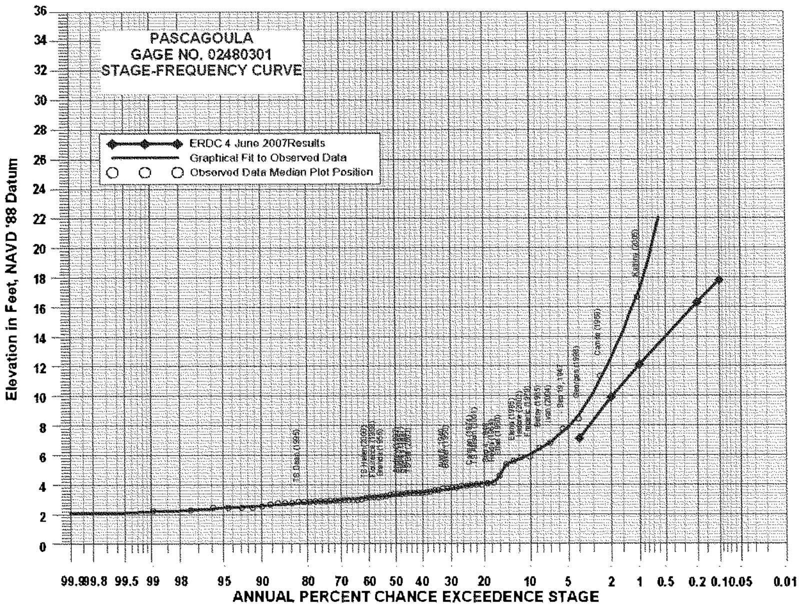
Gage Data: Systematic Period 1882-2005.

Figure 1.3-12. Graphical and Synthetic Stage-Frequency Curve Components at Biloxi



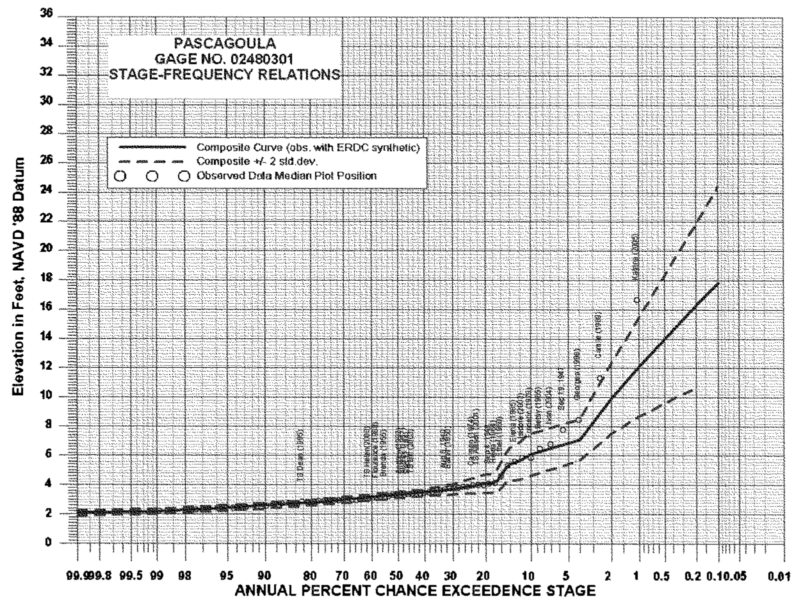
Observed Data: Systematic Period 1882-2005.

Figure 1.3-13. Composite Stage-Frequency Curve, Biloxi



Gage Data: Period of Record 1941-2005.

Figure 1.3-14. Graphical and Synthetic Stage-Frequency Curve Components at Pascagoula



Observed Data· Period of Record 1941-2005.

Figure 1.3-15. Composite Stage-Frequency Curve, Pascagoula

1.3.4 References

Resio, D.T. (2007). White Paper on Estimating Hurricane Inundation Probabilities. Version 11. US Army Corps of Engineers, Engineer Research and Development Center. Vicksburg, MS. April 2007.

USACE (1993). Hydrologic Frequency Analysis. Engineer Manual EM 1110-2-1415. US Army Corps of Engineers. Washington, DC. 5 March 1993.

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1.4 Typical Wind, Wave, Water Level, Current, and Sediment Transport Conditions

The Mississippi Sound extends from Mobile Bay, Alabama, to the east to Lake Borgne, Louisiana, to the west. The Sound is a mostly unstratified brackish water body approximately 81miles long, 6.8 to 15 miles wide, and 820 square miles in area. The Sound has a mean depth of 10 ft Mean Low Water (MLW) and more than 99% of it is shallower than 20 ft MLW. The Sound extends about nine miles north to south from the Mississippi mainland coastline to a series of low, typically sandy barrier islands on the edge of the coastal shelf which marks the Gulf of Mexico.

1.4.1 Winds

Prevailing winds for the Mississippi coast are produced by two pressure ridges which dominate weather conditions: the Bermuda High, centered over the Bermuda-Azores area of the Atlantic and the Mexican Heat Low centered over Texas during warm months. Prevailing winds are predominately from the east and south east during spring and summer months, and from the east and north east during fall and winter months. The strongest winds are recorded in February and March with the exception of storm and May through October hurricane conditions. Hurricane wind fields and their effects on storm surge and waves are an area of particular concern for this study and are discussed at length in Chapter 2 of this appendix.

1.4.2 Waves

Wave intensity of the Mississippi Sound is typically low to moderate. Fetch and depth limited waves within the sound average less than 1 ft in height. Breaking wave heights along the shoreline of the barrier islands average about 3 ft with periods of five to eight seconds. Hurricane and storm conditions, and strong winter cold fronts can produce significant surges and much larger wave conditions at the coast and barrier islands. Wave phenomena due to hurricanes are discussed in detail in Chapter 2 of this appendix.

1.4.3 Tides

The mean tidal range near the Mississippi Sound shoreline is approximately 1.5 ft. Although the tidal range caused by astronomical forces is relatively small, atmospheric pressure variation and, particularly, winds can induce larger variations. Strong winds blowing from the north can force water out of the sound and result in current velocities of several knots in the passes. The reverse occurs with winds blowing from the southeast, which forces water shoreward toward the Mississippi coastline. The tidal variation in the Mississippi Sound and adjacent waters is typically diurnal (one high tide and one low tide daily) though mixed tides (two high tides and two low tides) occur a few days out of the month. The average tide cycle is 24.8 hours which is slightly less than one lunar day. Mobile District has a long tide level monitoring history in Mississippi as discussed in section 1.3. The long period of record provides for an interpretation as to the relative rate of sea level rise as discussed in section 1.6.

1.4.4 Currents

The general circulation patterns in the Mississippi Sound are primarily induced by tides and winds, with freshwater inflows having secondary influences. The currents caused by the tide diverge and split the Mississippi Sound into two distinct areas. Horn Island Pass and the area north of the pass is the natural dividing point for tidal currents. Currents from this area to Lake Borgne generally flow into the Sound through the Barrier Island Passes and flow westward on the flood tide. During ebb tide, the flow is eastward and out of the Sound. From Horn Island Pass to Mobile Bay, currents flow in through the Barrier Island Passes and eastward on the flood tide, and reverse westward and out of the sound during ebb tide. Strong winds blowing from the north can force water out of the sound and result in current velocities of several knots in the passes. The reverse occurs with winds blowing from the southeast, which forces water shoreward toward the Mississippi coastline. Typical tidal currents range between 0.5 to 1.0 ft/s.

1.4.5 Sediment Transport

The Mississippi coast is a wave-dominated coastline. Because prevailing wind in the Mississippi barrier island and mainland areas is from the eastern quadrants, most waves approach the shoreline at an angle and induce longshore currents that move sediment to the west. The islands migrate west due to littoral drift at approximately 50 ft/yr. There are a variety of structures, such as outfalls, port facilities, and sand enclosures along the Mississippi mainland coastline that divide the shoreline into closed littoral cells. For annual average wave conditions, the beaches may shift due to specific storm event but remain largely in equilibrium. For higher wave conditions there appears to be a tendency for sand to bypass the structures. Small shoreline structures such as outfall pipes produce minor localized perturbations in the coastline with accretion on the east sides of the structures indicating a westward littoral drift, however, longshore processes have minimal influence on the beaches in comparison to the cross-shore processes that exert primary control on shoreline response. The Mississippi River and several rivers along the northern border direct silt and clay into the sound. Salinity-induced flocculation of these very fine sediments induces settling and results in the continuous infilling of the sound. The high sediment load also produced elevated turbidity levels, giving the water of the Mississippi Sound its characteristically brownish appearance.

1.5 Geologic Setting and General Geophysical Investigations

1.5.1 Geologic Setting and Physiography

The coastal area of Mississippi is part of the Gulf Coastal Plain that extends from Florida westward to Texas. Coastal plains are generally characterized by gently sloping sedimentary formations that dip towards the coast line. The Gulf Coastal Plain is also affected by the Mississippi Embayment which is a trough that underlies the Mississippi River delta. This trough extends inward from the coast and is gradually subsiding near the coast under the sediment load that is being transported by the Mississippi River and deposited at the mouth of the river. Subsidence along this trough has changed the dip of formations that make up the coastal plain of Miocene an older age to a somewhat southwesterly direction. Of interest to this study are the three counties that front the Mississippi Sound. The Sound is a narrow, east-west; shallow body of water that separates the mainland from barrier islands that lie 10 to 15 miles offshore and the Gulf of Mexico southward of the islands. These counties, east to west, are Jackson, Harrison, and Hancock.

The Geologic Map of Mississippi (Moore, 1976), published by the Mississippi Geological Survey identifies three strata or formations that underlie the three subject counties. These include the alluvial/coastal deposits of Holocene age, the Citronelle formation of Pliocene/Pleistocene age, and the Pascagoula/Hattiesburg formation of Miocene age. Later and more detailed work (Otvos, 1986, 1992 and 2005) has further defined the various formations and provided information as to their depositional environment. This work also provides information concerning the barrier islands which lie off the coast of Mississippi. Some of this later work also addressed the presence of or lack of sand and other sediments along the coast, in the Mississippi Sound and near the barrier islands.

Within the Mississippi Sound, Holocene aged deposits form thin, muddy, strata that cover the older Pleistocene formations. These include alluvial, estuarine, and lagoonal-bay deposits. Sampling studies have shown the strata to contain particle sizes from colloidal to sand size depending on the energy associated with its depositional environment (Upshaw, Creath and Brooks, 1966).

Closer to the coast, late Pleistocene sea level changes associated with global glacial action caused a transgressive-regressive sequence that reworked sand along the coast. The last glacial period created a coastline near the edge of the continental shelf. As the ice began to melt, the associated sea level rise and wave action began to form the exposed sand into barrier islands with replenishment to this system coming from the east associated with sediments from the Apalachicola River that contribute to the barrier islands in northwest Florida westward into Alabama along Dauphin Island. A predominant wave action from the southeast creates a westward littoral drift that replenishes the sand to the beaches and inlands as well as causing a westward drift to some of the islands in Mississippi. The transgressive-regressive sequence has reworked sand and other sediments along the coast that has resulted in three formations that correlate from the alluvium along the coast to the barrier islands. These formations are the Prairie, Biloxi, and Gulfport formations. The Gulfport and Prairie formations are generally very sandy and have some economic value because of the sand. A generalized geologic map of the Mississippi coast based on these studies is shown in Figure 1.5-1, (after Otvos, 1997). The Prairie formation is found just landward of the coast in all three counties and the Gulfport formation is found along the beaches and barrier islands.

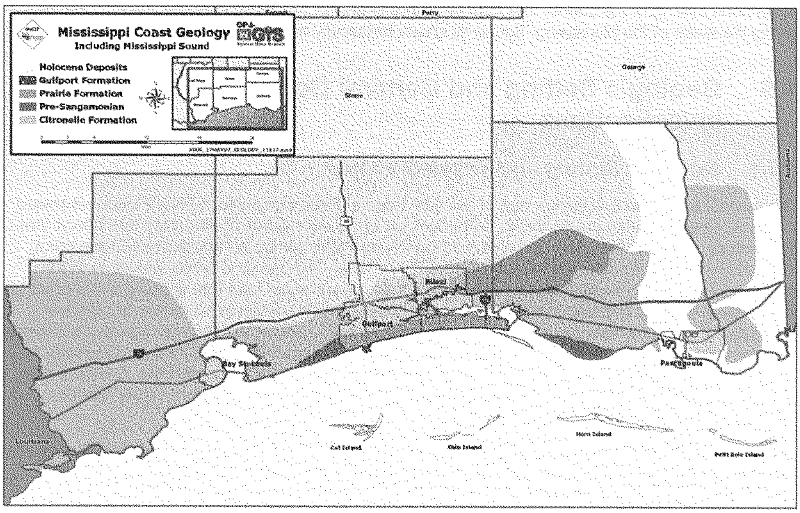


Figure 1.5-1. Generalized Geologic Map of Coastal Mississippi (After Otvos, 1997)

The Plio/Pleistocene Citronelle formation outcrops northward of the late Pleistocene formations. Utilizing outcrop, boring and fossil data from numerous locations, the Citronelle formation has been characterized as upland, alluvial/fluvial deposit that covers much of the study area. It consists predominantly of silt and sand with some gravelly deposits. The source of the sand came from rivers that drained to the Gulf coast. Where paleo-streams and rivers have been incised into the underlying Miocene formation, Citronelle has formed thicker sequences than its general sedimentary deposits that cover much of the three counties.

The northern portions of the three counties contain limited outcrops of the Miocene aged Pascagoula/Hattiesburg formation. This formation contains inter-bedded clay, silt, and sand and is exposed along river valleys that have incised through the younger Citronelle formation which overlies it in the study area.

Collectively, the formations that outcrop within the study area provide vast quantities of useful construction material that includes high quality sand, sandy clays and clay. The nature of the various options discussed in this document will require all of these types of materials and the availability of these materials commercially throughout the area will benefit any project costs. Other than limited locations that fall within river channels or the bay bottoms, the geologic formations are expected to provide good foundation conditions. The areas within the river channels and bay bottoms will require deep geotechnical exploration to define local conditions, however the presence of major highway bridges and train trestles indicate that suitable deep foundations can be designed.

The study area is located within the East Gulf Coastal Plain physiographic province. There are two major physiographic regions in the Mississippi coastal region. The Gulf Coast Flatwoods form an irregular belt through the southern half of the three-county region. This belt consists mainly of wet lowlands and poorly drained depressions, with some higher, adequately-drained areas. The second physiographic region, the Southern Lower Coastal Plain, is rolling and gently undulating, interior uplands. Elevations range from sea level along the coast in Hancock, Harrison, and Jackson Counties to about 420 feet above sea level. The slope of the land surface is generally oriented to the south. The area is underlain by a thick sequence of sedimentary deposits dipping to the south and west.

1.5.2 Historical Offshore Sampling and Geophysical Exploration

Historical Offshore Sampling and Geophysical Exploration - To support any nourishment of sand along the mainland and on the barrier islands, extensive deposits of beach quality sand will be required. The sand will have several physical requirements that include color, grain size, and particle shape. Starting in the 1950s, literature contains extensive information about the sediments and shallow strata in the Mississippi Sound and along the shoreline. These studies supported sediment studies, the construction of beaches in Harrison and Jackson County as well as investigations for proposed bridges out to the barrier islands. The Mississippi Office of Geology, Coastal Geology Section, within the Mississippi Department of Environmental Quality maintains extensive records of the borings and sampling that have occurred in the area of the Mississippi Sound, (http://geology.deq.state.ms.us/coastal). There is also an abundance of information available from the Gulf Coast Research Laboratory (Otvos, oral comm.) located in Ocean Springs, MS. Another source of data exists with the US Geological Survey office located in St. Petersburg, Florida. Vast amounts of acoustic profiles are contained within their files in analog format. (Oral communication, Flocks, 2006) These profiles include the areas within Mississippi Sound, around the barrier islands, and southward out into the Gulf.

Extensive additional information is also stored in archives at the United States Geological Survey, but not in a user friendly format. These records include thousands of miles of acoustic profiles that exist as analog data recorded on scrolls. Through cooperation with the Mineral Management Service, efforts are underway to have these records transferred to a digital format that can be incorporated into a GIS type database. Of particular interest to this study is the St. Bernard Shoals that lie about 45 miles south of the barrier islands. St. Bernard Shoals is now a series of submerged barrier islands that existed when the sea levels were much lower. It is believed that large quantities of high quality sand exists in the Shoals that could be used for the restoration of beaches and dunes both on the barrier islands and the mainland beaches.

1.5.3 Proposed Offshore Geophysical Exploration

Proposed Offshore Geophysical Exploration - Additional acoustic profiling is proposed for off-shore areas within Mississippi Sound and in some areas south of the barrier islands. These surveys will help identify sand deposits that could be used or re-nourishment of the islands and to provide data on the shallow strata between the islands. Some of the area is within the boundaries of the Gulf Islands National Seashore and work within these boundaries must be approved by the National Park Service. Acoustic profiling is based on a source of acoustic energy that is generated and acoustic reflections from that noise that are collected after bouncing off firm subsurface strata. The method used to perform the survey consists of towing the energy source and hydrophones behind a boat along traverse lines. The speed of the signal is measured and digitally recorded after it passes through the upper, softer strata, is reflected off the firmer sub-bottom and returns to hydrophones which act as receivers. This measured speed has a correlation to different types and thicknesses of sediments. The exact location of the reflected signal is constantly recorded during the process using GPS technology. Using data from a grid pattern, an isopach or 3-dimentional interpretation will be completed to estimate the volumes of available sand. Areas to be surveyed were selected from prior investigations that indicated large, extractable deposits of sand. This was based both on prior acoustic profiling and sampling. To ensure the resolution is sufficient to allow for proper interpolation, the proposed grid pattern will have a spacing of 500 feet while paralleling the coast and 1000 feet while operating perpendicular to the coastline. The areas proposed for the geophysical survey are shown in Figure 1.5-2.

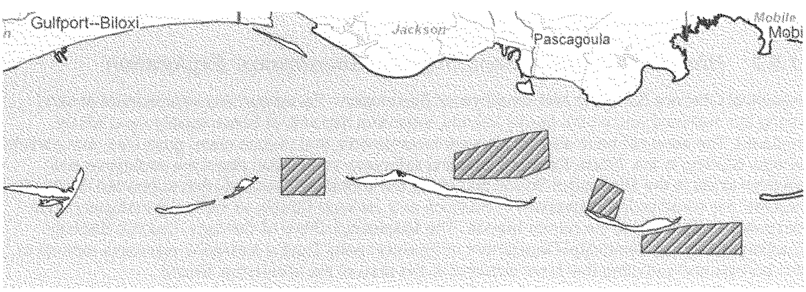


Figure 1.5-2. Proposed Areas for Geophysical Surveys

In addition to the acoustic profiles, the bottom of the selected study areas will be surveyed with side-scan sonar. This procedure locates any abrupt change in the bottom contour that may indicate debris, shipwrecks, or even vegetation growing on the bottom. This will prevent damaging dredging equipment if debris is found within the zones selected for borrow areas or damaging vegetation that has high value to marine life.

During the geophysical survey, some locations will be selected to obtain actual samples of the sediments to provide accurate correlation between the interpretations and actual conditions. The contractor that performs the geophysical survey will obtain these samples during the operation.

These samples will also provide for a general analysis of grain size distribution, particle shape, and color. All of these are important in selecting the borrow areas prior to placing the sand on beaches.

The results of the geophysical surveys will be used to estimate both location and quantities of the required sand. After the acoustic profiling is completed, the next phase will be a more complete exploration program that will verify the results of the geophysical survey. This phase will consist of taking numerous Vibracore samples which provide a continuous sample from the sound/gulf bottom to a depth of 20 feet. The spacing of these holes will be sufficient to ensure that the extracted sand meets all quality specifications from a given location.

1.5.4 Tectonic and Seismic Considerations

Tectonic and Seismic Considerations - Numerous studies have been made concerning subsidence around the mouth of the Mississippi River. General thoughts have attributed the subsidence to the sediment loading of the lower delta as the river enters the Gulf of Mexico. Other studies have concluded that recent faulting has occurred associated with both subsidence along the coast and uplifting in the coastal plain (Bowen, 1990). While this low order faulting in soft sediments produces no significant seismic events, associated displacements must be considered even if very small. Computed subsidence of first-order benchmarks has concluded that the Mississippi coast had a subsidence rate of 5 mm/year during the later half of the 20th century and continues to subside, (Shinkle and Dokka, 2004). These rates are the subject of much discussion among various agencies due to the fact that the primary benchmarks may not be stable thus influencing the results any surveys. The need to update the benchmarks to provide accurate elevation data is recognized by the National Geodetic Survey. Mississippi's subsidence has been factored into the relative sea level rise based on over eighty years of observation at three tide gauges along the coastline, Gulfport, Biloxi and Pascagoula. The relative sea level rise is based on both actual changes in sea level and any subsidence combined into a single value. This change would be what the casual observer would notice over time along the coast. The relative sea level values will be considered in all designs.

1.5.5 On-shore Borrow Areas

Coastal Mississippi, On-shore: There are a large number of commercial sources for different types of soil along the three coastal counties of Mississippi. Depending on the project, these sources may be utilized for construction of levees, beach nourishment and dune restoration. Deposits of sand found in the Prairie formation may be of beach quality and have potential use for beach nourishment along the mainland beaches. The presence of the Prairie and Citronelle formations in much of the study area can provide necessary reserves for construction of levees. The sands included in these formations can also be evaluated for beach restoration. These sources are permitted by the Mississippi Department of Environmental Quality which publishes a list of permit holders. A review of the listed sources shows that Jackson County has 14 operations, Harrison County has the most with 63 sources and Hancock has 33 sources. These locations are shown in Figure 1.5-3. Not all the listed sources are believed to be active operations. At the present time, no information is available on specific soil properties such as classification, gradations or color, all of which will be important characteristics if used for beach nourishment. This information will be collected before any material is selected for use. Attempts will be made to contact each of the listed operators to compile a current list of sources that will provide an estimate of reserves, operational output, and more specific information on the material that is actually produced. A review of the permitted size (acreage) of most of the operations indicates that their individual site reserves may be less than one million cubic yards, but collectively contain vast quantities of material. Many of the sources list specific information as to what type of material that they produce while some of the permits do not indicate the type of formation that is being mined other than a general statement such as "dirt". A list of the permitted sources for Jackson, Harrison and Hancock Counties are shown in Table 1.5-1, 1.5-2, and 1.5-3, respectively.

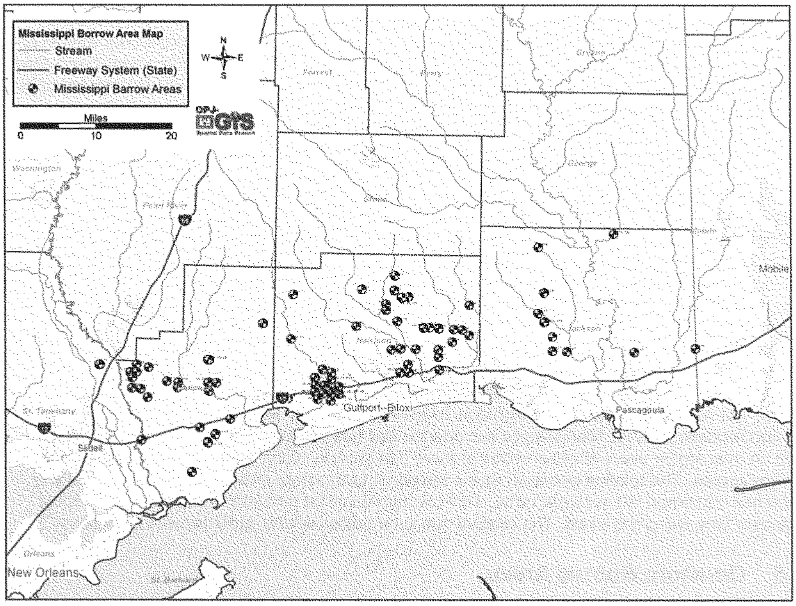


Figure 1.5-3. Location of Permitted Mining (Borrow) Operations in Coastal Mississippi Counties

Table 1.5-1.
Permitted Borrow Areas in Jackson County

County	Operator	Permit #	Permitted Acres	Material
Jackson	Bright	N/A	20	sand and clay
Jackson	Ward	P02-037	35	sandy clay
Jackson	Hence	P04-019	25	clay and sand
Jackson	Blain	P83-002	6	sand
Jackson	Yates	P-87-045T	29	sand and clay
Jackson	Jackson C	P91-061	10	sand and clay
Jackson	Mellette	P92-054	19	sand clay
Jackson	Talley	P93-020	24.8	dirt
Jackson	Graham	P93-029	20	sand and clay
Jackson	Dees	P94-036	6	dirt
Jackson	Dees	P95-058	16	dirt
Jackson	Jackson C	P96-014	19.5	soil clay fill
Jackson	Mellette K	P98-057	30	clay & sand
Jackson	Ward	P98-063	60	sandy clay

Table 1.5-2.
Permitted Borrow Areas in Harrison County

County	Operator	Permit #	Permitted Acres	Material
Harrison	Waits	N/A	40	fill dirt
Harrison	Fore	N/A	40	
Harrison	Blacker	N/A	49.6	soil
Harrison	Dirt works	P00-020	9.7	sand
Harrison	Anchor	P00-065	20	fill dirt
Harrison	Dirt works	P01-014A	21.98	dirt/clay
Harrison	Williams D	P02-004	25.6	dirt
Harrison	Edwards	P02-007	12.7	dirt, sand and gravel
Harrison	Wallace T	P02-018	53	dirt
Harrison	Wallace T	P02-045	40	dirt
Harrison	fore	P03-010	38.2	dirt and sand
Harrison	Edwards	P03-044	7	sand, gravel and dirt
Harrison	TCB	P03-046	20	clay/sand
Harrison	Lamely D	P04-006A	25	clay, sand
Harrison	Edwards	P04-017AA	22.5	sand and dirt
Harrison	Du Pont	P04-036	38	clay
Harrison	Wetzel	P04-37	5.6	sand
Harrison	Fore	P04-043A	46.17	sand
Harrison	Fore_W. C.LLC	P05-005	40.02	sand
Harrison	Fore_W. C.LLC	P05-006	40.4	sand
Harrison	Saunders	P05-007	14.2	clay, sand
Harrison	Fore_W. C.LLC	P05-010	44.23	sand
Harrison	Warren Paving	P05-025	14.5	dirt
Harrison	Dirt	P06-002	15	dirt
Harrison	Cams	P80-022	20	fill dirt

Table 1.5-2.
Permitted Borrow Areas in Harrison County (continued)

County	Operator	Permit #	Permitted Acres	Material
Harrison	Griffin	P81-030T	8	fill dirt
Harrison	Fore	P87-027	28	sand and clay
Harrison	Blackmer	P87-029T	8	clay/sand
Harrison	Dirtworks	P87-048T	5	fill dirt
Harrison	Mid C	P88-012	20	fill material
Harrison	Gulf	P88-025T	12	sand and gravel
Harrison	Fore	P88-027	30	sand and clay
Harrison	Fore	P88-027A	76	sand and clay
Harrison	Parker	P89-007	5	fill dirt
Harrison	Cams	P89-019	10	sand clay
Harrison	Lamey D	P89-022	5	fill dirt
Harrison	Ladner	P90-023	6.5	sand and gravel
Harrison	TCB	P90-024T	4	sand and gravel
Harrison	Ray	P92-014	10	soil/borrow
Harrison	Parker	P92-066	3	dirt
Harrison	Holden	P92-079T1	4.5	dirt
Harrison	Blackmer	P92-089	12	clay/sand fill
Harrison	Twin	P92-093	10	clay/sand fill
Harrison	Ladner	P93-009	6	sand and gravel
Harrison	Holden	P93-012	8	sand and clay
Harrison	Holden	P93-041	19.4	sand-clay
Harrison	Lamey D	P93-051	10	fill dirt
Harrison	Breeland	P93-064T	32	fill dirt
Harrison	Dubuison	P93-113	0.7	sand clay
Harrison	Newells	P94-035	11.5	clay sand gravel
Harrison	Holden	P94-064T1	4	fill material
Harrison	Blackmer	P95-018	28	sandy clay
Harrison	Holden	P95-073	20	clay, sand-clay
Harrison	Dirtworks	P95-080T	7	fill dirt
Harrison	Fore P	P95-082	3	sand and gravel
Harrison	Fore P	P95-083	3	sand and gravel
Harrison	Holden	P96-022T1	8	dirt
Harrison	Fore C	P96-047	30	sand and clay
Harrison	Parker	P96-067	3	dirt
Harrison	Holden	P97-021	15	clay and sand clay
Harrison	Twin	P98-048	35	sand and gravel
Harrison	Prince	P98-055	10	sand and clay
Harrison	Wallace T	P99-052T	22	sand clay

Table 1.5-3.
Permitted Borrow Areas in Hancock County

County	Operator	Permit #	Permitted Acres	Material
Hancock	Gibson	P00-034	4	fill dirt
Hancock	Boudin	P00-058	10	sand/clay/fill
Hancock	Phillips Tru	P02-016	40	sand and clay
Hancock	Fore	P02-027	37.25	dirt and sand
Hancock	Cuevas	P02-058	4	clay gravel
Hancock	B&C	P03-011A	12	dirt and sand
Hancock	Henley C	P03-028	8.75	clay and sand
Hancock	DK Agg	P04-007	40	sand and gravel
Hancock	DK Agg	P04-008	20	dirt/clay
Hancock	Frierson	P04-012	6	sand and clay
Hancock	Larry Nicks	P05-001	12	sandy clay
Hancock	Phillips Tru	P05-003	25	sand and dirt
Hancock	Knight	P86-016	1	sand and gravel
Hancock	Fore	P92-024	20	borrow/soil
Hancock	TCB	P93-022	25	sand clay
Hancock	SCI	P93-033	13.1	borrow
Hancock	Fore	P93-048	29	fill dirt
Hancock	Fore	P93-048	N/A	fill dirt
Hancock	Ladner P	P93-079	15	sand and clay
Hancock	Haas	P93-110	16.3	sandy clay
Hancock	Frierson	P95-012	4	dirt
Hancock	Fore	P95-047T	10	sand and sandy clay
Hancock	Henley C	P96-008	3.7	clay/sand
Hancock	C & G	P96-064	5	dirt/sand
Hancock	Ladner R	P97-023	3	fill dirt
Hancock	Pittman	P-97-032	46	sand and clay
Hancock	Fricke's	P97-044	6	sand and sandy clay
Hancock	Fore S	P-97-045T	20	sand and gravel
Hancock	Thigpen	P98-017	9	sand and gravel
Hancock	Fore	P98-064T	10	sand/clay/fill
Hancock	Fricke's	P98-065	8.7	sand, sandy clay
Hancock	Moran	P99-021	31.5	fill dirt
Hancock	Thigpen	P99-034	14	sand and gravel

Some projects along the coast are already under design as interim projects and will require sand for beaches. These projects are located in all three coastal counties and the in-place quantities are as follows:

- Jackson County, Pascagoula Beach - 270,000 cubic yards sand
- Harrison County Beach - 681,000 cubic yards sand
- Hancock County, Bay St, Louis Seawall - 159,000 cubic yards sand

All of these projects are limited in scope and could be easily supported by local on-shore commercial operations or sand deposits that have located just offshore. These offshore sand deposits are limited in size and may be due to past beach construction and nourishment projects where the sand was eroded from the beach due to storms and wave action.

1.5.6 Offshore Borrow Areas

To provide the sand necessary to rebuild or nourish the beaches on the barrier islands, large quantities of quality sand must be located. The inventory of these sand resources has been the subject of many studies. Within the Seven Point Hurricane Recovery Strategy developed by the Governor of the State of Mississippi, one is restoring the barrier islands of the coast of Mississippi to a pre-hurricane Camille footprint. This is addressed in this appendix as Option A under the Barrier Islands. This will involve establishing islands of a size similar to a pre-Camille condition with allowances made for migration of the islands over time. This includes an estimated 30 percent loss of volume during placement due to the losing finer sand particles in the outwash. All of these areas may be contained within the littoral drift zone that transports sand along the chain of barrier islands. The impacts of transferring this sand within the littoral drift zone will be evaluated through sediment transport models. Some of these areas also are within the boundaries of the Gulf Islands National Seashore which extend one mile from the shores of Petit Bois, Horn, and Ship Island. Other than close to the mainland and island beaches, most areas within the Sound are expected to have muddy Holocene deposits overlying any sand deposits. These deposits may render the sand unusable without segregation of the different materials prior to being placed along the beaches.

At the present time, four areas have been selected for acoustic profiling near the barrier islands to assist in identifying potentially useful deposits of sand. An initial quantity of 66,000,000 cubic yards of sand has been estimated for use on the barrier islands as the quantity of sand for restortation to a pre-Camille footprint as described above and would be the target for this survey. During hurricane Katrina, the breach of Ship Island was widened to approximately three to four miles. This breaching also occurred during Hurricanes Fredrick and Camille with a low sand spit reforming over time. This erosion and other lesser amounts of erosion on the other islands has scattered sand on an area of unknown extent. Much of this sand may still remain in the littoral drift zone. It may eventually be transported where it could be naturally deposited on a beach. However, this process is slow and will not aid in storm protection for a very long period of time. Identification of these sand deposits and using them to restore the island would provide a more timely protection for the coast during lower intensity storms.

If the islands were restored to the pre-Camille footprint, the restoration of Ship Island will be the largest single project requiring up to 30,000,000 cubic yards of excavated sand. This volume is roughly based on restoring the breach to an island width of 2,000 feet (including submerged portion) for the full length of the breach and bringing sand dunes to at least elevation 20 feet (NAVD 88) with a 10 foot existing water depth. This height will allow better protection against breaching during future low intensity storms (Otvos, oral comm. 2006). Based on previous work (Otvos, 1975/76 and Upshaw, Creath, and Brooks, 1966) which involved sampling and sub-bottom profiling, four areas have been selected for exploration using acoustic profiling and vibracore sampling. This procedure has been previously described in Proposed Off-shore Geophysical Exploration and the proposed areas are shown in Figure 1.5-2. Three of the areas are located either partly or wholly within the boundaries of the Gulf Islands National Seashore and any work within these boundaries must be coordinated with the National Park Service. These boundaries include Petit Bois, Horn and Ship Islands. Petit Bois and Horn Islands are also designated as Wilderness Areas by the Park Service and receive a higher level of protection than Ship Island.

Review of the samples that were collected during these and other studies also indicate that sand deposits underlie some of the Holocene deposits within the Mississippi Sound. The use of these sands for beach nourishment would be dependant on segregation and removal of the overlying muddy Holocene sediments. The Holocene sediments may have some value for use in the creation of marshes and wetlands that could be considered if the underlying sands were needed to complete a project. An example of this condition exists about two miles south of Deer Island. In a boring referenced as Hole 785 and reported by Otvos (1985), the bottom of the Sound was recorded at 9.0 feet. From 9.0 to 13.3 feet the sample was described as muddy medium sands, poorly sorted. Underlying this muddy sand, the samples showed medium sand from 13.3 to 16.7 feet and very to well/moderately sorted, fine sand from 16.7 to 27.1 feet.

As one might expect, much of the quality sand deposits are within the littoral drift zone of the barrier island chain. This high energy environment provides a sorting process that allows for deposition of sand while preventing finer grained sediments from being deposited. While not removing the sand from the littoral drift zone, the process of relocating of sand from any given area within the drift zone and transporting it to another area within the zone must be considered. Using the same reference as above (Otvos, 1985), a boring taken within the littoral drift zone between Horn and Ship Inland, Boring S-6, the upper eleven feet of sediment to be well to moderately well sorted medium sand with additional sand units below.

Prior studies of the St. Bernard Shoals (Oral Communication, USGS, 2006) are probably the best source of the sand, although additional studies and sampling will be required to ensure the sediments meet the quantity and quality requirements. St. Bernard Shoals are a series of submerged barrier islands located south of the existing islands (see Figure 1.5-4) and are believed to contain substantial quantities of high quality sand, more than enough to supply the quantity needed for any use at the barrier islands. The US Geological Survey is presently compiling historical data on offshore sand deposits that will include the St. Bernard Shoals area. This study will also include some sampling of selected areas.

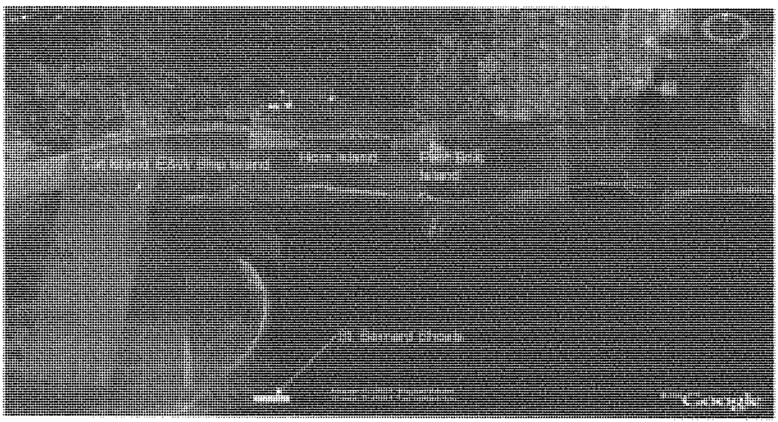


Figure 1.5-4. Map Showing the Location of St. Bernard Shoals

1.5.7 Inland River System Sand (Dredged Material)

After the construction of inland waterways in Alabama and Mississippi, maintenance dredging is sometimes required to maintain the channel depths and alignments. This material is typically moved to disposal areas along the banks of the river where it accumulates in diked areas. Figure 1.5-5 shows an aerial view of one of the sites. Dredging of some of the areas along the river produces large quantities of sand that have potential use for beach nourishment. An inventory of current disposal sites indicates that approximately 30,000,000 cubic yards of sand may be available. Information on available sand on these two river systems is shown in Tables 1.5-4 and 1.5-5. Only disposal sites that contain a minimum of 100,000 cubic yards of sand were included in the inventory. Of interest to this study are disposal sites that are located along the Black Warrior – Tombigbee River system and the Tennessee – Tombigbee Waterway. Figure 1.5-10 shows the relationship of these disposal areas to the project sites along the Mississippi coast. The range of haul distances (by water) to the barrier islands western extent varies from 163 to 500 miles. Material from these sites could easily be transported by barge down the river system for use along the beaches. The cost to store this type of dredged material is high and it has recently been estimated that removing the sand from the existing disposal areas would save the Government over $100,000,000 at today's cost.

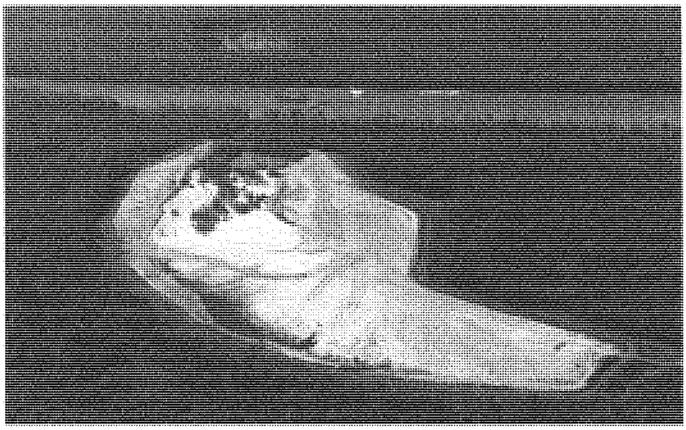


Figure 1.5-5. Sunflower disposal area on the Tombigbee River with large quantities of sand available for use on coastal projects in Mississippi

Table 1.5-4.
BWT Dredge Material Disposal Areas Over 100,000 CY

Site	River Mile	Acquisition	Access/ Land	Access/ River	Est Material Placed To Date(CY)
C	78.2	Easement	No	Yes	1,500,000
D-1	82	Easement	No	Yes	515,000
E	86	Easement	No	Yes	250,000
E-2	87	Fee	No	Yes	110,000
F	88.5	Easement	No	Yes	315,000

Table 1.5-4.
BWT Dredge Material Disposal Areas Over 100,000 CY (continued)

Site	River Mile	Acquisition	Access/ Land	Access/ River	Est Material Placed To Date(CY)
I	91.5	Easement	Yes	Yes	260,000
J	96	Easement	No	Yes	140,000
N	103.5	Easement	No	Yes	1,400,000
R	105	Fee	No	Yes	130,000
X-2	108	Fee	No	Yes	205,000
X	108.2	Easement	No	Yes	1,500,000
X-4	108.4	Fee	No	Yes	810,000
Z	108.6	Easement	No	Yes	1,250,000
CA-1	191.3	Easement	Yes	Yes	135,000
BA	297	Easement	No	Yes	300,000
AD	299.2	Easement	No	Yes	440,000
AE	300.4	Easement	No	Yes	465,000
AF	307	Easement	No	Yes	1,600,000
AG	313	Easement	No	Yes	1,020,000
BE	324	Easement	Yes	Yes	160,000
BD	329	Easement	No	Yes	170,000
TOTAL					**12,675,000**

Table 1.5-5.
TTW Dredge Material Disposal Areas Over 100,000 CY

Site	River Mile	Acquisition	Access/ Land	Access/ River	Est Material Placed To Date(CY)
D-20	243.5	Easement	Yes	Yes	721985
D-24	249.5	Easement	Yes	Yes	196392
D-25	250.6	Easement	No	Yes	257137
D-29	256.5	Easement	Yes	Yes	127014
D-30A	257.3	Easement	Yes	Yes	750654
D-30B	257.7	Easement	Yes	Yes	195291
D-31A	259.3	Easement	Yes	Yes	298684
D-31B	260.3	Easement	Yes	Yes	231121
D-33	263.1	Easement	No	Yes	1825225
D-36	265.4	Easement	Yes	Yes	900317
G-13	287.8	Easement	No	Yes	242129
G-14	289.4	Easement	Yes	Yes	622745
G-15	290.5	Easement	No	Yes	710754
G-18	295.4	Easement	Yes	Yes	249803
G-20A	297.6	Fee	No	Yes	209650
G-21	299.8	Fee	No	Yes	1653977
G-22	301.8	Easement	No	Yes	116938
G-24	303.6	Easement	No	Yes	244175
G-25A	304.8	Easement	Yes	Yes	694172
G-26	305.7	Easement	Yes	Yes	295961
AL-7	317.3	Easement	Yes	Yes	109131

Table 1.5-5.
TTW Dredge Material Disposal Areas Over 100,000 CY (continued)

Site	River Mile	Acquisition	Access/ Land	Access/ River	Est Material Placed To Date(CY)
AL-9	320.4	Easement	No	Yes	334863
AL-13	326.4	Easement	Yes	Yes	1274697
AL-14	328.2	Easement	Yes	Yes	271563
AL-16	333.6	Easement	Yes	Yes	130691
C-14	350	Easement	Yes	Yes	575875
C-18	352.1	Easement	No	Yes	140864
C-19	353.3	Easement	Yes	Yes	1049792
C-20B	355	Easement	Yes	Yes	148024
AB-6	362.3	Easement	No	Yes	270663
AB-9	364.3	Easement	Yes	Yes	116522
AB-12	365.9	Easement	Yes	Yes	3171722
AB-13	366.5	Easement	Yes	Yes	448743
PE-3	410.2	Easement	No	Yes	195636
PE-4	411.1	Easement	No	Yes	122290
TOTAL					18,905,200

Because of the shortage of additional disposal areas, the Corps of Engineers' Operations Division has contracted for several studies on the beneficial use of the sand. Some of these studies have been targeted at using the sand for beach nourishment, (Thompson Engineering, 2001). Using sand samples from some of the inland disposal areas along the Black Warrior – Tombigbee River, a series of analyses were conducted on the samples. For comparison purposes, several samples of actual beach sand and from the littoral drift zone from coastal Alabama were taken and subjected to the same tests. These tests included grain size distribution (gradation), color and roundness. The results of the tests indicated that some of the samples may be suitable for beach nourishment. The sand from the river was typically a finer grain size that the beach sand with the predominant river size being a fine sand while the beach sand was mostly medium sand. It was also noted that the beach sand was slightly more rounded than the river sand.

One factor that warranted further analysis was the color difference of the river sand as compared to the beach sand. All of the river sand had a brown tint described as "very pale brown" or "light yellow brown". This compared to the beach sand samples which were described as "pale olive, white or light grey". These colors were assigned along with evaluations for hue, value and chroma from a Munsell Soil Color chart which provides a standard method of assigning color to soils. The report also noted that beach sand came from a higher energy environment where any staining due the depositional environment may have been removed by abrasion due to wave action. It also noted that the sand might undergo bleaching from the ultraviolet radiation from the sun if the color was caused by a mineral staining. To test these conditions that may change the color of the sand, a series of tests were conducted on samples from the same areas that were used during the initial analyses, (Thompson, 2002). The samples were subjected to two tests. The first involved actual bleaching of the samples using a chemical oxidizer, hydrogen peroxide, for different periods of time. These tests did indicate that the bleaching process was detectable after 72 hours. Other tests were conducted to simulate the process of wave action causing an agitation of the particles which may remove any mineral coating or staining along with exposure to ultraviolet light. This process was conducted for 144 hours without a notable difference in color.

Other studies on the dredge disposal areas by the Bureau of Mines, U.S. Department of the Interior were conducted to characterize the sand for use as an aggregate in making concrete (Smith, 1995). While these tests were not directed at use of the sand for beach nourishment, they did supply information on chemical and physical characteristics of the materials from several locations. These tests provided data that shows the sand to be clean, mostly fine grained, quartz sand with little of no fines, to be non-toxic based on Toxic Characteristic Leachate Procedure (TCLP) and to contain very little heavy minerals. All of these tests would indicate the material would be safe to place on a beach.

Review of the documents referenced above indicated that the color issue was not resolved and this would be an important factor in the use of the sand on the barrier island beaches. The methods employed, beaching and agitation with exposure to ultraviolet light, were not considered to be effective in removal of what is suspected to be the basis of the color on the sand grains, amorphous iron oxide more commonly referred to as rust. Hydrogen peroxide is a common household bleaching agent that is effective in oxidation of organic matter, but would not effect iron oxide through chemical removal. The same is true for the effects of ultraviolet light on iron oxide. The idea of using agitation would be the most effective of the methods attempted if the color was a coating on the mineral grains, but the test, as conducted, was not conclusive.

With the renewed interest in the possibility of using the sand as a source of material for the littoral zone associated with the Mississippi barrier islands, the disposal areas warranted further study. Again the color of the sand is a concern that has been raised by the National Park Service who has control of the Mississippi Barrier Islands. This concern has both aesthetic and environmental aspects. Aesthetically, the beaches on the barrier islands are composed of relatively white sand. Numerous studies have indicated that the primary source of this sand is an Appalachian origin probably associated with river systems discharging onto the Continental Shelf of present-day Florida (Stone and Others, 2004). This sand is transported westward from the discharge of the river into the Gulf of Mexico. Transport of this sand along the prevailing littoral current has created the white beaches and barrier islands that extend from the mouth of the river in Florida westward across Alabama to Mississippi.

Looking at the color differences of the sand along this system reveals a definite change as shown in Figure 1.5-7. The sample on the left was taken from sand dredged from the Chattahoochee River which is a major tributary of the Apalachicola River. This sampling location is approximately 150 river miles above the Gulf. The middle sample was taken from Disposal Area 39 on the Apalachicola River approximately 37 river miles above the Gulf. The sample on the right was taken from the south beach of Petit Bois Island in Mississippi. Note the change progressive change in color from brown to tan to white.

Geochemical processes could account for the consistent staining of the sand grains while in the river system. As the sand entered the Gulf's littoral system, changes in the geochemical process would not allow additional staining of the sand and any removal of the coating would allow the underlying sand grain to display its true color. The mechanical process of abrasion would occur both in the river system and the littoral system, but if the iron oxide staining was continuously reoccurring in the river system, the resulting color would remain. As the sand grains entered a different geochemical environment where re-staining did not occur, it would account for the difference where the color was a coating. Review of selected sand samples taken from the Black Warrior–Tombigbee River system disposal areas the reveal the same general color that is characteristic of the Chattahoochee-Apalachicola River system. Figure 1.5-8 is a photograph of five samples that include the same samples used in Figure 1.5-7 plus two additional samples, one from the Black Warrior River and another from the Tombigbee River. Note the similarities in color of the Apalachicola River (fourth from left), the Black Warrior (third from left and marked BWT North Star), and the Lower Princess (second from left, Lower Tombigbee River).

Figure 1.5-6. Littoral zone (white beaches and islands) along Central Gulf Coast extending from Bay County, Florida (top of picture) to Mississippi Barrier Islands (lower left), looking east

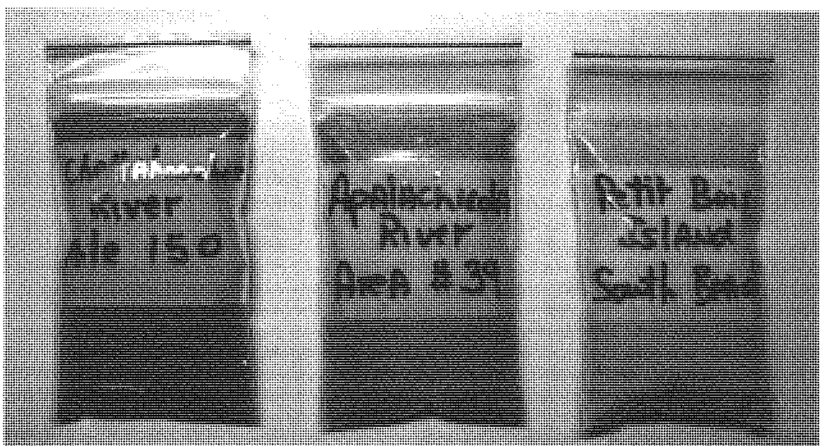


Figure 1.5-7. Samples of sand taken from (left to right) Chattahoochee River Mile 150, Disposal Area #39 on the Apalachicola River, and Petit Bois Island

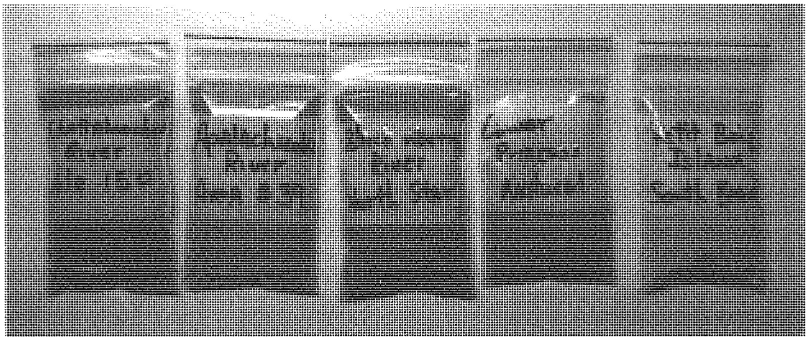


Figure 1.5-8. Samples of sand taken from (left to right) Chattahoochee River Mile 150, Disposal Area #39 on the Apalachicola River, North Star disposal area on the Black Warrior River, Lower Princess disposal area on the Tombigbee River, and Petit Bois Island in Mississippi

Assuming that the previous testing was not effective at removing the iron oxide staining on the sand grains, a different bench-top test was performed. If iron oxide is only a coating on the sand grains and occurs as a stain, abrasion would be effective in the removal. The addition of a week acid would also aid in keeping the iron oxide from re-coating the sand grains as it is being removed. For the experiment, I used a small "rock tumbler" of the type used to polish small stones. Into the chamber of the rock tumbler was added a small quantity of sand obtained from the Lower Princess disposal area on the Tombigbee River, enough water to just cover the sand and a tablespoon of "Zud". Zud is a household cleaning product that is composed of oxalic acid and abrasives. Oxalic acid is a weak acid commonly used to remove rust stains. Zud contains about 10% oxalic acid and 90% fine abrasives. The tumbling chamber was closed and placed the tumbler. An electric motor spins the chamber which allows the contents to tumble. This process would mimic the process of sand grains being transported along the littoral zone with the sand grains being abraded as they strike each other. In the almost infinite volume of water in the Gulf, any iron stain that was removed would not re-coat the sand, but be diluted away. This process started on 4 October 2007 and concluded 10 October 2007. The tumbler did not run over the included long weekend, but did operate for about 4 days. At the completion of the tumbling process, rinse water was added and decanted several times until the turbidity levels dropped and the fines were removed. The remaining sand was air dried and placed in a clear plastic bag for comparison with sand from the same parent sample. As shown in Figure 1.5-9, the results of the experiment are quite dramatic. The tumbled sand lost most of the tan color and is approaching white. This supports the process that occurs with the tan sand from the Apalachicola River system becoming the white sand so familiar to beach-goers along the central Gulf Coast.

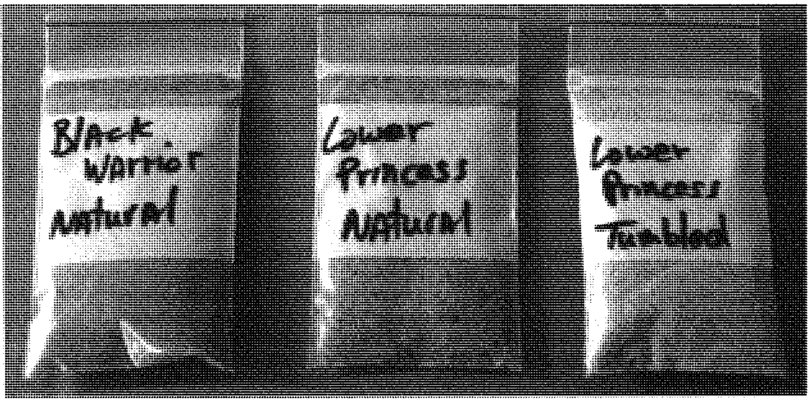
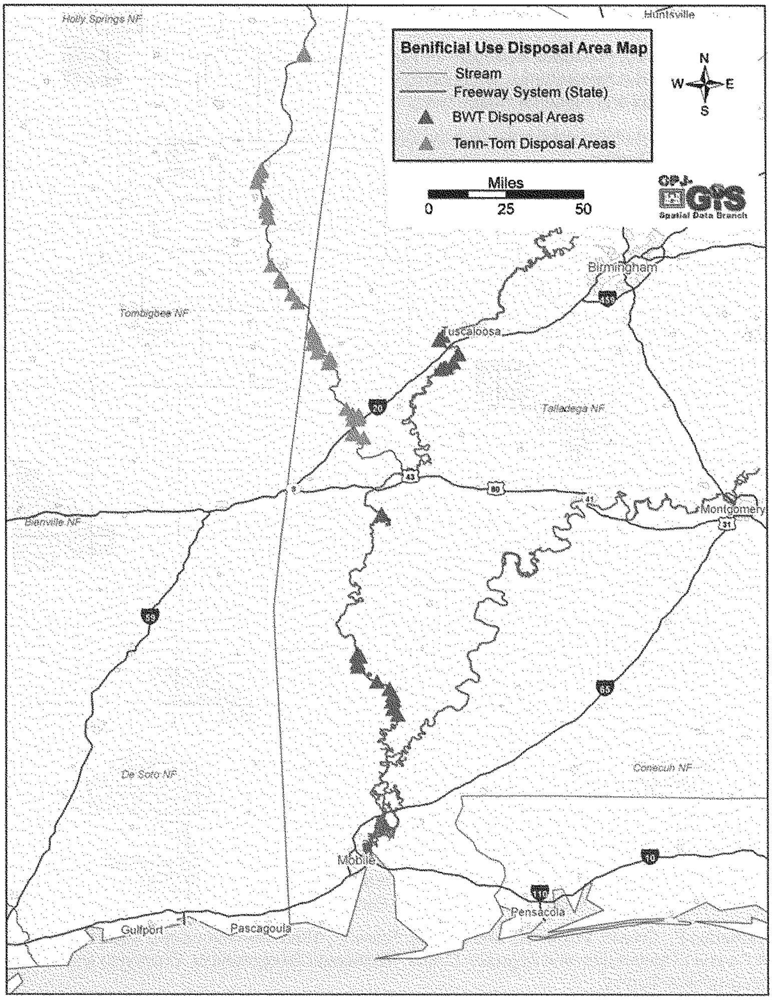


Figure 1.5-9. Samples of sand taken from (left to right) North Star disposal area on the Black Warrior River, Lower Princess disposal area, and "Tumbled Lower Princess disposal area"

Adding the sand into the littoral system along the gulf coast should provide the proper geochemical and mechanical processes to remove the iron staining and provide the quality of sand that is desired as it is transported along the littoral drift zone which contain the Mississippi Barrier Islands. Littoral zone placement will also allow additional sorting by the currents and rounding of the sand grains through continued abrasion during transport. Additional research and testing will be conducted to ensure that these processes will in fact provide sand that is compatible with the existing sand in the barrier island system.



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2 **Figure 1.5-10. Inland Disposal Areas that Contain Economic Deposits of Sand**

1.5.8 References

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1.6 Sea Level Rise

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, with 60 percent of the world's population, and 53 percent of the US population, living near the shoreline (Reference 1), 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.

Sea level rise may be viewed in different ways. 'Eustatic' sea level rise refers to estimates of the rate of sea level rise applied uniformly over the earth's oceanic water bodies. This is an interesting concept and useful for communicating an averaged rate, but because sea level rise is not uniform over the globe, it is not perhaps the most useful concept from a local or regional engineering point of view. Eustatic sea level concepts are usually associated with studies of pre-historic sea level and predictions of future sea level behavior but have been used in the Gulf Coast region in forensic studies of modern coastal subsidence rates (Ref. 2).

'Relative' sea level rise (RSL) at a given location is the change in mean sea level at that location with respect to an observer standing on or near the shoreline. It is determined by fitting a linear relationship to monthly mean or annual mean sea level, either of which is computed from tide gage observations. The slope of the fitted line gives the rate of sea level rise at the location of the tide gage. The computed rate includes the rate of subsidence or uplift of the location upon which the tide gage is founded, and thus the computed RSL rates may be extended locally or regionally to areas with similar geotechnical and tidal conditions.

The National Research Council (NRC) alternatively defines relative sea level change as "the difference between eustatic (global) sea level change and any change in local land elevation" (Ref. 3). This definition is in keeping with the previous interpretation in that local vertical land motion is represented in the change estimate, however, it seems to equate eustatic sea level change to the local absolute sea level component of that change, whereas the previous interpretation makes no such assumption. In practice, the distinction is often ignored because, excepting at the poles where sea level rise would be expected to be higher than an average eustatic value, there are no consistent relationships between eustatic sea level rise and sea level rise at any particular location.

Corps of Engineers Planning Guidance Notebook (Ref. 4) states that potential relative sea level rise should be taken into consideration for coastal or estuarine projects at the feasibility level of study and recommends, given the uncertainty of future sea level rise estimates, preference be given to developing strategies that are robust over the entire range of potential sea level rise rates versus those that perform well only over a limited range of potential sea level rise rates. The guidance states that, at a minimum, project performance would be evaluated based on extrapolation of the observed historic rate and should also consider a higher rate than that historically observed. The guidance specifies, in the absence of more current, definitive information, that Curve 3 of the 1987 NRC study (Ref. 2), a curve presented as a high forecast rate of rise, be used as the eustatic component in estimating the locally 'higher than observed' rate.

It is necessary then to determine (a) the observed historic relative rate of sea level rise along the Mississippi Gulf Coast, (b) the observed and/or forecast rates of subsidence there, and (c) the Curve 3 rate and, if available, other updated, definitive estimate of eustatic sea level rise that may be extended to the Mississippi coast. The following sections describe these determinations.

MsCIP studies are interpreting the guidance as requiring estimates of the magnitude of sea level rise for the expected project life beginning at the base year. Early on in the study, this time period was set at 2005-2100, but has since been revised to 2012 through 2011 (100 years). A number of engineering activities had been well underway or substantially completed by the time the project lifetime window had been revised and as such the relative sea level rise values used for those activities were not revised to the period 2012 to 2100. It will be shown that the difference in selected sea level rise predictions accorded these time windows is small and would not be expected to materially change one's impression of project performance in and of itself.

1.6.1 Mississippi Coast Relative Sea Level Rise

Apparently, no long-term Mississippi coast tide gage records had been used to quantify relative sea level rise since 1947. Mississippi is the only Gulf Coast state for which this is true.

The National Oceanic and Atmospheric Administration (NOAA) is responsible for monitoring, forecasting, and publishing U.S. tide data. In 2001, NOAA published RSL estimates for all of its National Water Level Observation Network (NWLON) tide gage stations with records equaling or exceeding 25 years (Ref 5). Twenty-five years is considered the minimum record from which reasonably reliable sea level rise rates might be determined. There were no NWLON stations in Mississippi meeting this criterion and no RSL estimates were published.

The Permanent Service for Mean Sea Level (PSMSL) was established in 1933 at the Proudman Oceanographic Laboratory, Liverpool, England and collects and interprets sea level data from approximately 2,000 tide stations world-wide. The PSMSL regularly updates RSL estimates for most locations they monitor; one of these is the NOAA station at Bay Waveland Yacht Club (USGS station no. 8747437), though the period of record at that station is considered too short to provide a reliable estimate of RSL.

Mobile District has long-term tide gages at Gulfport (USACE station no. 02481341), Biloxi (02480351), and Pascagoula (02480301). A 1947 report of the Mobile District Engineer submitted to Congress for the Harrison County Beach Erosion Control Study reported, based on 49 years of record at the Biloxi gage, that annual mean stage was "rising gradually and is now approximately 0.3 of a foot higher than at the turn of the century."[2] RSL was computed for these and other stations for present purposes by using the method of least squares to fit a linear relationship to the monthly mean tide level (MTL). Monthly MTL is the average of the daily high and low water observations. The resultant rate was multiplied by 12 to arrive at the average annual RSL rate. Annual MTL values (the average of a calendar year's monthly MTL values) were also fit for comparison to RSL rates computed using monthly data. This method is similar to that employed by NOAA and the PSMSL, though there are differences. Monthly data were not weighted by the number of days in each month in computing the annual MTL. Records for years missing more than 3 months of data were discarded to minimize seasonal bias. The differences are not of significance here.

Computed RSL rates and the standard error of rates, in millimeters per year, spanning coastal Mississippi are presented in Table 1.6-1. Computed RSL rates from the Permanent Service for Mean Sea Level (PSMSL) web site, from NOAA's report (Ref. 5), and from Mobile District, USACE are shown for comparison. Large discrepancies in the rates are mostly attributable to the period of record analyzed; in general, rates computed from longer records are considered superior. Smaller discrepancies are due to differences in methods used to compute the rates.

Neither NOAA nor PSMSL had estimated rates for the Mississippi tide gages at Gulfport, Biloxi, nor Pascagoula. This is probably because these gages have historically been owned and operated by the Corps of Engineers, though the Corps turned the Biloxi gage over to NOAA (USACE continues to collect data from that gage) in September of 1999.

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[2] As reported in U.S. House of Representatives Document No. 682, 80th Congress, 2nd Session, 1948. 'Annual Mean Stage' is therein defined as the average of all hourly tidal readings in a calendar year (8,760 readings might be obtained in one year) and is analogous to 'annual mean sea level.'

The Gulfport and Biloxi gages are in Harrison County. The Pascagoula gage is in Jackson County. Long-term gage data is not available for any locations in Hancock County, but data from short-record gages at Waveland Yacht Club (Y.C.) and Waveland were analyzed and are presented in Table 1.6-1 but application of those results is not recommended due to the short periods of record at these sites.

Table 1.6-1.
Relative Sea Level Rise Rates in the Vicinity of Coastal Mississippi

			USACE based on			
			Monthly Average Data		Annual Average Data	
			MTL	MSL	MTL	MSL
	PSMSL (2006)	NOAA (2001)	mm/yr. + - std. error			
Grand Isle, LA	9.52 +/- 0.37	9.85 +/- 0.35				
Record	1974-2003 (52 yrs)	1947-1999				
Bay Waveland Y.C., MS	16.31 +/- 7.83	NA	5 40 +/- 0 17	5.21 +/- 0.16	4.65 +/- 2.04	4.44 +/- 2.06
Record	1987-1992 (5 yrs)		1979-1992		1979-1992	
Waveland, MS	N/A	8.05 +/- 9.28*	9.33 +/- 0.42	10.58 +/- 0.41		
		1997-? 6 yrs.	1997-2005			
Gulfport, MS	N/A	N/A	1.70 +/- 0.04	N/A	1 96 +/- 0.7	N/A
Record			1964-1999		1964-2002	
Biloxi, MS	N/A	N/A	4.73 +/- 0.04	N/A	2.26 +/- 0.26	N/A
Record			1960-'98		1928-'76, '79-98	
Pascagoula, MS	N/A	N/A	2.9 +/- 0.04	N/A	3 72 +/- 0.30	N/A
Record			1960-'97		1940-'97	
Dauphin Island, AL	3.31 +/- 0.62	2.93 +/- 0.59	3.07 +/- 0.04	3.08 +/- 0.04	2.96 +/- 0.52	3.01 +/- 0.55
Record	1967-2003	1966-'97	1967-'68, '72-'74, '76-'80, '82-'97, '02-04		1967-'68, '72-'74, '76-'80, '82-'97, '02-04	
Pensacola, FL	2.12 +/- 0.17	2.14 +/- 0 15				
Record	1924-2003 (78 yrs.)	1923-'99				

*NOAA (2004) TR NOS/NGS 50.

Table 1.6-2 shows what were adopted, based on length of record, as the RSL rates for the vicinity of USACE gages in Mississippi. The computed rate for Biloxi, taken in conjunction with the 0.3 feet observed rise from 1900-1947 (1.94 mm/yr), suggests a 20th century relative sea level rise there of between 7.8 to 9.3 inches. These values may be compared to those computed by NOAA (Ref. 5) for all Gulf of Mexico tide stations with records exceeding 25 years in length shown in Table 1.6-3. The RSL rates computed for the Mississippi stations are lower than the average of all Gulf station values and consistent with those for coastal Florida and the southwestern Texas coast.

Table 1.6-2.
Relative Sea Level Rise as Indicated by USACE MS Coast Gages

Location	Rise in mm/yr	Std. Error of Rise
Gulfport, MS	1.70	0.04
Record	1964-1999	
Biloxi, MS	2.26	0.26
Record	1928-'76, '79-98	
Pascagoula, MS	3.72	0.30
Record	1940-'97	

Table 1.6-3.
Relative Sea Level Rise Rates at Various Gulf Coast Gages

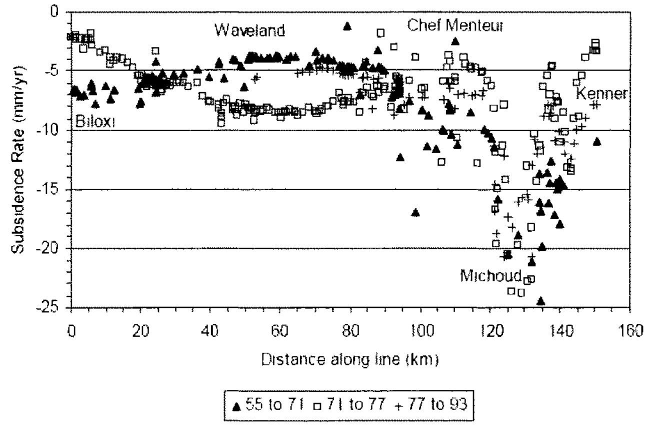
Station Name	First Year	Record Length	MSL Trend (mm/yr)	Std. Error (mm/yr)
Key West	1913	87	2.27	0.09
Naples	1965	35	2.08	0.43
Fort Meyers	1965	35	2.29	0.45
St. Petersburg	1947	53	2.4	0.18
Clearwater Beach	1973	27	2.76	0.65
Cedar Key	1914	86	1.87	0.11
Apalachicola	1967	33	1.53	0.58
Panama City	1973	27	0.3	0.64
Pensacola	1923	77	2.14	0.15
Dauphin Island, AL	1966	32	2.93	0.59
Grand Isle, LA	1947	53	9.85	0.35
Eugene Island, LA	1939	36	9.74	0.63
Sabine Pass, LA	1958	42	6.54	0.72
Galveston Pier 21, TX	1908	92	6.5	0.16
Galveston Pleasure Pier, TX	1957	43	7.39	0.53
Freeport, TX	1954	46	5.87	0.74
Rockport, TX	1948	52	4.6	0.41
Port Mansfield, TX	1963	35	2.05	0.75
Padre Island, TX	1958	37	3.44	0.56
Port Isabel, TX	1944	56	3.38	0.27
Average		49.2	4.00	
Weighted Average			4.06	
Median		42.5	2.85	

From Ref 5

1.6.1.1 Mississippi Coast Subsidence

NOAA's National Geodetic Survey published (Ref. 2) estimated relative vertical displacement rates for areas including the Mississippi Gulf Coast in 2004. The rates were estimated by adjusting historic first-order leveling runs according to the estimated historic elevation of a Louisiana tide gage benchmarks in Louisiana. The elevation of said benchmark at the time of the historic leveling surveys was estimated by assuming it was subjected to an averaged eustatic sea level rise of 1.25 mm/year. This value is comparable to the 1.20 mm/year given in NRC's document for 20^{th} century eustatic sea level rise. The leveling data were then adjusted to estimate their true elevations at the time of the surveys; the elevation of a given point in one year was then compared to the elevation of the same point during a following survey many years later, which gave an estimate of the rate of subsidence. Results for surveys generally following the east-west alignment of the CSX railway line across Mississippi are shown in Figure 1.

Figure 1.6-1 gives estimated subsidence rates for the periods 1955 to 1971, 1971 to 1977, and 1977 to 1993. The figure suggests that Mississippi coast subsidence varies from about -2 mm/year to -9 mm/year and that the average subsidence is on the order of -6 mm/year (negative values imply that the ground is subsiding). It is interesting that series of the Mississippi portion of the comparison appear to be reflections of each other, though the reason for this is not apparent. The average subsidence rate, approximately 6 mm/year, of the railway line near the coast exceeds the RSL rates (1.7 to 3.7 mm/yr) determined from tide gage data.



From Ref. 2 Appendix 4

Figure 1.6-1. Biloxi, MS to New Orleans, LA Subsidence Rates for Periods Indicated in Years

If equal confidence is given to both the RSL rate and the subsidence data, one must conclude that eustatic sea level in the Gulf of Mexico is not rising, but falling; this is doubtful. Therefore, it appears that either the gage data is erroneous, the subsidence estimates are flawed, or both. While it is most likely that neither the subsidence estimates nor the RSL estimates are infallible, the RSL rates are generally consistent with those observed elsewhere along the Gulf Coast, excepting those areas in Louisiana which are known to subside at abnormally large rates. This suggests that, while subsidence is probably occurring in Mississippi, tide gage data suggest that it may be occurring over much of the Mississippi coast at a rate that is consistent with Gulf Coast locations not associated with Mississippi River Delta formations. Also, since the question as to why subsidence estimates, taken in conjunction with tide gage data, suggest that sea level is dropping, as opposed to rising, remains unresolved, there is at present no clear rationale nor means to employ these subsidence estimates for purposes of estimating future RSL.

1.6.2 Projected Sea Level Rise

Table 1.6-4 shows extrapolated RSL for the period 2005-2100 based only on the rates derived from historic USACE station records (Table 1.6-2). The total relative rise predicted for the 95 year period is consistent with that suggested by Biloxi gage records over the 20th century.

Table 1.6-4.
Relative Sea Level Rise Assuming Observed Rates Persist, 2005-2100

Gulfport		Pascagoula		Biloxi	
meters	**feet**	**meters**	**feet**	**meters**	**feet**
0.16	0.53	0.35	1.16	0.21	0.70

1.6.2.1 National Research Council (NRC) Methods

Corps of Engineers guidance recommends Curve 3 of the NRC report (Ref. 3), or more definitive information, be used as the eustatic component of RSL for future high scenario estimates.

The NRC produced three curves, Curves 1, 2, and 3, which might be thought of as low, medium, and high rate of rise estimates due to climate change and are reproduced here as Figure 1.6-2. These curves were developed based on studies published between 1983 and 1986 and assume in global eustatic sea level of 0.5 meters, 1 meter, and 1.5 meters, respectively between 1986 and 2100. The curves are a function of time squared and thus suggest that the rate of sea level rise will increase into the future, though as of 2001, no such increase had been detected (Ref. f). The suggestion that sea level rise rates will increase in the future is common to all reports reviewed. These curves yield high, medium, and low eustatic sea level increases of 0.47 m., 0.95 m., and 1.44 m. (1.54 ft., 3.13 ft., 4.72 feet) respectively for the period 2005 to 2100. Relative sea level rise for a given location at the

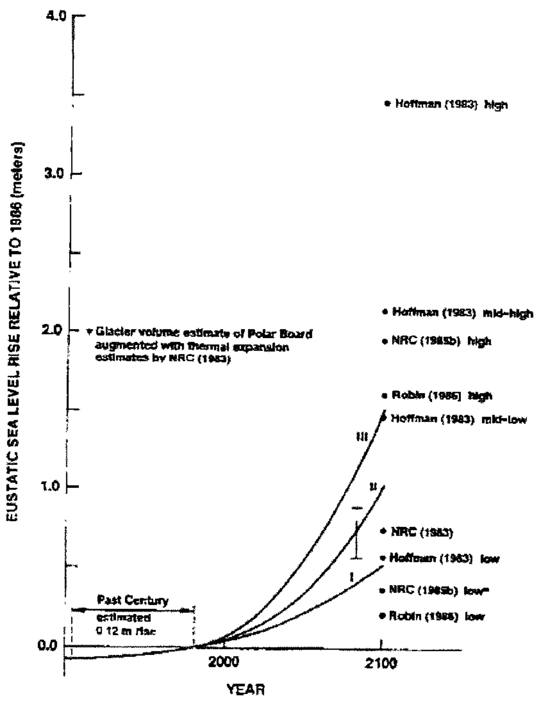


Figure 1.6-2. Eustatic Sea Level Rise Scenarios (Figure 2-2 from NRC, 1987)

year 2100 would be arrived at by adding these values to the locally predicted subsidence, where the local subsidence would be the observed (or estimated rate where observations were not available) subsidence rate multiplied by the time span (in this case, 2100-2005 = 95 years). The document implies that local subsidence rates might be estimated by subtracting 1.2 mm/year (the assumed rate of global eustatic sea level rise) from RSL rates computed from tide gage data.

Relative sea level rise estimates for the period 2005 to 2100 at the locations of coastal Mississippi USACE tide stations using NRC methods are shown in Table 1.6-5. The values in the table have been computed converting the gage RSL rates to subsidence rates by subtracting 1.2 mm/year as suggested by the NRC. The total rise given in this table for Curve 3 is five to eight times those predicted by extrapolation of rates computed from historic gage data (Table 1.6-4).

Table 1.6-5.
Relative Sea Level Rise Estimates by NRC (1987) Methods, 2005-2100

	Gulfport		Pascagoula		Biloxi	
Basis	**meters**	**feet**	**meters**	**feet**	**meters**	**feet**
Curve 1	0.51	1.69	0.71	2.32	0.57	1.86
Curve 2	1.00	3.28	1.19	3.91	1.05	3.46
Curve 3	1.49	4.88	1.68	5.51	1.54	5.05

1.6.2.2 Environmental Protection Agency (EPA) Methods

The EPA (Ref. 6) estimated future eustatic sea level rise and also attempted to identify the probability distribution of this rise occurring. The EPA report is the only report reviewed which has attempted to assign probabilities to the sea level rise phenomenon. The one percent, mean, and 99 percent non-exceedance eustatic sea level rise estimates for the time interval 1990 to 2100 are -0.01 m. (-0.03 ft.), 0.34 m. (1.11 ft.), and 1.04 m. (3.41 ft.). Estimates are also provided by EPA for the years 2050 and 2200. As with the other eustatic sea level rise forecasts discussed in this document, the estimates account for only those changes in sea level which might be attributed to climate change.

The EPA report recommends a simple procedure for estimating regional sea level rise based on their eustatic sea level rise estimates. The procedure is to add a normalized projection to the current (observed) relative rate of sea level rise as given by the following equation:

Local (t) = normalized (t) + (t -1990) x trend Eqn. 1.6-1

Where: Local (t) is the projected local rise in sea level in some future year t.

Normalized (t) is the normalized eustatic rise given by Ref. 6 Table 9-1.

Trend is the observed trend at a representative gage location.

The 'normalized' eustatic rise value was developed by EPA in order to avoid double-counting the effects of the historic contribution of climate change, which are inherent in the observed trend value; double-counting would occur were future projections made using the predicted (as opposed to the normalized) eustatic sea level rise values in this equation. This concern over double counting does not come into effect if the predicted eustatic sea level rise contribution were to be combined with a known local subsidence rate.

EPA methods were used to develop sea level rise estimates for the period 2005 to 2100 for the vicinities of the USACE tide gages at Biloxi, Gulfport, and Pascagoula. The 50% and 99% non-exceedance eustatic normalized sea-level rise predictions were used in conjunction with the historically observed rates for this purpose. Results are shown in Table 1.6-6. These values compare favorably to values give by NRC Curves 1 and 2 but are, as a rule, much lower than those given by Curve 3 (see Table 1.6-5). The 50% values are approximately 0.7 to 0.8 feet higher than those predicted by historical rates alone (see Table 1.6-4).

Table 1.6-6.
Relative Sea Level Rise Estimates by EPA (1995) Methods, 2005-2100

Location	m	feet
Gulfport 50%	0.39	1.3
99%	0.99	3.2
Biloxi 50%	0.44	1.4
99%	0.98	3.2
Pascagoula 50%	0.60	2.0
99%	1.18	3.9

1.6.2.3 Intergovernmental Panel for Climate Change (IPCC) Methods

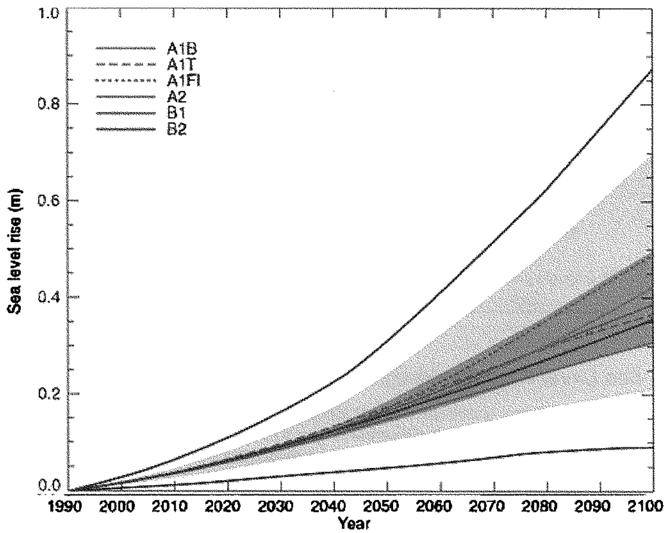
The Climate Change 2001 document (Ref. 7) by the IPCC is the most current and comprehensive publication available for this effort regarding the science of climate change and its implications for sea level rise. An updated IPCC climate change report is due in May of 2007 but due to the MsCIP schedule it arrives too late to be of use for estimating future sea level rise, though a summary of the findings of that report, released in early 2007, suggest that the global eustatic sea level rise central value estimate has not changed significantly.

The full suite of IPCC sea level rise projections is shown in Figure 1.6-3. The projections result from over 35 climate change scenarios, run in a number of different global circulation models. The projections represent the contribution of climate change to global average sea level rise. The IPCC predicts eustatic sea level rise of 0.09 to 0.88 m between 1990 and 2100 with a central value of 0.48 meters. The central value averaged over this time period is 4.36 mm/year, which is two to four times the average rate suggested by 20th century Mississippi Coast tide gage data.

In Figure 1.6-3:

- The black outer lines describe the range of all model estimates, including sensitivity to land ice withdrawal, sedimentation, and other assumptions.
- The lightly-shaded region shows the range from 35 scenarios tested in all circulation models.
- The darkly-shaded region shows the range of the average of those scenarios.
- The colored lines represent the computed average from each demonstration model, which are a subset of the 35 scenarios.

The values shown in Figure 1.6-3 are lower than those suggested in the earlier NRC study, and similar to those in the EPA publication. Since publication of the NRC document, estimates of the magnitude of future global warming have been cut in half, and this resulted in a reduction of the range of estimates of future sea level rise. The IPCC document suggests this reduction is primarily due to improvements in technology, improvements in the understanding of pollutant behavior (particularly aerosols), and revised pollutant discharge forecasts.



From Ref. 7 Figure 11.12.

Figure 1.6-3. IPCC Global Eustatic Sea Level Rise Estimates

The IPCC does not prescribe how these global eustatic sea level rise estimates might be adapted to estimate future local relative sea level rise. Like the EPA before it, the IPCC acknowledges double-counting as a valid issue, but does not provide normalized sea level rise estimates for use with their eustatic sea level rise estimates, nor do they provide explicit instructions for adapting their predicted sea level rise values to specific locations. The IPCC report does, however, suggest that the approach advocated in EPA's report might be used.

Comparison of EPA's normalized and non-normalized eustatic sea level rise estimates (Tables 9-1 and 7-4, respectively, Ref. 6) reveal that EPA estimates the 20th century climatological contribution to sea level rise at 0.82 mm/year. This contribution is essentially constant throughout the range of EPA's probable sea level rise estimates. This value is reasonably consistent with IPCC's central value (c.v.) estimate of said contribution at 0.7 mm/year (Table 11.10, Ref. 7). Since EPA has applied a constant normalizing rate adjustment, it may be argued that the IPCC's estimate of 0.7 mm/year might be used in the same manner to normalize IPCC's estimate and facilitate use with RSL rates obtained from gage data.

Therefore, future estimates of local sea level rise over the interval 2005 to 2100 might be obtained using IPCC values as follows:

Local rise = [(IPCC 2100 – IPCC 2005) – n*(2100-2005)] + (2100-2005) * trend   Eqn. 1.6-2

Where: IPCC is the projected eustatic rise in sea level for the given year, from Figure 3 herein.

Trend is the observed trend at a representative gage location.

n is the normalizing factor = 0.7 mm/yr.

The normalization function is shown in brackets on the right-hand side of Equation 1.6-2.

Results of this method applied to the vicinity of the USACE gages are shown in Table 1.6-7.

Table 1.6-7.
Relative Sea Level Rise Estimates using IPCC Predictions, 2005-2100

Location	m	feet
Gulfport c.v.	0.54	1.8
high	0.96	3.2
Biloxi c.v.	0.60	2.0
high	1.02	3.3
Pascagoula c.v.	0.74	2.4
high	1.16	3.8

1.6.3 Relative Sea Level Rise Summary

Corps of Engineers Planning Guidance Notebook (Ref. 4) states that potential relative sea level rise should be taken into consideration for coastal or estuarine projects at the feasibility level of study and recommends. At a minimum, project performance would be evaluated based on extrapolation of the observed historic rate and should also consider a higher rate, based on NRC Curve 3 or more definitive data, than that historically observed.

'High,' 'medium,' and 'low' eustatic sea level rise estimates as given in the NRC in 1987 and more recent authoritative reports by the EPA (1995) and IPCC (2001) reports are summarized below in Table 1.6-8. The values in the table are eustatic values only and do not reflect local nor historic trends at the Mississippi Coast. While the three methodologies differ slightly, they commonly adjust, according to each agency's prediction of climate change effects, extrapolated historic local relative sea level rise. In other words, the only difference in the predicted RSL for each scenario at each location is that portion of rise attributed to possible effects of climate change. The table shows that the climate-driven component of sea level rise estimates has dropped substantially since publication of the NRC report, primarily due to advances in global fluid dynamics modeling technology and revised pollutant discharge estimates.

Table 1.6-8.
Comparison of Eustatic Sea Level Rise Predictions, 1990-2100

	Low, in m. (ft)	Medium, in m. (ft)	High, in m. (ft)
NRC[1] (1987)	0.47 (1.53)	0.95 (3.13)	1.44 (4.72)
EPA[2] (1995)	-0.01 (-0.03)	0.34 (1.11)	1.04 (3.41)
IPCC[3] (2001)	0.09 (0.29)	0.48 (1.57)	0.88 (2.89)

Notes: 1. NRC (1987) curves 1, 2, and 3 respectively. 1%, 50%, and 99% non-exceedance probabilities, respectively. From Ref. 6 Table 7-3. 2. Low and high values represent the extreme range with uncertainty and the medium value is the 'central estimate.'

The observed historic relative rates of relative sea level rise along the Mississippi Gulf Coast were determined from long-term USACE tide gage data and are summarized in Table 1.6-2. The rates are typical of RSL rates determined from other long-term Gulf of Mexico tide and lower than rates observed in Louisiana and eastern Texas.

Extrapolation of historically observed Mississippi coast RSL rates results in a relative sea level rise of 0.5 to 1.2 feet for the period 2005 to 2100. Extrapolation of observed rates is inconsistent with the climate change community view, held since at least the early 1980's, that sea level rise will accelerate in the 21^{st} century. The USACE Mississippi coast gage data have not been interrogated to detect RSL rise acceleration for present purposes.

Subsidence rates and magnitudes have been estimated for the MS Coast but the estimated rates, weighed in consideration of RSL rates derived from tide gage data, do not seem to support the generally accepted view that sea level is rising. The reason this is so cannot at present be resolved and therefore the subsidence estimates were not used in favor of RSL rates determined from tide gage records to estimate future sea level rise.

Future relative sea level rise estimates were developed using NRC, EPA, and IPCC projections. The IPCC estimates are the most current available. The findings are summarized in Table 1.6-9 and rounded to the nearest 0.1 feet.

IPCC's 'high' values compare to within 0.1 feet of those computed using EPA's 99% non-exceedance values, while IPCC's central value (c.v.) estimates are slightly higher than those yielded using EPA's 50% (mean) normative sea level rise values. The 'high' and c.v. are similar to values yielded using NRC's Curve 1 ('low') and Curve 2 ('expected'; see Table 1.6-5).

The IPCC 2001 predictions were the most current and definitive available. The IPCC 'high' values were selected for evaluating project performance as the 'higher than observed rate' versus those predicted using EPA and NRC methods because the IPCC values are more recent and more widely (globally) used. In a subtle departure from USACE guidance, relative sea level rise values based on IPCC 'expected' (also referred to as 'medium' and 'central value') eustatic sea level rise predictions were adopted for present study purposes in lieu of rise computed using extrapolated historic rates because most experts believe that the rate of sea level rise will increase in this century and extrapolated historic rise assumes past relative sea level rise rates will persist.

Table 1.6-9.
Comparison of Computed Relative Sea Level Rise Estimates, 2005-2100

	Gulfport		Pascagoula		Biloxi	
Basis	**High[1] m. (ft)**	**Expected[2] m. (ft.)**	**High[1] m. (ft)**	**Expected[2] m. (ft.)**	**High[1] m. (ft)**	**Expected[2] m. (ft.)**
Extrapolated	-	0.16 (0.5)	-	0.35 (1.2)	-	0.21 (0.7)
NRC (1987)	1.49 (4.9)	1.00 (3.3)	1.68 (5.51)	1.19 (3.9)	1.51 (5.0)	1.05 (3.5)
EPA (1995)	0.99 (3.2)	0.39 (1.3)	1.18 (3.9)	0.60 (2.0)	0.98 (3.2)	0.44 (1.4)
IPCC (2001)	**0.96 (3.2)**	**0.54 (1.8)**	**1.16 (3.8)**	**0.74 (2.4)**	**1.02 (3.3)**	**0.60 (2.0)**

Values in **bold** are adopted.

Notes: 1. NRC Curve 3; EPA 99% non-exceedence; IPCC upper-bound. 2. NRC Curve 2; EPA 50% non-exceedeence; IPCC 'central value'.

It was mentioned earlier that the project lifetime evaluation period had been revised from 2005 – 2100 to the 100-year period 2012 through 2111 after the time had passed for which RSL revisions might have been able to have been incorporated into related engineering efforts. RSL estimates were generated for the revised time frame using the IPCC predictions and compared to the adopted results from the 2005-2100 time frame as in Table 1.6-10. The project lifetime shift results in about 0.2 feet (2.4 inches) difference which is believed to be insignificant for present purposes.

Table 1.6-10.
Comparison of Adopted RSL 2005-2100 Versus Computed 2012-2111 RSL

	Gulfport		Pascagoula		Biloxi	
Time Frame	High[1] m. (ft)	Expected[2] m. (ft.)	High[1] m. (ft)	Expected[2] m. (ft.)	High[1] m. (ft)	Expected[2] m. (ft.)
2005-2100	**0.96 (3.2)**	**0.54 (1.8)**	**1.16 (3.8)**	**0.74 (2.4)**	**1.02 (3.3)**	**0.60 (2.0)**
2012-2112	1.01 (3.3)	0.60 (2.0)	1.21 (4.0)	0.81 (2.6)	1.05 (3.5)	.66 (2.2)
	Values in **bold** are adopted.					

Notes: 1. IPCC upper-bound. 2. IPCC 'central value'.

1.6.4 Relative Sea Level Rise Application

Plan formulation has identified three RSL scenarios to be evaluated over the project lifetime: (1) existing sea level; (2) 'expected' sea level rise, and (3) 'high' sea level rise. Existing sea level was selected primarily for exploratory comparative economic analysis of damage attributable to sea level rise in and of itself, which can be inferred by comparing storm damages due to storm surge at existing sea level against storm damage due to storm surge at some higher sea level. Note that there is no accompanying expectation or recommendation that any storm damage reduction system or element would be formulated or proposed based on a future sea level as it exists today. Expected relative sea level rise is interpreted to be that prediction based on IPCC's 'central value' eustatic sea level rise, and 'high' sea level rise was adopted based on the upper bound of IPCC's scenario testing results. Results are consistent with the level of detail appropriate for present needs but should be viewed as a 'first cut' at identifying historic and predicted relative sea level rise in the vicinity of coastal Mississippi.

The effects of sea level rise are many. From a practical standpoint, it is impossible to thoroughly explore all ramifications of sea level rise. Sea level rise implications will be tested in economic terms using the Hydrologic Engineering Center's Flood Damage Analysis (HEC-FDA) software, and the Engineer Research and Development Center's BeachFX program; these efforts are discussed in Chapter 2 of this Engineering Appendix, and related plan formulation considerations are discussed in the main body of this report. Flood damage evaluations will also be performed in HEC-FDA over a 50-yr planning period to test the sensitivity of economic damages to the assumed project lifetime; computed relative sea level rise values using IPCC (2001) eustatic sea level rise predictions for this purpose are shown in Table 1.6-11. Coastal levee construction cost and levee protection implications are also discussed in Chapter 3 of this report.

Table 1.6-11.
Computed 50-year Relative Sea Level Rise Estimates, 2005-2055

	Gulfport		Pascagoula		Biloxi	
	High m. (ft)	Expected m. (ft.)	High m. (ft)	Expected m. (ft.)	High m. (ft)	Expected m. (ft.)
Extrapolated	-	0.09 (0.3)	-	0.19 (0.6)	-	0.11 (0.4)
IPCC (2001)	0.40 (1.3)[1]	0.26 (0.9)[2]	0.60 (2.0)[1]	0.46 (1.5)[2]	0.46 (1.5)[1]	0.32 (1.0)[2]

Notes: 1. IPCC upper-bound. 2. IPCC 'central value'.

Future design and evaluation efforts will require that these relative sea level rise predictions be updated, as (a) the IPCC published updated climate change effects documents in May of 2007 and (b) there are opportunities to improve local relative sea level rise estimation and prediction methods versus the status quo methodologies presented herein.

1.6.5 References

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PART 2. LONG-TERM ENGINEERING SOLUTIONS

2.1 Long-term Engineering Solutions

With the task of developing a hurricane damage reduction plan for the coast of Mississippi, several issues had to be considered. First, it had to be technically feasible. Could a storm damage reduction system be designed that would be constructible and at the same time not destroy what it was supposed to help protect? It had to be reliable so when needed, it would do the job it was designed for. It also needed to be cost effective. This system also had to integrate into other storm reduction concepts such as non-structural solutions such as buy-out programs and re-establishing some areas as environmental components of the plan. The development along the coast had some areas that were not contiguous to highly developed areas like found in Harrison County where the entire coastline is densely developed. These outlying areas may require individual means for any storm damage reduction. Almost any project along a coastline has environmental concerns and this is true in Mississippi. In Jackson County, the Pascagoula River system separates the city of Pascagoula from most of the coast to the west. This river system in one of the last major free-flowing rivers in the southeast and is home to endangered fish. In the western portion of the state, extensive marshes create other concerns along with the Pearl River that separates Mississippi from Louisiana. Other technical issues also made working in this river problematic. Another issue that was voiced early in this project was the population did not want a high structural seawall along the coast. The concern of losing the view of the water and beaches was repeated consistently in public meetings.

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 realized as having a role in formulating a storm defense system. An existing railway track crosses the entire state near the coast and in the typical fashion of railways, these tracks follow high ground. This same general alignment was judged to be favorable for any type of inland barrier.

Review of the inundation maps from Katrina also revealed the extensive low-lying areas associated with two bays that extend inland from the coast. It was apparent that any storm protection systems would have to consider these as breaks in the line. Closing off rivers and bays with surge gates are used in Europe to protect inland areas and these type structures could be considered for Mississippi.

During planning sessions with the project delivery team, a structural "Lines of Defense" (LOD) concept was drafted that started with the offshore barrier islands and progressed inland to what could be considered the worst possible scenario with a extremely large hurricane, even worse than Katrina. Research identified numerous methods that have been developed to provide protection from flooding. Along with the traditional methods of levee or structural seawall construction, many other types of protection were reviewed. These included inflatable barriers, concrete sidewalks or roadways that could be hydraulically rotated upwards to form a seawall, sliding panel gates, offshore breakwaters, and many types of surge barriers to close off the bays. The lines would also provide increasing levels of protection as you transgressed inland. It was understood that some lines would not provide protection from large storms. It was also evident that several areas of the coast could not be included in continuous line of defense and would be either placed in a ring levee system or designated to a non-structural solution.

In the early stages of the study, it was understood that the results of proposed storm surge modeling would not be available to the designers. These studies would be used to develop new stage-frequency curves to predict a wide range of storm surge for the entire cost of Mississippi based on a large suite of storms. This modeling effort would also provide a prediction of the largest hurricane surge event that is considered possible along the coast of Mississippi. This storm, labeled the Maximum Possible Intensity (MPI) event would be used to define a line, based on ground surface elevation that a storm surge would not exceed.

From the planning session came five conceptual lines of defense. The general concept for this plan was made during project delivery team meetings that included engineers, environmentalists, planners, and geologists. Information from along the coastline was gathered that included large scale aerial photography, topographic maps, navigation maps, and a large collection of pre and post-Katrina photographs. As this discussion progressed, a color illustration, shown in Figure 2.1-1, was drawn that evolved into the five lines of defense that is the foundation to the structural aspect of this study. A refined version by a graphic artist, Figure 2.1-2, was completed based this initial sketch.

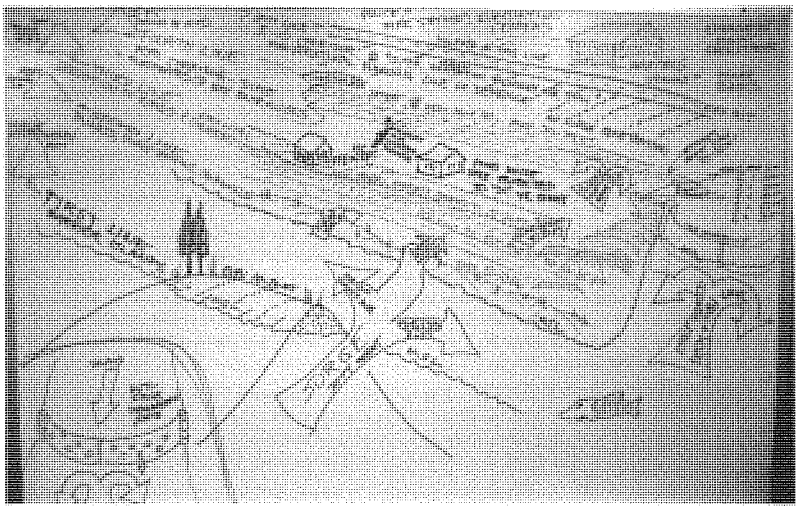


Figure 2.1-1. Graphic developed during initial planning sessions that visualized a "Lines of Defense" approach

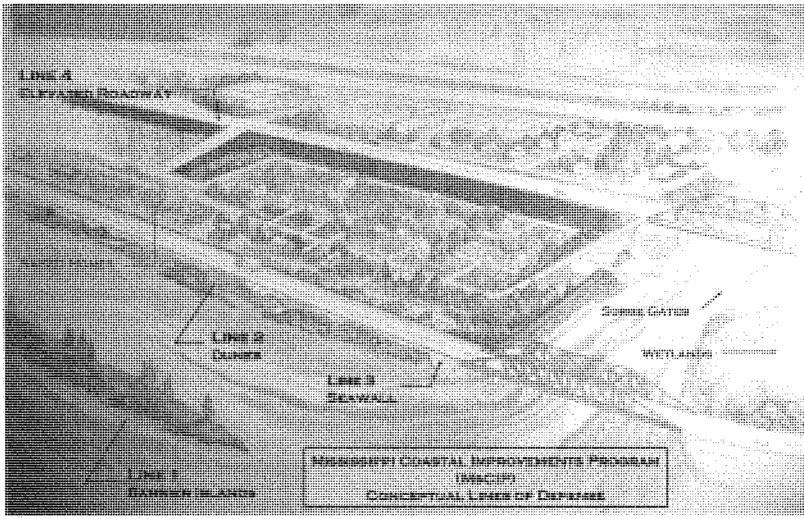


Figure 2.1-2. Artist's conceptual drawing based on the initial vision for Lines of Defense (Dawkins, 2006)

The first apparent feature to be discussed was the offshore barrier islands that had been included in the Mississippi Governor's recovery plan. Designated as LOD 1, the barrier islands have been eroded by numerous storms. In 1969, Hurricane Camille caused extensive erosion on the islands and created a large breach in Ship Island. 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. It was decided to model that scenario to help predict what effects the islands play in storm reduction.

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 the inclusion of dunes on the beaches. Other projects were underway to improve the some of the beaches and proposed projects would construct small dunes on most of the beaches. Improving on these by studying dunes at crest elevations of 10.0 (NAVD88) and 15.0 (NAVD88) 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.

Another existing condition along 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. Elevations of 12.0 (NAVD88), 18.0 (NAVD88) and 24.0 (NAVD88) were initially selected for study. It was also recognized that LOD-3 would require that barrier be placed at the mouths of the bays to be effective.

Some areas of the coast were not associated with these beaches and existing roadways or for environmental and/or technical reasons could only be viewed as stand alone projects such as ring levees. These areas included six communities in Jackson County and one in Hancock County. For discussion purposes, these were also included in LOD-3 and would be studied at the same proposed elevations.

Further inland, the existing railroad grade had provided a levee-like barrier to storm surge from Katrina in some areas. Using the same high-ground alignment, 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 from surge to be effective. As LOD-4, this barrier was to be studied at elevations of 24.0 (NAVD88), 32.0 (NAVD88) and 40.0 (NAVD88). Many alignments were considered before one that was recommended 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.

For the highest level of protection from the largest storm surge event, the limits of surge predicted from the MPI event was transposed to maps and while 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 and emergency facilities.

Figure 2.1-3 represents a section extending from the barrier islands to the MPI line.

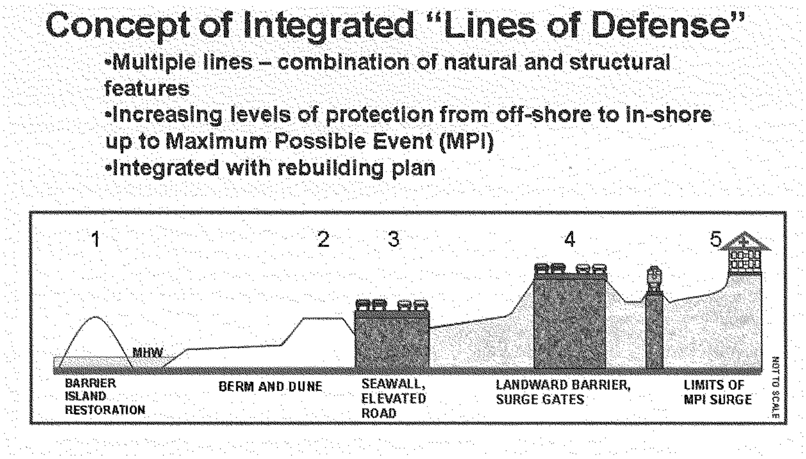


Figure 2.1-3. Conceptual section that includes five lines of defense extending from the barrier islands inland to the upper limits of the maximum possible intensity (MPI) hurricane

The proposed alignments for the LODs in each of the three coastal counties are shown in Figures 2.1-4, 2.1-5 and 2.1-6.

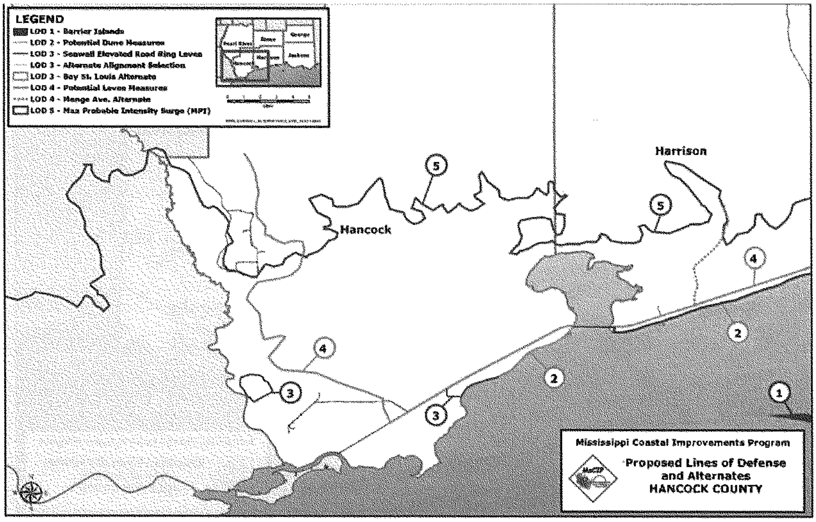


Figure 2.1-4. Line of Defense Alignments in Hancock County

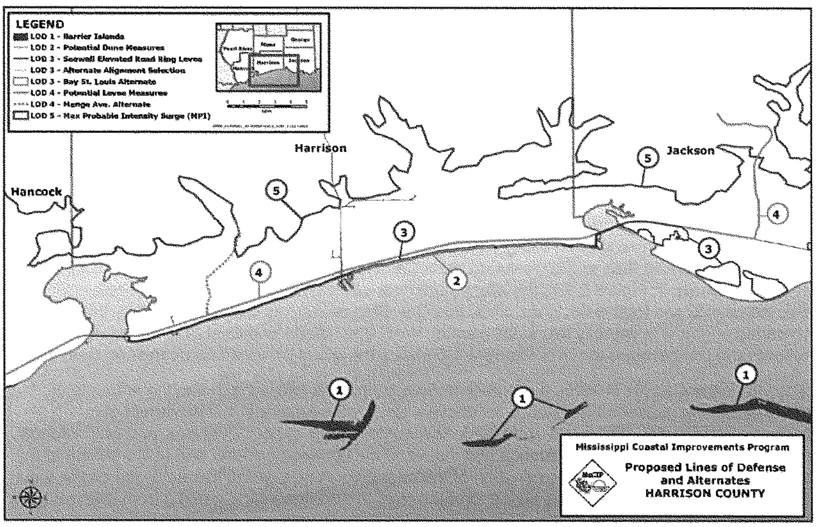


Figure 2.1-5. Line of Defense Alignments in Harrison County

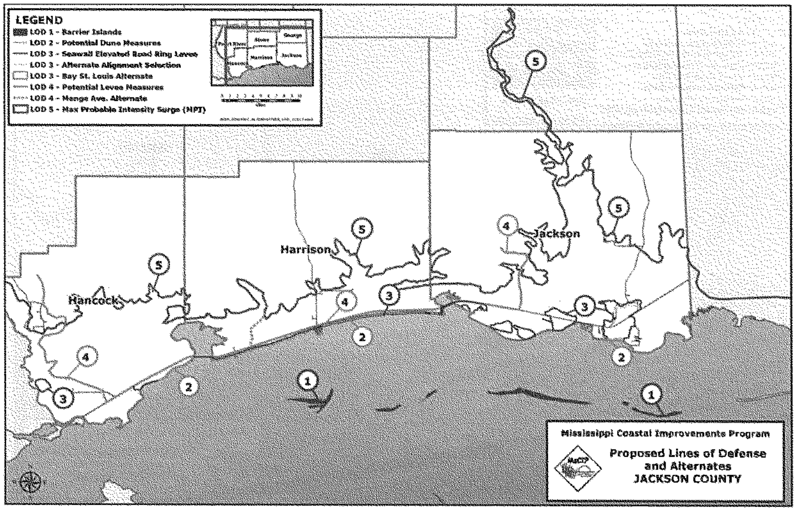


Figure 2.1-6. Line of Defense Alignments in Jackson County

The following discussions provide more detailed descriptions of the evolutions of each of the Lines of Defense from the initial concepts. Since this study generally did not provide feasibility level of design, there is still components that must be completed during "engineering and design" activities as shown in the cost estimates. This will include the completion of geotechnical investigations on the options that are carried forward. Part of the geotechnical work will be the verification of the different borrow areas including both onshore and off-shore sources.

2.1.1 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 10 to 15 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 Cat Island where littoral currents are not as well defined. As shown in Figure 2.1-7, the islands are near several navigation channels. 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. Figure 2.1-8 shows the effect of recent hurricanes on Ship Island.

Since Hurricane Camille in 1969, the breach in Ship Island has existed with varying amounts of natural rebuilding between later storms as documented by the Mississippi Department of Environmental Quality, (Schmid and Yassin). The western ends of both Petit Bois and Ship Islands have migrated to the edge of 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.

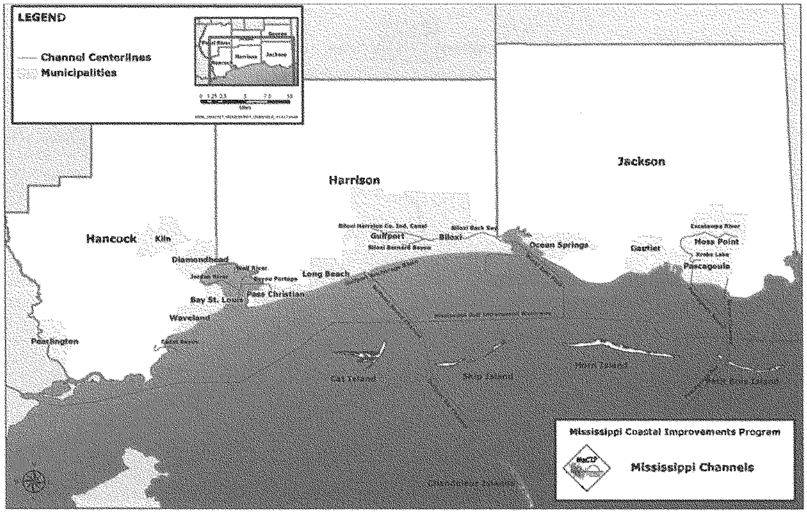
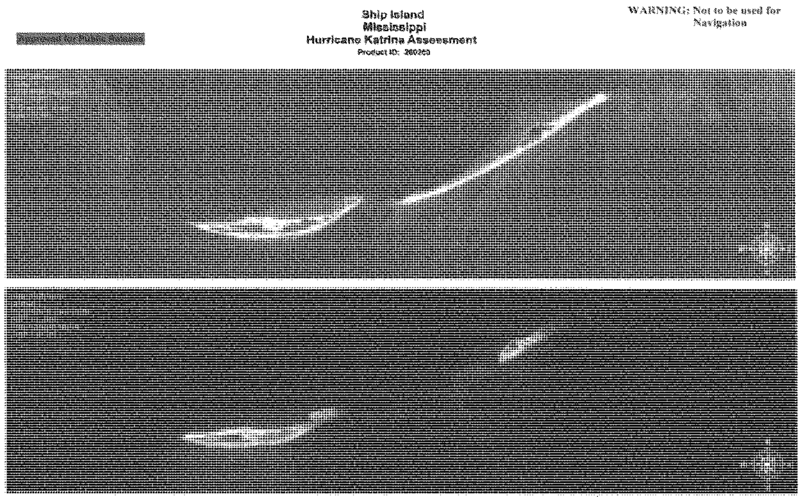


Figure 2.1-7. The Mississippi Barrier Islands shown in relationship to the numerous navigation channels near the islands

All of Petit Bois, Horn, and Ship Islands and part of Cat Island are within the boundaries of the Gulf Islands National Seashore under the jurisdiction of the National Park Service. In most cases, the boundary extends one mile from the shore of the island. The National Seashore boundaries are shown in Figure 2.1-9. Petit Bois and Horn Islands have also been designated as Wilderness Areas by the U.S. Department of the Interior and have a higher degree of protection than the other islands.

Other locations outside of park boundaries were studied for potential sites to construct breakwater type barriers that might serve the same purpose as a barrier island. Numerous constraints were identified with this concept. The depth of the water, other than being very close to the mainland shoreline, would have required a vast amount of material such as jetty stone in creating these breakwaters. And, as identified as a concern to local residents, locating these type structures close to the mainline shoreline would not be aesthetically acceptable.

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 which called for restoring the islands to a pre-Camille footprint. This concept was included in the hurricane protection study as LOD-1.



(Source – US Navy)

Figure 2.1-8. The aerial photograph on top shows the islands in 1997 prior to Hurricane George in 1998. The bottom photograph shows the same view of the eroded condition of East and West Ship Island after Hurricane Katrina. Prior to a breach during Hurricane Camille, Ship Island was a single island, although the island has been breached prior to Camille.

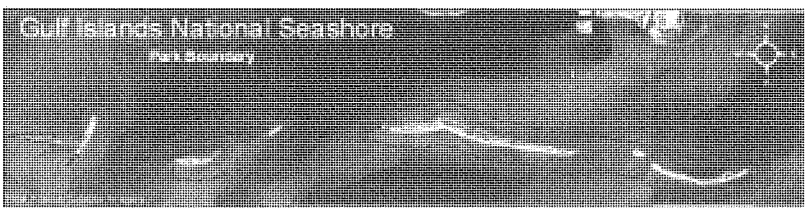


Figure 2.1-9. Aerial view of the Gulf Islands National Seashore showing the park boundaries that extend approximately one mile offshore in most areas (National Park Service)

To determine the effects of the islands in reducing the surge damage to the mainland, a number of storms were selected to model against the chain of islands in a pre-Camille and a post-Katrina configuration. The post-Katrina condition can be considered a baseline condition for the modeling and the pre-Camille condition would be an improved condition. The pre-Camille footprint of the islands was obtained from historical records. It should be noted that some of the islands have migrated and any reconstruction would be to increase their footprint at their present location and not move them back to historical locations. Restoration of Ship Island in a pre-Camille configuration includes closing the post-Katrina, 3-mile long breach to a 2000-foot width and with dunes, along with some rebuilding of the other islands to a larger land area. Modeling efforts have concluded that over a wide range of storms, there would be some protection provided to the eastern coast of Mississippi along the Jackson County shoreline if the islands are in the pre-Camille condition. This area is the most protected from the restored islands and this protection may result in only up to a 10% reduction in storm surge. The result of the modeling is shown in Figure 2.1-10. The effect of this protection diminishes rapidly to the west from Jackson County.

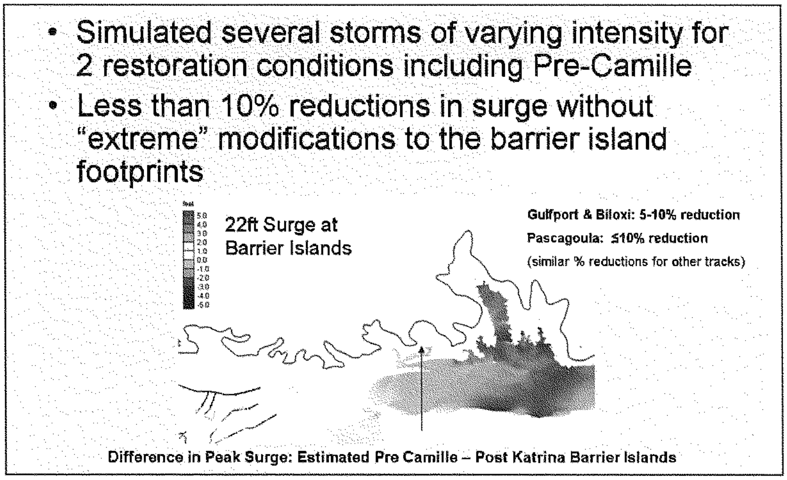


Figure 2.1-10. Sensitivity analysis of barrier island modification to differences in changes in surge heights along mainland

Another positive affect that the islands have is to provide a natural off-shore breakwater for the large sea waves that are generated from hurricanes. The presence of the islands and the relatively shallow water of the Mississippi Sound between the islands and the mainland prevent the sea waves from maintaining their considerable size as they move towards the mainland. Sea waves, often reported at heights of 40 feet and higher in large storms, would break as they approach the chain of islands. The open water between the islands and the mainland, generally ten miles or more, would have enough fetch for waves to regenerate, but at a much lower height due to the shallower water. The generally accepted relationship between water depth and wave height is that the wave can sustain itself at a height that is one half the depth of the water.

An environmental impact of the islands continuing to diminish in size is to allow salinity increases in the Mississippi Sound. Under current conditions, the islands provide a boundary condition between the sea water salinity of the open Gulf of Mexico and the brackish water found in the Sound. Loss of the islands would allow the salinity in the Sound to increase and result in a change of the ecological habitats that exist now. This would impact shellfish and other forms of marine life. This occurred at the Chandeleur Islands near the Mississippi barrier islands when almost the entire island structure was eroded away by Hurricane Katrina (see Figure 2.1-11). Like Cat Island on the Mississippi barrier islands, Chandeleur Islands are a remnant of a delta lobe from the Mississippi River where wave action created a beach that remained as an island after sea level rise and erosion removed the land mass between the island and the mainland.

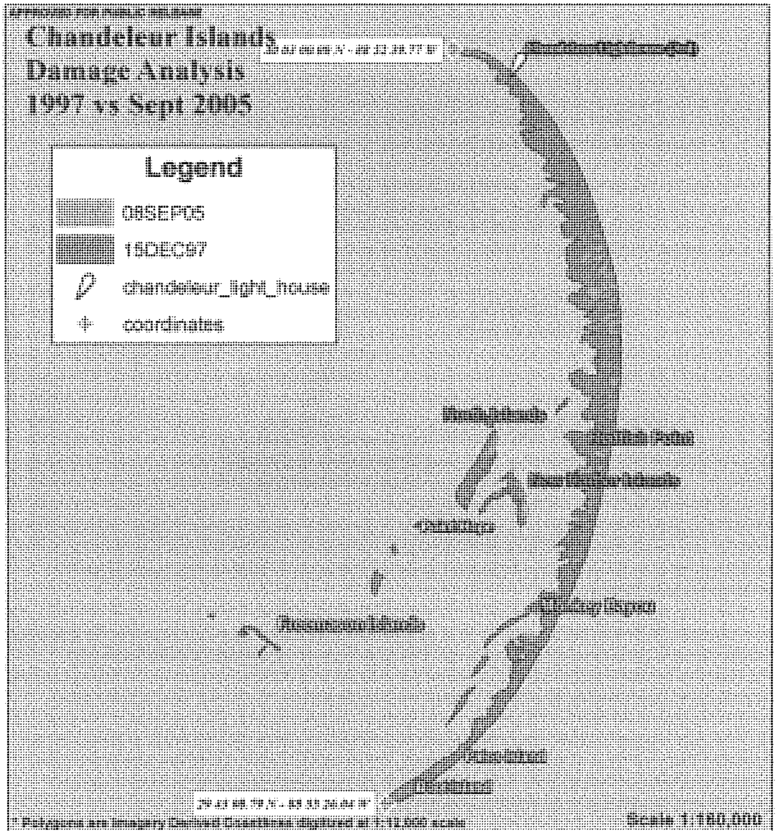


Figure 2.1-11. Loss of land mass from storm erosion at the Chandeleur Islands, 1997 to 2005. (US Navy)

With the consideration that these islands are within the National Park Service and that Petit Bois and Horn Islands are designated Wilderness Areas, any improvements to these islands may be politically difficult. One other consideration to help restore the islands is to supplement the sand in the littoral system. This could be accomplished by adding sand in specific locations based on sediment transport modeling. This would allow the littoral currents to move the sand onto the islands where the natural process of island building could take place. This would not directly affect the present-day islands and would help mitigate any effects of dredging the ship channels that pass through the chain of islands where sand may have been lost from the system.

Another plan could involve environmental restoration of the islands through reshaping dunes on the beaches with planted vegetation, planting of marshes and maritime forests, and planting sea grasses in the near-shore areas of the islands.

2.1.2 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 provide reduction of damaging wave action from smaller storms. A project to restore the beaches in Harrison County has been funded and is underway. Other projects to construct dunes to a height of 5-feet in Harrison County and to 2-feet in Hancock and Jackson County has been proposed as an interim projects and has already been designed and are awaiting funding.

Figure 2.1.2-1. View of Harrison County beach looking towards existing seawall at US Highway 90

The beaches, as situated immediately seaward of roads and developed areas, provide a location where elevated dunes could be constructed to provide some protection from smaller hurricanes. Original concepts were to look at crest elevations of 10.0 (NAVD88) and 15.0 (NAVD88) as options for the all dunes. Further discussions focused on the top elevation of the dunes needing to be below the elevation of the adjoining roadway. This was to help mitigate the migration of the sand onto the roadway as eolian (wind blown) deposits. It was decided to correlate the top of the dune to an elevation that would be 1-foot lower than the adjacent road that would be included in LOD-3. As described in the following section, LOD-3 elevated roadway elevations of 11.0 (NAVD88) were selected for Jackson and Hancock Counties and 16.0 (NAVD88) for Harrison County. These decisions for LOD-3 then dictated dune crest elevations of 10.0 (NAVD88) for Jackson and Hancock Counties and 15.0 (NAVD88) for Harrison County.

Dunes are consistent with public preference for a more natural appearing defense than a hard structure. Construction of dunes will include adding vegetation and sand fencing to help stabilize the dunes. The dunes would be a sacrificial barrier, but could also be important by providing additional protection for the toe of the existing roadway, especially in an elevated seawall or roadway configuration as LOD-3. Placement of the dunes directly against a raised seawall or roadway would also serve aesthetically to mask the appearance of a structural barrier.

While the measure described above joins LOD-2 with the adjoining roadway, consideration could be given to having a stand-alone LOD-2 dune system that is on the existing beach, but separated from the road. The quantity of sand for an option such as this would increase since the northern slope of the dune would go down to a grade elevation of about 5.0 (NAVD88) and not abut against the roadway. By doing so, the top elevation of the dune could vary and be above the roadway as necessary. This may increase the need for maintaining the sand in the designated dune alignment since it would be expected that the sand dune would tend to migrate under the prevailing wind direction. This option was not fully designed as many unanswered questions remain that may have to be simulated with models. This includes the width of the dune crest and the width of the beach berm that might be required in front of the dune. This option would also block any view of the water from the existing roadway in most areas, replacing the view with a dune scene including plantings of sea oats or other beach type vegetation.

2.1.3 Third Line of Defense – Elevated Roadways/Seawalls and Ring Levees

As previously mentioned, all of the beaches described as LOD-2 have a roadway landward of the beach. The 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 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. This line will be the first hard engineered structure that will not be affected by erosion from a storm such as a dune system.

Figure 2.1.3-1. Photo of existing beach-front roadway and sea wall in Hancock County, June 2006. Equipment in the background is moving sand from the area just off-shore back onto the beach after being eroded by Hurricane Katrina.

Initial strategy was to study three elevations for the structure, elevations 12.0 (NAVD88), 18.0 (NAVD88) and 24.0 (NAVD88). It was understood that due to limited heights, it would only provide protection from more frequent, smaller storms, but would be overtopped by some large storms. This coastal barrier will coincide with the beaches where they exist. Raising the beach-front road did present some engineering challenges due to the numerous intersections with other streets and roads. With several feet of elevation, the intersecting roads would require ramps that would be extremely long to have a reasonable grade. Each of these ramps would also create areas where rainfall would collect and have to be removed during a storm. It also soon became apparent that public opinion was against any structure that would block the view of the beaches and water from the adjoining properties immediately north of the roads. This was voiced in public meetings and also from agencies that were involved in the study. To maintain some level of support for this defense, it was decided to raise the roadways an average of six feet. This allowed reasonable road intersection construction and allowed the aesthetic view of the water to be maintained and would not be perceived as a high seawall along the coast.

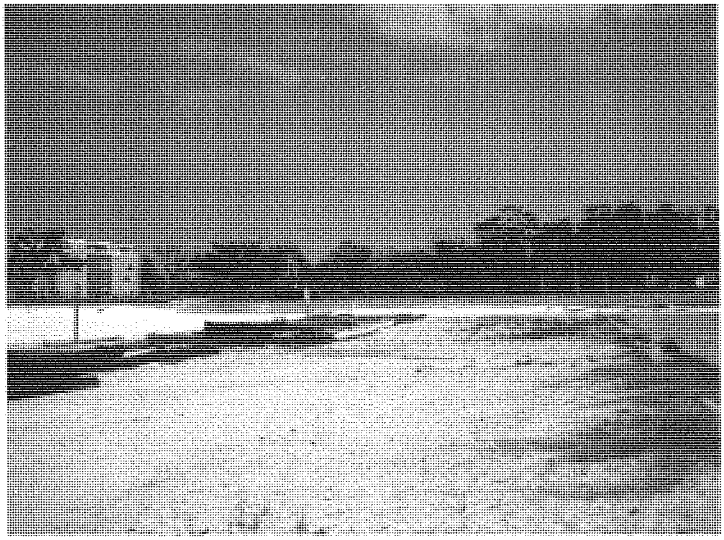


Figure 2.1.3-2. Photo of existing beach and seawall/US Highway 90 in Harrison County, 13 June 2007.

Review of the typical roadway elevations allowed raising the roadways in Jackson and Hancock County to Elevation 11.0 (NAVD88) and Highway 90 in Harrison County to Elevation 16.0 (NAVD88). It was decided to study these elevations without other options as the main part of LOD-3 with the understanding that these structures would not provide protection from large storms. As describe above, the LOD-2 dunes could also be constructed against the elevated roadway to help protect the toe of the structural wall associated with the road.

This line of defense would be connected to Line 4, described below, at the mouth of Biloxi Bay and St. Louis Bay. It would also extend northward to higher ground or to Line 4 in Jackson County and Hancock County. The bays are an inlet for storm surge that will be controlled by surge gates that are a part of Line 4. It was also recognized that if LOD-3 was constructed without LOD-4, surge gates across the bays would have to be included as part of LOD-3.

As the first hard structural defense, Line 3 will exclude some areas that may be considered potential areas of retreat or have other non-structural solutions. This may be due to low population density, ecological sensitivity, areas that contain numerous waterway crossings or areas that could not function with a structural barrier in place. In Jackson County, Line 3 will encompass the southern portion of Ocean Springs, but due to extended marshes and streams, it will extend northeastward from near the eastern end of East Beach Road to higher ground. Areas east of this location contain numerous marshes, streams, and scattered development. Ring levees will be evaluated for housing developments in some areas. Further east in Jackson County are the cities of Gautier, Pascagoula and Moss Point. The presence of numerous streams and inlets will make a continuous barrier very difficult and these areas are also envisioned to have individual ring levees.

At the western end of LOD-3, the barrier will extend down North Beach Boulevard for several miles to near Bayou Caddy and then turn north to tie in with higher ground. By following this path, the existing roadway will provide an alignment and it will encompass much of the developed waterfront from Bay St. Louis to Waveland, MS. Further west, the town of Pearlington will be evaluated for construction of a ring levee.

As with the main portion of LOD-3, the ring levees were initially considered with the same three elevations of 12.0 (NAVD88), 18.0 (NAVD88) and 24.0 (NAVD88). Closer study revealed that in many cases, the elevation 12.0 (NAVD88) was too low based on existing ground surfaces and the elevation 24.0 (NAVD88) may not be high enough to be certified by FEMA for a 100-year storm event. The elevations to be studied for the ring levees then was changed to 20.0 (NAVD88) and 30.0 (NAVD88) with the assumption that the 100-year event would fall between these elevations and that the elevation 30.0 (NAVD88) design would be sufficiently high for even a 500-year event. A 100-year minimum event is necessary for levee certification by FEMA. Having a conceptual design with cost estimates for these two elevations would allow for a cost curve to help predict the costs for certain storm events once the modeling studies were complete and stage frequency curves developed.

Initial alignments were set for the levees that tried to enclose most of the development. These alignments were used to estimate quantities of materials required for construction. After these alignments had been analyzed, the results of the surge modeling indicated that large reductions in the quantities of material could be realized by moving the alignments to higher ground in some areas to exclude some properties that facing or near the edges of marsh or water. Placing the levee behind the structures on these properties would not provide any type of protection, but would greatly decrease the cost of construction and at the same time preserve the aesthetic valve that brought the residents there. An example of this is shown in Figure 2.1.3-3. It was also noted that some of these properties were within potential non-structural zones that were identified as potential flood-proofing areas, either by raising or buyouts.

Another consideration is the presence of multiple large drainages or tidal inlets. Enclosing these drainages within the levee system will require pumping stations to remove rainfall during storm events. Depending on the area to be drained during a storm, these pumping stations can be very large items, both in space required to construct them as well as initial cost and future maintenance. These pumping facilities require a design that can withstand large storm events as they must stay operational during and after the hurricane passes. Depending on topography, some areas such as the interior of the potential Pascagoula – Moss Point levee (see Figure 2.1.3-4) would have numerous drainages that would require water removal.

Using these stations in Mississippi has both advantages and disadvantages over their popular use in Louisiana. In Louisiana, the pumps are required to keep large areas dry because parts of the city are below sea level and the Mississippi River. This condition does not allow many areas to drain by gravity flow. In Mississippi, operation of the pumps are only required when a hurricane has caused a storm surge to push against the levee and gravity flow structures are closed. In most cases, this drainage will be through culverts with flap gates that will not require any type of mechanically assisted closure. This can also present a problem in many cases since the pumps will be in drainages that will be dry unless there is rainfall occurring. Without a supply of water, exercising the pumps as part of a maintenance program may be a problem. During this initial phase of design, most drainages had pumping stations assigned to remove rainfall. Additional studies should allow for the siting and design of storm water retention areas in many of the drainages that will negate the need for pumps, but will require the acquisition of some property.

Figure 2.1.3-3. Bell Fountaine Ring levee alignments. The alignment inside the outer line is being considered for cost savings due to being located on a higher base elevation. This alternate alignment would place any structures between the lines into a non-structural solution.

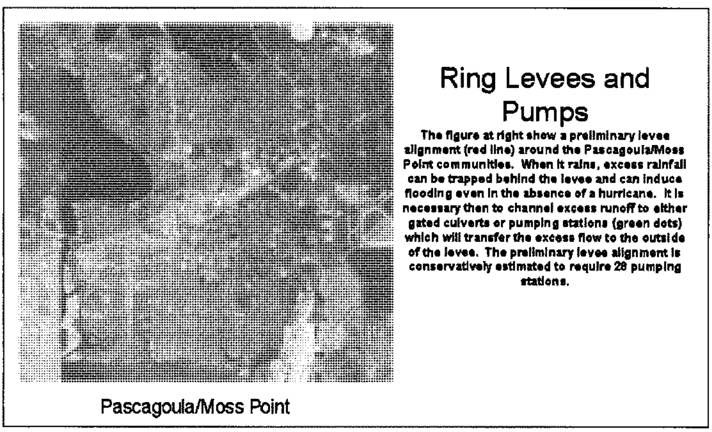


Figure 2.1.3-4. Required Pumping Stations for the Pascagoula-Moss Point Ring Levee

Modeling for storms that could impact the Mississippi Coast will define the predicted return frequency for these storms. The LOD-3 structures that might be used in Mississippi will not provide protection from large storms and this level of protection will vary based on the location and type of structure. While many options were reviewed for the type of structure to be used along the roadways, a simple elevated roadway associated with an extension of the existing seawall was chosen for reliability reasons. A structure that did not mainly rely on powered systems or with multiple moving systems was deemed more suitable for the purposes of this line of defense. As previously described, numerous conceptual designs were considered including inflatable barriers, concrete sidewalks or roadways that could be hydraulically rotated upwards to form a seawall, sliding panel gates within a seawall, and structural concrete seawalls. The ring levees were all designed as earthen structures. It should be understood that all of these LOD-3 structures would provide much less protection than would be required for a Camille or Katrina-like storm. LOD-3 storm damage reduction levels are limited and will be determined based on public and local government acceptance and the amount of risk that Mississippi is willing to accept.

As previously mentioned, this line is dependent on having the ability of closure across the two bays to prevent the storm surge from running inside the mouths of the bays. While the plan calls for surge gates to be associated with Line 4, surge gates would also have to be incorporated with Line 3 if Line 4 was not selected as an alternative. The top elevation of surge gates used solely for Line 3 would be of an elevation that would be compatible with the rest of that barrier. To develop a cost curve for the barriers, cost estimates for elevations of 20.0 (NAVD88), 30.0 (NAVD88) and 40.0 (NAVD88) have been completed and will be used in conjunction with both LOD-3 and LOD-4. More detailed discussion of the surge gates is found below under the LOD-4 section.

Interior drainage behind these barriers must be considered. Any large rainfall event would require that the water trapped behind the barrier have a means to drain or even be mechanically pumped. The amount of storage that a given watershed could provide behind a barrier during surge conditions will vary. The means to block surge but allow drainage as the surge passes may include conduits with flap valves or gated culverts up to surge gates across large bodies of water. The areas where pumping is required are numerous, but necessary to prevent residual damages associated with this blockage of normal drainage.

The pumping stations, where required, must survive any storm damage and continue to operate until the storm event has passed. Elevated pump housing and power systems would be constructed to a height commensurate with the risk associated with that line of defense. In some instances, housings may need to be hardened to ensure protection from wind related damage.

2.1.4 Forth Line of Defense – Inland Barrier

To preserve the shoreline environment as much as possible, a 4th line of defense for very large storms is envisioned that would be inland from the coast. This line of defense would be the highest line and could contain a larger storm surge up to that associated with a "Maximum Possible Intensity" (MPI) hurricane. LOD-4 was to be modeled as an infinitely high barrier with the screening storms defining a surge elevation against the barrier. The top elevation could then be defined based on selected protection from a selected screening storm. Storms that will be modeled against this line will vary up to the MPI.

As the requirements of the MsCIP project studies were developed it became apparent early on that several massive gate structures would be required to protect the large inlets from tidal surges during larger storm events. In order to protect much of the developed areas around Biloxi and St. Louis Bays, LOD-4 would have to include a structural surge barrier that would also cross the mouth of these bays. These surge barriers would prevent storm surge from moving in through the inlets of the bays. The structural barriers across the bays could be similar to designs used in Europe for storm surge protection.

Initially it was thought that some adaptation of our customary tainter or vertical lift gate assemblies might serve this purpose, but as the water levels to be resisted and the required length of the structures were developed it became apparent that much more massive construction than we had heretofore experienced would be required. This was further complicated by the need to minimize the visual impact, obstruction to small vessel traffic, and normal tidal flow.

The search for a method of construction that would be efficient and effective while optimizing freedom of tide flow and minimizing visual and physical obstruction under normal conditions led us to the Netherlands, Italy, Russia, and the River Thames in the United Kingdom, where several very massive and large scale projects of this type have been constructed or are presently in the planning stages. While many types of barriers were reviewed, the rising sector design used on the Thames River in London, England was selected

The Thames River Barrier was constructed during the 1980's to protect portions of historic London and the surrounding area from tidal flooding. At this site there is a naturally wide variation in the "spring tides" resulting in frequent very high tides, the maximum observed to date being +3.2 meters (i.e. 3.2 meters above the normal tide influenced water level). Also at this site storm surges of as much as +3.66 meters have been experienced. In the event that a storm surge equivalent to the maximum experienced to date and a very high spring tide were to occur at the same time, the water level could conceivably reach as much as +6.86 meters at this site. Based on this possibility, the top of the gates at the Thames River barrier was set at +6.9 meters. This elevation is sufficient to fully contain the 100-year flood event which would yield a water elevation of approximately +5.5 meters. The design flood event was estimated as being the 2000-year flood.

The Barrier constructed includes a series of reinforced concrete piers and sills, supporting massive steel gates. Each main pier is 11 meters wide and extends to a point slightly above the top of the gates, with the operating machinery and machinery housings mounted atop each pier. Protective and decorative machinery housings were constructed consisting of large curved coverings made of wood and clad with stainless steel. The lowest pier foundations were sunk some 17 meters into the chalk beneath the river bottom.

The barrier includes four main navigation openings measuring 61 meters (approximately 200 feet) in width and two 31.5 meter (approximately 103-foot) openings for passage of smaller vessels. Each of these openings is fitted with a rising sector gate. To allow for free water flow for practically the full width of the river, four more 31.5 meter openings were included each having a falling radial gate, similar to the tainter type gates common to our inland waterway control structures, as a barrier against flood waters.

The rising sector gates are hollow stainless steel structures with the downriver side curved. Each gate is mounted at either end to large steel disks giving the entire gate structure the appearance of a cut-away cylinder. The gates are supported on trunnion shafts which rotate in bearings mounted in the piers. They are operated by means of reversible hydraulic rams and operating arms mounted on the top of the piers. Under normal conditions the gates lie flat in curved concrete sill recesses in the river bed. Each can be operated upward and stopped at four positions, partially closed (1/8 turn of the disk upward), fully closed (1/4 turn of the disk upward), underspill position (3/8 turn of the disk upward), and maintenance position (1/2 turn of the disk upward). To facilitate operation of the gate the interior of each gate chamber is evacuated of water resulting in a partially buoyant structure.

The facilities are operated from a Control Tower located on one bank of the river with a backup control room on the opposite bank. Two service tunnels pass through the foundation of the barrier beneath the river to connect between the two control rooms and to provide power and other utility service access to each pier. In case of extreme emergency each gate can be operated from the individual pier engine rooms. Operating power is provided by three 1.5 MW on-site power generating units, with backup connection to the local electrical grid.

Since its commissioning the Thames River Barrier has been operated 4 to 5 times per year, for a total of 276 times as of 29 April 2002. Each closing cycle takes approximately 15 minutes, though the operation time is greatly extended because of the coordination required with operation of the port facilities.

The Thames River Barrier was constructed between 1972 and 1982 and was formally opened in 1984. The total project construction cost was approximately $760 million. The annual operating and maintenance cost for the Barrier and appurtenant facilities is approximately $13 million.

In considering the rising sector gate design for application to the MsCIP barrier structures several points of advantage were identified. Under normal conditions the gates rest out of view at river bottom level. This is appealing in that it would offer a minimum of obstruction to view, to tidal ebb and flow, and to navigation through the structure. The piers, while substantial, are placed wide enough apart that they should be no more obtrusive than the existing bridge structures. The speed of operation would minimize the time the gates would be required to be in place before and after a storm event, and the fact that the gates can be rotated to a full up position for maintenance completely in the dry without installation of unwatering devices or dismantling of the structure is a great maintenance advantage. The maintenance aspect is further enhanced by the fact that the gate surface material is all stainless steel.

Readily observable disadvantages or questionable considerations include the very high construction cost, the relatively small design head required at the Thames River installation as compared to those for the MsCIP sites, the considerably weaker foundation materials existing at the Mississippi Gulf Coast sites, and the relative lengths of the barrier structures required for the MsCIP project sites compared to the Thames River site.

This type of structure would allow the least restriction to natural tidal flow and with gates flush with the natural bottom, provide the least environmental concern.

The general alignment of line 4 is envisioned along the path of a railway that crosses the coast of Mississippi. In Harrison County, this pathway is through heavily populated and commercial zones. To the east in Jackson County, a decision was made not to cross the Pascagoula River and associated marshes. To do so would have both technical and environmental concerns. Crossing this major river system would create environmental problems as well as interior flooding. Constructing barriers or levees across the marshes will change the surface water flow, restrict tidal exchange and could alter existing salinity conditions leading to major ecosystem changes. Blocking the rivers with surge gates, even for short periods could cause extensive flooding due to water backing up behind the gates during storms as rain falls inland. This could cause more flooding than the storm surge. The Pascagoula River system is also habitat to the endangered Gulf Sturgeon and any approved construction or modifications in the river would be unlikely.

For these reasons, the first major watershed divide west of the Pascagoula River was selected to turn the barrier north and extend it to a location beyond the extent of the storm surge associated with a MPI event. Similarly to the west in Hancock County, LOD-4 follows the railway to a watershed divide that is located east of the Pearl River where it follows the divide north to the MPI line. Both of these northward extensions will cross the path of Interstate 10 and may dictate some modifications to the highway depending on the selected top elevation of the line.

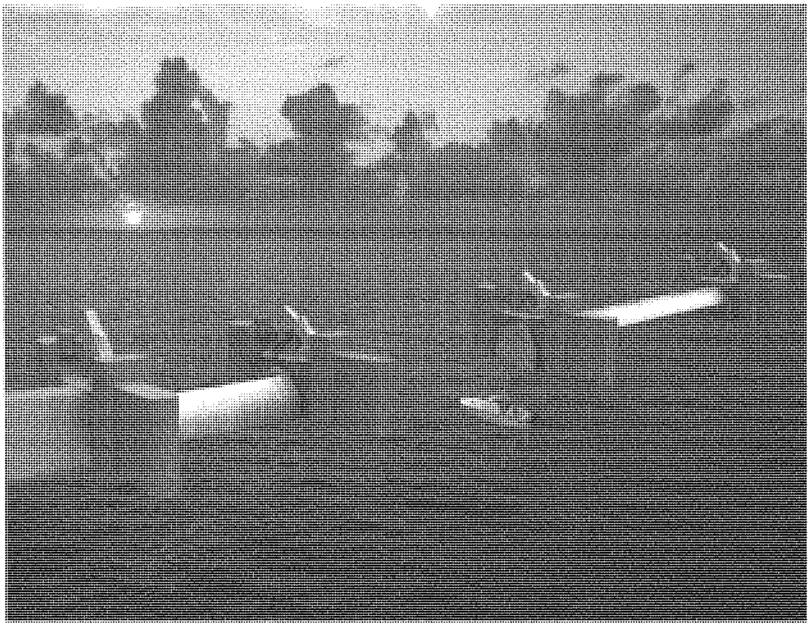


Figure 2.1.4-1. Conceptual graphic of rising sector gate used to close the mouths of the bays in Mississippi during a storm surge. This would be of similar design to what was used on the Thames River in London. The gate to the left of the boat is in the raised position, the gate in front of the boat is in the down or open position and the gate to the right of the boat is in the up or maintenance position.

LOD-4 could also be designed to have roadways, even major highways on top if desired. This line would be the highest defense, but would not protect structures seaward from the larger storms that might overtop Line 3. All facilities seaward of Line 4 would be prone to flooding in a large storm, so flood-proofing would be necessary in this zone. As described prior, this barrier would extend from high ground east of the Pearl River to high ground west of the Pascagoula River for a distance of approximately 57 miles. It would not cross either of these river systems.

Like Line 3, interior drainage behind this barrier must also be considered. The watersheds may be large and large rainfall events would require substantial structures designed to allow the water to drain or be pumped over the structure in a storm.

2.1.5 Fifth Line of Defense – Beyond the Surge Limits

Computer simulations have predicted how far inland storm surge will extend if the worse-case hurricane or maximum possible intensity (MPI) event hits the Mississippi coast. This line represents a line of safety where homes, facilities or transportation routes north of this line should not be affected by any storm surge. This would be an area where hospitals, schools, emergency response and management facilities might be located. Present predictions based on modeling sets this line near elevation 40 feet.

2.2 Hydrodynamic and Coastal Process Modeling

Part 2 documents the hydrodynamic and coastal processes modeling required to evaluate the lines of defense. The coastal processes modeling analysis employed the engineering-economic model Beach-*fx* (Gravens et al. 2007) is discussed first. 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 is primarily concerned with levels of protection below a 50-year return period and therefore the shore response database was developed with an existing surge database commonly applied for beach studies. The statistical methodology for computing the frequency relationships necessary for the evaluation of the no project condition and lines three and four is then introduced. The numerical models and methodology for providing the data to the statistical analysis is detailed including wind and atmospheric pressure modeling, offshore wave modeling, nearshore wave modeling, and storm surge modeling. The resulting frequency relationships are presented and discussed. The part concludes with documentation of various sensitivity analyses, including sensitivity to barrier island configuration (an evaluation of line of defense one), and wetlands.

2.2.1 Introduction

Part 2 documents the hydrodynamic and coastal processes modeling required to evaluate the lines of defense. The coastal processes modeling analysis employed the engineering-economic model Beach-*fx* (Gravens et al. 2007) is discussed first. 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 is primarily concerned with levels of protection below a 50-year return period and therefore the shore response database was developed with an existing surge database commonly applied for beach studies. The statistical methodology for computing the stage-frequency curves necessary for the evaluation of the no project condition and lines three and four is then introduced. The numerical models and methodology for providing the data to the statistical analysis is detailed including wind and atmospheric pressure modeling, offshore wave modeling, nearshore wave modeling, and storm surge modeling. The resulting stage-frequency curves are presented and discussed. The part concludes with documentation of various sensitivity analyses, including sensitivity to model inputs, barrier island configuration (an evaluation of line of defense one), and wetlands.

2.3 Shore Response Database

2.3.1 Purpose

The coastal processes modeling analysis employed the engineering-economic model Beach-*fx* as the primary analysis tool. 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. This section of the report documents development of the coastal processes input data and physical performance results of the Beach-*fx* analysis, the economic results of the Beach-*fx* analysis are documented elsewhere in this report. Central to the application of Beach-*fx* is development of the Shore Response Database (SRD). The SRD is a relational database that stores results of beach profile change simulations of a historically based suite of plausible storms impacting a pre-defined range of anticipated beach profile configurations, as defined by ranges of berm width, dune width, and dune height. The SRD contains the primary coastal morphology change data that is one of the basic elements of Beach-*fx*, a comprehensive analytical framework for evaluating the physical performance and economic benefits and costs of shore-protection projects, particularly, beach nourishment along sandy shores. The SRD is site- and study-specific; that is, it is developed uniquely for each shore protection project study area. Results stored in the SRD for each storm/profile combination are changes in berm width, dune width, dune height and upland width, and cross-shore profiles of erosion, maximum wave height, and total water elevation. The morphology changes (berm width, dune width, dune height and upland width changes) are used to update the simplified pre-storm beach profile to obtain the post-storm profile. Hence, through Monte Carlo simulations of the project lifecycle the morphological evolution of the study area is estimated along with project costs and infrastructure damage estimates. Simulation of multiple project lifecycles allows for the quantification of average expected project evolution, project costs, and infrastructure damages together with statistical distributions of these quantities. The damage driving parameters (cross-shore profiles of erosion, maximum wave height, and total water elevation) are used to estimate damages within reaches associated with that representative profile. The SRD is thus a pre-generated set of beach profile responses to storms and a range of profile configurations that are expected to exist under different scenarios of storm events and management actions (beach nourishment). The SRD, once generated, serves as a look-up table by the Monte Carlo simulation model. The Monte Carlo simulation has available to it the same set of storms used in populating the SRD.

2.3.2 Computational Models

The models applied to evaluate beach profile response to storms and project induced shoreline change are model 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 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.

Estimates of the project-induced shoreline change rate are obtained through application of a one-line shoreline change model such as GENESIS (Hanson and Kraus 1989). The GENESIS model has been applied to numerous engineering projects and has demonstrated favorable capability to predict long-term shoreline change. GENESIS was designed to simulate long-term shoreline change produced by temporal and spatial differences in the longshore sand transport at coastal engineering projects. The beach profile is assumed to remain in a state of quasi-equilibrium over the long-term. The accretion or erosion of the beach is realized as a seaward or landward translation of the entire profile so that only one point of the profile, taken as the shoreline, is required to model the evolution of a sandy coast. Project-induced shoreline change rates are computed for each of the planned beach nourishment cycles which accounts for the improved performance of beach nourishment projects that comes with project maturation. That is, theory and beach nourishment experience has shown that dispersion losses at a beach nourishment project tend to decrease with the number of project renourishments. This information is stored in the database by reach and nourishment cycle. Project-induced shoreline changes capture the "spreading out" of a nourishment project on a long straight shoreline. In this phase of the analysis, potential improvements along the Mississippi Sound shoreline are assumed to be continuous along the Harrison and Hancock County shorelines. The project in Harrison County is assumed to extend from Biloxi Bay in the east to Saint Louis Bay in the west. In Hancock County the project is assumed to extend from Saint Louis Bay to Bayou Caddy.

Consequently, project-induced shoreline changes were assumed negligible because as the project is continuous across the study domain.

2.3.3 Surge Database

The DRP tropical storm database consists of surge data hydrographs recorded at 486 discrete locations corresponding to selected WIS and nearshore stations along the east and Gulf of Mexico Coasts and Puerto Rico. The database was constructed by numerically simulating historically based hurricanes that have impacted the east and Gulf coasts. The source of data for the simulations was the National Oceanic and Atmospheric Administration's National Hurricane Center's HURDAT (HURicane DATabase).

For this study, a storm suite containing 71 historical storms from the year 1886 to 2001 with at least a foot of storm surge along the Mississippi coast were identified. Storm surge hydrographs were extracted from the DRP database for these 71 historical events at stations 509 and 510. The storm surge hydrographs were subsequently combined with statistically representative astronomical tides corresponding to high, mean, and low tidal ranges and the peak storm surge was aligned with four tidal phases (high tide, mean tide falling, mean tide rising and low tide) to expand the historical storm suite by a factor of 12 resulting in a plausible storm suite of 852 unique storm events. Time series of wave heights and periods were obtained from WIS station 144 for those storms coinciding with the WIS database. For storms not included in the WIS database wave heights and periods were estimated based on methods outlined in the Shore Protection Manual.

2.3.4 Methodology

The methodology for generating the SRD involves a series of steps. First, representative beach profiles are generated based on available measured beach profiles. Then the expected range of upper beach profile configurations (dune height, dune width, and berm width) are surmised and combined with the representative submerged beach profile. SBEACH simulations of beach profile response are then performed for each unique beach profile and plausible storm combination. Finally, a data extraction routine extracts upland width, dune height, dune width and berm width changes as well as cross-shore profiles of erosion, total water elevation and maximum wave height from the SBEACH output files and writes these data to the SRD. The SRD, once generated, serves as a look-up table by the Beach-*fx* Monte Carlo simulation model. The Monte Carlo simulation has available to it the same set of storms used in populating the SRD. As a given storm from the simulated sequence takes place, the current profile (defined by representative profile, dune width, dune height and berm width) is used to look up the results that are associated with that storm in the SRD for the profile that is closest to the pre-storm profile as tracked in the simulation. The SRD results define the post-storm profile to track volume changes and to determine within-storm erosion, and wave heights and water elevations associated with the storm along the cross-shore profile. Within Beach-*fx*, storm-based morphology change includes a representation of scarping of the seaward dune face. Dune scarping takes place when the berm retreat is calculated to invade the seaward toe of the dune.

In this study, SRD databases were separately generated for Harrison and Hancock counties because the representative profiles, design conditions and storm surge hydrographs differ between the two counties. Unique SRD databases were generated for existing and future without-project conditions and for the with-project conditions. In Harrison County the existing and future without-project condition SRD is comprised of beach profile responses for a total of 10,224 beach profile – storm combinations (12 beach profiles by 852 storms). The Harrison County with-project SRD is comprised of beach profile responses for a total of 127,800 beach profile – storm combinations (150 beach profiles by 852 storms). In Hancock County the existing and future without-project condition SRD is comprised of beach profile responses for a total of 6,816 beach profile – storm combinations

(8 beach profiles by 852 storms). The Hancock County with-project SRD is comprised of beach profile responses for a total of 58,788 beach profile – storm combinations (69 beach profiles by 852 storms).

The SRD also includes an applied shoreline change rate, project-induced shoreline change rate, and post-storm berm width recovery. The user-specified applied shoreline change rate is a reach level calibration parameter and is specified in feet per year, for each reach. The applied shoreline change rate is set so that the combination of the applied shoreline change rate and storm-induced change returns on average over multiple lifecycle simulations the historical shoreline change rate for the reach. The target historical shoreline change rate is determined based on a separate analysis of the available historical beach profile and or shoreline position data. In this study, the applied shoreline change rate for Harrison County was assigned a value of -0.244 ft/year to cause Beach-fx to return the estimated historical shoreline change rate of -3.00 ft/year, based on available historical shoreline position data. In Hancock County the applied shoreline change rate was assigned a value of -2.116 ft/year to cause Beach-fx to return the estimated historical shoreline change rate of -4.85 ft/year.

Post-storm recovery of eroded berm width after passage of a major storm is recognized by the coastal engineering community although the present state of coastal engineering practice has not yet developed a predictive capability for estimating this process. Consequently, the post-storm recovery is represented in an ad hoc procedure in which the user specifies the percentage of the estimated berm width loss during the storm that is recovered over a user specified recovery interval. In this study the post-storm recovery factor was assigned a value of 80 percent and a recovery interval of 21 days. That is, 80 percent of the berm width loss caused by a storm in the simulation is restored over the 21 days following the storm event. If a second storm event occurs prior to full berm width recovery (within 21 days) berm width recovery for the first storm is suspended. The post-storm recovery factor in combination with the applied shoreline change rate serve as calibration factors in Beach-*fx*. The basis for the selected recovery factor was made based on engineering judgment and the expectation that, in the absence of storm activity, the Mississippi mainland shoreline should be either stable or modestly erosional, selection of an 80 percent recovery factor resulted in an applied erosion rate of -0.244 ft/year to achieve the long-term historical shoreline change rate of -3.00 ft/year, which satisfies the assumption of a mostly stable shoreline in the absence of storm activity.

2.3.4.1 Treatment of Future Sea Level Rise

The analysis described above was repeated three times for three different potential sea level rise scenarios corresponding to the existing rate of sea level rise, a potential future moderate rate of sea level rise and a potential future high rate of sea level rise. Incorporating potential future sea level rise in the coastal processes analysis involved adding an increment of water elevation to the total water elevation input to SBEACH. For the potential moderate future rate of sea level rise input water levels were increased 2.4 ft and for the potential high future rate of sea level rise input water levels were increased 3.8 ft. The potential future sea level rise scenarios significantly change the predicted morphology evolution, the required nourishment fill volumes, and the predicted damages. For example, in Harrison County the average long-term shoreline change rate of -3.00 ft/year for the existing rate of sea level rise increases to -5.83 ft/year for the moderate rate of future sea level rise and to -5.18 ft/year for the high rate of future sea level rise. The reason for the decrease in the average annual rate of shoreline change between the moderate rate of sea level rise and the high rate of sea level rise is due to more frequent complete inundation of the beach berm for the high rate of sea level rise which results in less berm erosion and consequently less shoreline change. In Hancock county the average long-term shoreline change rate of -4.85 ft/year for the existing rate of sea level change increases to -5.18 ft/year for the moderate rate of future sea level rise and to -5.98 ft/year for the high rate of future sea level rise.

As mentioned, the future potential sea level rise scenarios result in much more frequent inundation of the beach system. The potential moderate rate of future sea level rise increases the peak total water elevation of 48 percent of the historical storms by more than a factor of 2. Similarly, the potential high rate of future sea level rise increases the peak total water elevation of 78 percent of the historical storms by more than a factor of 2, the peak total water elevation of 20 percent of the historical storms is increased by more than a factor of 3.

2.3.5 Results

The results of the coastal processes analysis are presented in the context of the with- and without-project simulations. All Beach-*fx* simulations involved consideration of 300 potential future lifecycles of 105 year duration. The sequence and number of storm events in each lifecycle was randomly selected from the plausible storm suite of 852 historically-based storm events. The sequence and number of storms encountered in each lifecycle simulation is unique. However, the series of lifecycles used in the evaluation of the with- and without-project alternatives are identical. On average, 65 storms were encountered in each of the 105-year lifecycle simulations whereas the maximum and minimum number of storms per lifecycle is 90 and 45 storms, respectively. The standard deviation in the number of storms per lifecycle is 8. To illustrate the stochastic character of the Beach-*fx* simulations Hurricane Camille, the most intense event in the suite of historically-based plausible storms, is encountered a total of 267 times in the 300 105-year lifecycle simulations. In 96 lifecycles Camille is encountered just once, in 54 lifecycles Camille is encountered twice, in 14 lifecycles Camille is encountered three times, in four lifecycles Camille is encountered four times and in one lifecycle Camille is encountered five different times. In 33 of the 300 simulated lifecycles Hurricane Camille is never encountered.

2.3.5.1 Future Without-Project Simulations

The future without-project simulations assumed continuation of existing shore protection activities and two alternative scenarios of the future shore protection activities were examined. The first alternative examined continued maintenance of the existing berm project in Harrison and Hancock counties. The second future without project alternative involved not only maintenance of the existing berm project but also construction and maintenance of the "interim dune" feature, which involves a 2.9 yd^3/ft dune feature positioned 50 ft seaward of the Hwy. 90 seawall with a 10 ft (NAVD 88) dune elevation and a 10 ft dune crest width in Harrison County. In Hancock County the interim dune feature is comprised of approximately 1.6 yd^3/ft of sand with a 7 ft (NAVD 88) dune elevation and a 10 ft dune crest width. The berm project in Harrison County involves a 230 ft wide berm extending seaward from the Hwy. 90 seawall to the Sound. The berm elevation varies from an elevation of approximately 7.2 ft (NAVD 88) at the seawall to 3.5 ft at the slope break to the Sound. The Hancock County berm project involves a 150 ft wide berm extending from the seawall to the Sound. The berm elevation varies from approximately 5.0 (NAVD88) ft at the seawall to 3.5 ft at the slope break to the Sound.

Maintenance of the future without project alternatives in Harrison County occurs on a 12 year interval at which time the without project alternative template is restored by hydraulic placement of fill material obtained from offshore sand sources. In Hancock County maintenance of the future without project alternatives occurs on an annual basis by truck haul placement. These differences in the frequency of beach maintenance in Harrison and Hancock Counties significantly influence the volume requirements of maintaining the beaches in the two counties. The magnitude of the influence of the maintenance cycle on with and without project volume requirements is discussed further in section 2.3.4.

Table 2.3-1 summarizes the results of the Harrison County without-project Beach-*fx* simulations. The data in Table 2.3-1 indicate that existing beach maintenance practices will require approximately 130 yd^3/ft of beach over a 100 year project life assuming the existing rate of sea level rise persists into the future. If however, future rate of sea level rise increases the simulations indicate that the potential moderate rate of future sea level rise will result in about a 90 percent increase in volume requirements, whereas, a high rate of future sea level rise will result in about a 115 percent increase in project volume requirements.

Table 2.3-1.
Harrison County Without-Project Summary

Alternative Name[1]	Number of Nourishments				Nourishment Volume (yd^3/ft)			
	mean	SD	max	min	mean	SD	max	min
Berm_ESLR	6	1	8	4	142.3	22.0	214.7	85.6
Interim Dune & Berm ESLR	7	1	8	5	124.9	22.1	208.6	72.5
Berm_MSLR	8	1	8	5	278.1	36.6	385.3	179.6
Interim Dune & Berm MSLR	8	0	8	7	229.2	26.1	310.4	169.4
Berm_HSLR	8	0	8	6	324.4	39.2	437.7	211.3
Interim Dune & Berm HSLR	8	0	8	7	248.9	28.5	338.9	192.1

[1] ESLR refers to "existing" sea level rise, MSLR refers to a "moderate" potential future sea level rise rate, and HSLR refers to a "high" potential future sea level rise rate

Table 2.3-2 summarizes the results of the Hancock County without-project Beach-*fx* simulations. The data in Table 2.3-2 indicate that existing beach maintenance practices will require approximately 304 yd^3/ft of beach over a 100 year project life assuming the existing rate of sea level rise persists into the future. If however, future rate of sea level rise increases the simulations indicate that the potential moderate rate of future sea level rise will result in about a 51 percent increase in volume requirements, whereas, a high rate of future sea level rise will result in about a 69 percent increase in project volume requirements.

Table 2.3-2.
Hancock County Without-Project Summary

Alternative Name[1]	Number of Nourishments				Nourishment Volume (yd^3/ft)			
	mean	SD	max	min	mean	SD	max	min
Berm_ESLR	100	0	100	100	297.7	28.1	379.7	250
Interim Dune & Berm ESLR	100	0	100	100	310.3	31.6	396.9	250
Berm_MSLR	100	0	100	100	443.7	47.0	581.7	302.9
Interim Dune & Berm MSLR	100	0	100	100	473.1	53.5	607.0	285.7
Berm_HSLR	100	0	100	100	497.2	53.1	654.8	351.9
Interim Dune & Berm HSLR	100	0	100	100	531.5	32.1	619.7	452.1

[1] ESLR refers to "existing" sea level rise, MSLR refers to a "moderate" potential future sea level rise rate, and HSLR refers to a "high" potential future sea level rise rate.

2.3.5.2 Future With-Project Simulations

The future with-project simulations involved evaluation of four alternative design cross-sections in both Harrison and Hancock counties. The maintenance or renourishment of the design cross-sections are the same as those used in evaluation of the future without-project alternatives: renourishment every 12 years by hydraulic placement in Harrison County and annual reconstruction of the design cross-section, as required, by truck haul placement in Hancock County. The design cross-sections in Harrison County involved a 15 ft dune height, 35 ft dune crest width and a 160 ft berm width (Alternative 1); a 15 ft dune height, 25 ft dune crest width and a 170 ft berm width (Alternative 2); a 13 ft dune height, 45 ft dune crest width and a 160 ft berm width (Alternative 3); and a 13 ft dune height, 15 ft dune crest width and a 160 ft berm width (Alternative 4). Dune volumes for the four Harrison County design alternatives are 17.2 yd^3/ft, 13.9 yd^3/ft, 14.2 yd^3/ft, and 6.7 yd^3/ft for Alternatives 1, 2, 3, and 4, respectively. The design cross-sections in Hancock County involved a 10 ft dune height, 40 ft dune crest width and 80 ft berm width (Alternative 1); a 10 ft dune height, 20 ft dune crest width and 100 ft berm width (Alternative 2); an 8 ft dune height, 50 ft dune crest width and 80 berm width (Alternative 3); and an 8 ft dune height, 30 ft dune crest width and 100 ft berm width. Dune volumes for the four Hancock County design alternatives are 10.7 yd^3/ft, 6.6 yd^3/ft, 7.3 yd^3/ft, and 4.7 yd^3/ft, for Alternatives 1, 2, 3, and 4, respectively.

Table 2.3-3 summarizes the results of the Harrison County with-project Beach-*fx* simulations. The data in Table 2.3-3 indicate that, in general, nourishment is required at the end of every nourishment cycle (the maximum number nourishments is 9) for the moderate and high potential future sea level rise rate. However, for the existing rate of sea level rise on average 2 nourishment cycles can be skipped for Alternative 1 and one nourishment cycle can be skipped for Alternatives 2 and 4. Nourishment volume requirements over the 100-year project life are approximately 197 yd^3/ft of beach assuming the existing rate of sea level rise persists into the future. If however, the future rates of sea level rise increases the simulations indicate that the potential moderate rate of future sea level rise will result in about a 65 percent increase in volume requirements, whereas, a high rate of future sea level rise will result in about an 86 percent increase in project volume requirements.

Table 2.3-4 summarizes the results of the Hancock County without-project Beach-*fx* simulations. The data in Table 2.3-4 indicate that with-project nourishment volumes for the existing rate of sea level rise are approximately 369 yd^3/ft of beach over a 100-year project life. If however, future rate of sea level rise increases the simulations indicate that the potential moderate rate of future sea level rise will result in about a 75 percent increase in volume requirements, whereas, a high rate of future sea level rise will result in about a 102 percent increase in project volume requirements.

Table 2.3-3.
Harrison County With-Project Summary

Alternative Name[1]	Number of Nourishments				Nourishment Volume (yd^3/ft)			
	mean	SD	Max	min	mean	SD	max	min
Alternative 1 ESLR	7	1	9	4	202.6	37.5	334.7	116.6
Alternative 2 ESLR	8	1	9	4	199.9	37.3	360.2	99.4
Alternative 3 ESLR	8	1	9	4	203.7	38.0	351.9	122.8
Alternative 4 ESLR	8	1	9	4	180.7	35.5	321.3	82.8
Alternative 1 MSLR	9	1	9	7	366.7	48.5	506.6	240.8
Alternative 2 MSLR	9	0	9	7	360.9	47.9	488.6	243.1
Alternative 3 MSLR	9	1	9	7	351.5	46.7	483.7	235.0
Alternative 4 MSLR	9	0	9	7	296.9	40.1	396.2	203.8
Alternative 1 HSLR	9	0	9	7	421.4	49.1	531.2	312.0
Alternative 2 HSLR	9	0	9	7	411.2	49.4	539.9	278.1
Alternative 3 HSLR	9	0	9	7	418.0	44.7	540.8	294.9
Alternative 4 HSLR	9	0	9	7	335.5	36.8	437.1	247.8

[1] ESLR refers to "existing" sea level rise, MSLR refers to a "moderate" potential future sea level rise rate, and HSLR refers to a "high" potential future sea level rise rate.

Table 2.3-4.
Hancock County With-Project Summary

Alternative Name[1]	Number of Nourishments				Nourishment Volume (yd^3/ft)			
	mean	SD	max	min	mean	SD	max	Min
Alternative 1ESLR	100	0	100	100	384.1	68.3	829.8	283.6
Alternative 2 ESLR	100	0	100	100	352.9	61.8	758.5	272.0
Alternative 3 ESLR	100	0	100	100	380.6	65.8	748.8	294.7
Alternative 4 ESLR	100	0	100	100	358.1	75.7	1,117.7	279.3
Alternative 1MSLR	100	0	100	100	690.1	121.9	1,034.5	445.8
Alternative 2 MSLR	100	0	100	100	587.5	93.0	877.4	404.7
Alternative 3 MSLR	100	0	100	100	674.1	136.3	1,059.4	410.3
Alternative 4 MSLR	100	0	100	100	587.4	100.1	887.6	371.6
Alternative 1HSLR	100	0	100	100	835.8	107.6	1,252.4	624.3
Alternative 2 HSLR	100	0	100	100	682.1	77.3	883.9	490.9
Alternative 3 HSLR	100	0	100	100	704.0	80.5	1,012.8	549.6
Alternative 4 HSLR	100	0	100	100	599.9	63.7	853.2	449.3

[1] ESLR refers to "existing" sea level rise, MSLR refers to a "moderate" potential future sea level rise rate, and HSLR refers to a "high" potential future sea level rise rate.

2.3.6 Summary

The coastal processes analysis conducted as a part of this study has provided a number of useful insights with respect to morphology change, coastal evolution, and the primary drivers for storm-induced damages along the Mississippi Sound shoreline. First, the Mississippi Sound shoreline is primarily a stable, low energy coast that is dramatically impacted by tropical storm events. In the absence of tropical storm events the shoreline is expected to be only slightly erosive with shoreline change rates on the order of -1 ft/year. In general, moderate storm events produce more coastal erosion and volumetric beach change along the Mississippi Sound shoreline than do major hurricanes. This is because the large storm surge associated with the very intense storms completely inundates the beach system and protects it from the high energy dissipation associated with wave breaking, which results in less overall shoreline change and volumetric erosion of the beach. Damages to upland infrastructure are largely driven by inundation and direct wave attack as opposed to erosion, partly because most of the infrastructure is located landward of the sea wall that runs along Hwy 90 Harrison County and Beach Boulevard in Hancock County.

As a result of the difference in maintenance cycles in Harrison and Hancock counties the project volume requirements in Hancock County exceed those in Harrison County by approximately 225 percent for without project conditions under existing sea level rise conditions, for the potential future sea level rise scenarios the increase in volume requirement is about 180 percent. For with project conditions the volume requirements in Hancock County exceed those in Harrison County by approximately 190 percent. The reason the volume requirements are so much higher in Hancock County is because the beach is restored to design conditions every year if needed, whereas in Harrison County the beach is restored to design conditions once every 12 years. If the beach in Harrison County is damaged by a major storm in the year following reconstruction of the design template the beach remains vulnerable for the remainder of the 11 year nourishment cycle. Essentially, the present analysis indicates that the nourishment cycle in Harrison County should be shortened or augmented with a provision for emergency dune reconstruction after the occurrence of a major storm event.

2.4 Statistical Methodology

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 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). The JPM-OS methodology was applied for this study and is summarized here. For a full description, see Resio (2007).

2.4.1 JPM-OS

The JPM was developed in the 1970's (Myers, 1975; Ho and Meyers, 1975) and subsequently extended by a number of investigators (Schwerdt *et al.*, 1979; Ho *et al.*, 1987) in an attempt to circumvent problems related to limited historical records. In this approach, information characterizing a small set of storm parameters was analyzed from a relatively broad geographic area. The underlying concept of the JPM-OS methodology is to provide a good estimate of the surges in as small a number of dimensions as possible, while retaining the effects of additional dimensions by including an ε term within the estimated Cumulative Distribution Function (CDF) for surges. The ε term is considered to include, at a minimum, tides, random variations in the Holland B parameter, track variations not captured in storm set, model errors (including errors in bathymetry, errors in model physics, etc.), and errors in wind fields due to neglect of variations not included in the PBL winds. It is evident that the overall distribution of ε can only be approximated from ancillary information on errors in comparisons to high water marks and comparisons of results from runs with the "best-estimate" wind fields and PBL wind fields. Tides are factored into the analysis assuming linear superposition, with some degree of error introduced. Based on the best available approximations to all of these terms, assuming that all the "error" contributions are independent, and a loose application of the Central Limit Theorem, it is assumed that the "error" term can be represented as a Gaussian distribution with a mean of zero (assuming that the model suite is calibrated to this condition) and a standard deviation equal to some percentage of the modeled surge.

The JPM-OS treats geographic variation by using the Chouinard et al. (1997) method for determining optimal spatial size for estimating hurricane statistics. In this method, the optimal size for spatial sampling is estimated in a manner that balances the opposing effects of spatial variability and uncertainties related to sample size. It can be shown that the optimal spatial sample (kernel) size is in the range of 160 km for frequency analyses, and that the optimal spatial size for intensities reaches a plateau above about 200 km and does not drop off substantially at higher spatial kernel sizes. For developing the JPM-OS for the Mississippi and Louisiana coasts, a basic data set of 22 hurricanes, which had central pressures less than 955 mb, were analyzed. The hurricane sample set covers the interval 1941 through 2005.

A "line-crossing" frequency analysis methodology was applied since the frequency of landfalling storms is inherently better posed in this context. Sensitivity studies showed that the results for spatial samples for spatial kernels above 250 km do not vary markedly and a sample size of ±3 degrees (333 km) along this line was selected. Results from this analysis were converted into an estimate of the frequency of hurricanes (which attain a minimum central pressure of 955 mb or less) making landfall within contiguous 1-degree increments along the reference line. For each 1-degree increment along the coast, pressure differentials at the time of landfall for all storms making landfall within the ±3-degree distance along the reference line were used to define a best-fit (conditional) Gumbel distribution, i.e. the distribution of hurricane intensity given that a hurricane (with central pressure less than 955 mb) does occur. Combining the storm frequency estimates with the Gumbel coefficients for the pressure differentials, estimates of the omni-directional probability of intensity along the Gulf coast at the time of landfall can be made.

Storm size is not independent of storm intensity. Recently, Shen (2006) has shown that the potential intensity achievable by a hurricane is very sensitive to the size of a hurricane eye. Figures 2.4-1a and 2.4-1b show the relationships between the pressure scale radius (R_p) (i.e storm size) and central pressure of all storms exceeding Category 2 within the Gulf of Mexico at their time of maximum strength (52 storms –shown in Figure 2.4-1a) and the 22-storm sample of landfalling storms (Figure 2.4-1b). The following equation gives an estimate of the conditional probability of storm size as a function of central pressure:

$$P(R_p \mid \Delta p) = \frac{1}{\sigma(\Delta p)\sqrt{2\pi}} e^{-\frac{x^2}{2}}$$

where E2.4-1

$$x = \left(\frac{R_p - \overline{R}_p(\Delta p)}{\sigma(\Delta p)} \right)$$

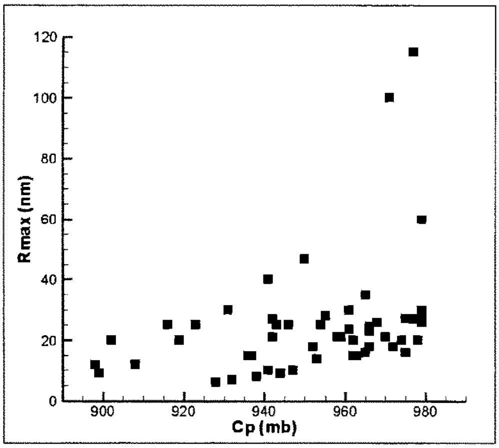


Figure 2.4-1a. Relationship between size scaling parameter (Rp) versus Central Pressure for 52 storm set in Gulf of Mexico (all storms > Cat 2). For reference, Hurricane Camille is characterized as Cp=909 mb and Rmax=11 nm. Hurricane Katrina is characterized as Cp=920 mb and Rmax=19 nm.

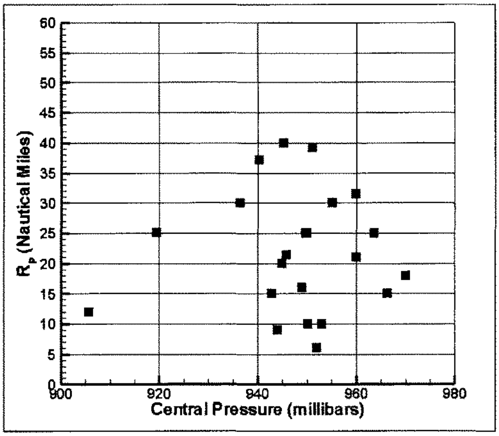


Figure 2.4-1b. Relationship between size scaling parameter (Rp) versus Central Pressure for 22 storm set in Gulf of Mexico (all storms with central pressure < 955)

Figure 2.4-2 gives the mean angle of storm heading as a function of distance along the reference line shown in Figure 2.4-3, along with the standard deviation of the heading angles around this mean value. The direction convention used here is that a heading of due north represents an angle of zero degrees. Storms heading more westerly than due north will have positive angles, while storms heading more easterly will have negative angles. These estimates were derived by the same spatial averaging procedure used in deriving the central pressures and frequencies. A circular normal distribution is used to represent the storm heading probability distribution as a function of location along the reference line.

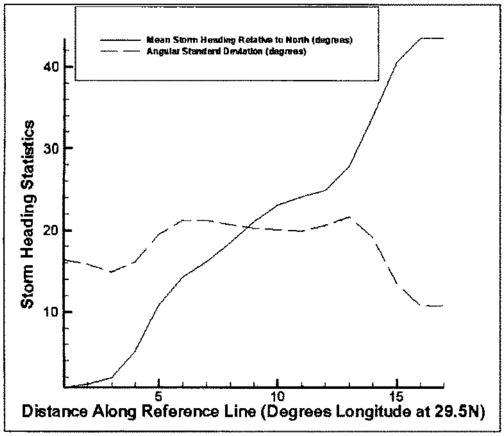


Figure 2.4-2. Plot of mean storm heading angle and standard deviation around this angle as a function of location along reference line. Distance along the x-axis can be taken as equivalent to 1-degree increments along the coast.

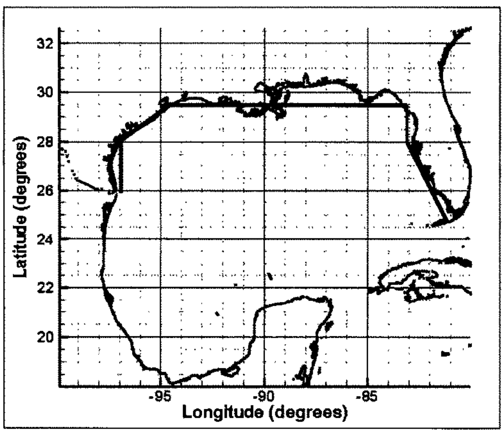


Figure 2.4-3. Location of line for analysis of hurricane landfalling characteristics

Figure 2.4-4 presents the estimated forward storm speed as a function of central pressure. This figure suggests that storm intensity and the forward speed of the storm are approximately independently distributed. Forward storm speed is plotted as a function of storm heading at landfall for the 14 storm subset that intersect with the 29.5-degree latitude portion of the reference line in Figure 2.4-3 and for the entire 22-storm sample of landfalling storms (shown in Figures 2.4-5a and 2.4-5b). These figures show that there is a tendency for higher forward speeds to be associated with lower storm heading angle (a correlation of 0.52 which is significant at the 0.05 level of significance with 21 degrees of freedom in a "Student's *t*" test). This is consistent with the expected behavior of re-curving storms that become swept up in stronger westerly circulations. The primary exception to the overall relationship is Hurricane Betsy, represented by the point in the upper right-hand corner of Figure 2.4-5b. This storm moved rapidly into the New Orleans area after crossing the lower portion of the Florida peninsula.

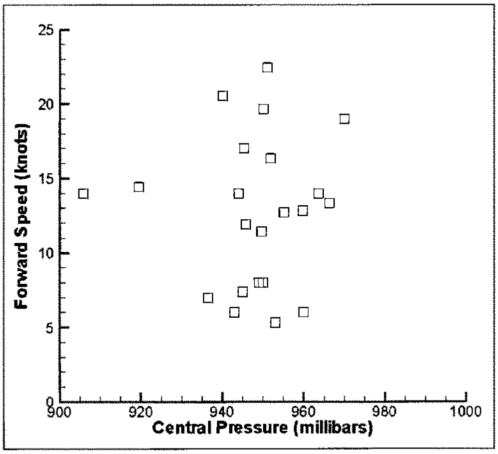


Figure 2.4-4. Plot of forward speed of storm at landfall versus central pressure at landfall

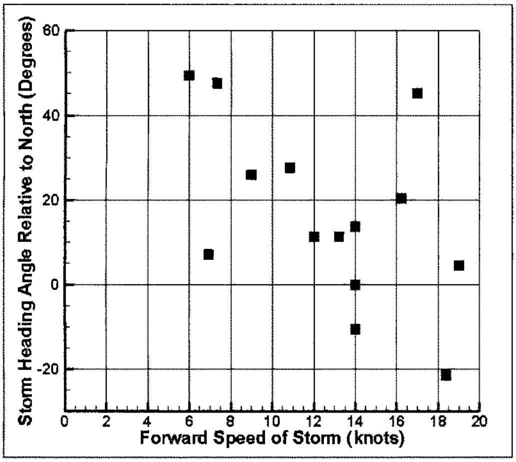


Figure 2.4-5a. Plot of storm heading and forward speed at time of landfall for only central Gulf landfalling storms

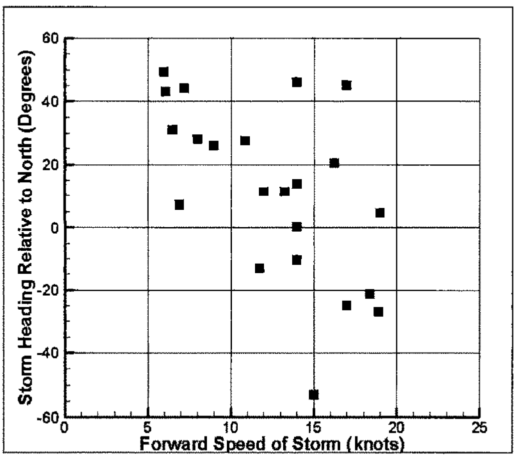


Figure 2.4-5b. Plot of storm heading and forward speed at time of landfall for the entire 22-storm sample

Consolidating this information, for any point in the five-dimensional parameter space (retaining appropriate interrelationships among parameters), the final estimates of joint probability densities can be written as

$$p(c_p, R_p, v_f, \theta_l, x) = \Lambda_1 \cdot \Lambda_2 \cdot \Lambda_3 \cdot \Lambda_4 \cdot \Lambda_5$$

$$\Lambda_1 = p(c_p \mid x) = \frac{\partial F[a_0(x), a_1(x)]}{\partial c_p} = \frac{\partial}{\partial x}\left\{ \exp\left\{ -\exp -\left[\frac{c_p - a_0(x)}{a_1(x)} \right] \right\} \right\} \text{ (Gumbel Distribution)}$$

$$\Lambda_2 = p(R_p \mid c_p) = \frac{1}{\sigma(\Delta P)\sqrt{2\pi}} e^{-\frac{(\bar{R}_p(\Delta P) - R_p)^2}{2\sigma^2(\Delta P)}}$$

$$\Lambda_3 = p(v_f \mid \theta_l) = \frac{1}{\sigma\sqrt{2\pi}} e^{-\frac{(\bar{v}_f(\theta_l) - v_f)^2}{2\sigma^2}} \qquad \text{E2.4-2}$$

$$\Lambda_4 = p(\theta_l \mid x) = \frac{1}{\sigma(x)\sqrt{2\pi}} e^{-\frac{(\bar{\theta}_l(x) - \theta_l)^2}{2\sigma^2(x)}}$$

$$\Lambda_5 = \Phi(x)$$

where the overbars denote average values of the dependent variable for a specified value of an independent variable in a regression equation, $a_0(x)$ and $a_1(x)$ are the Gumbel coefficients for the assumed Gumbel form of the central pressures, and $\Phi(x)$ is the frequency of storms per year per specified distance along the coast (taken as one degree in examples presented here).

2.4.1.1 Estimation of the ε term

Although there may be some degree of nonlinearity in the superposition of tides and storm surges, numerical experiments have shown that for the most part linear superposition provides a reasonable estimate of the (linearly) combined effects of tides and surges. Thus, the tidal component of the ε term, represents the percentage of time occupied by a given tidal stage and can be directly derived from available tidal information along the coast.

Careful analyses appropriate for formulating Holland B parameters for ocean response modeling have shown that this parameter falls primarily in the range of 1.1–1.6 offshore and 0.9–1.2 at the coast. For Gulf of Mexico hurricanes, a mean value of 1.27 in offshore areas is assumed with a standard deviation of 0.15, while at the coast the corresponding mean and standard deviation is 1.0 and 0.10, respectively. Via numerical experiments, the maximum storm surge generated by a hurricane has been found to vary approximately linearly with variations in the Holland B parameter, at least for changes of the Holland B parameter in the range of 10–20%.

Off-coast track variations affect surges at the coast primarily through the effects of these track variations on wave fields, rather than by their effects on direct wind-driven surges. Wave fields tend to integrate wind field inputs over tens of hours; consequently, off-coast track variations tend to shift the wave fields somewhat while maintaining the general form and magnitude of the wave height contours. Near-coast radiation stresses are approximately proportional to gradients in wave energy fluxes, which, in turn, can be related to the square of the wave height gradient. In shallow water, where contributions of radiation stresses to surges are most important, wave heights tend to be depth limited. It is only in the incremental region, where larger waves make additional contributions due to increased energy losses offshore, that larger wave conditions affect the total wave set-up at the coast. Numerical sensitivity studies suggest that once incident waves become much larger than about 10 meters, most of the additional energy loss is in depths that do not contribute very much to wave set up. For this reason plus the fact that in general the wave set-up term tends to be only about 15-30% of the total surge, we expect the effect of storm track variations on wave set-up at the coast to be fairly small (due to the fact that surge response is on a much faster scale than wave generation, where we noted that the "straight-track" approximation was not very good). It is assumed that the deviations around the mean surge will be approximately Gaussian. A standard deviation of 20% of the calculated wave-set up contributions to the total surge (determined by subtracting the direct wind-only surge from the total surge due to winds and waves combined) will be used within this distribution.

Model errors combined in calibration/verification runs of ADCIRC have shown that this combination of model and forcing in the Louisiana-Mississippi coastal area provides relatively unbiased results with a standard deviation in the range of 1.75–2.50 ft. Details on model validation are given in IPET (2007a). Relative errors associated with the use of PBL winds increase the value of the standard deviation to 2.00 to 3.50 ft. See IPET (2007b) for details. This is not too surprising, since the accuracy of HWM's (the primary measurements to which the model results are compared) are quite variable.

Combining all of these terms, under the assumption that they are each independently distributed, gives

$$p(\varepsilon) = \iint\iint \delta(\varepsilon_1 + \varepsilon_2 + \varepsilon_3 + \varepsilon_4 - \varepsilon) p(\varepsilon_1) p(\varepsilon_2) p(\varepsilon_3) p(\varepsilon_4) d\varepsilon_1 d\varepsilon_2 d\varepsilon_3 d\varepsilon_4 \qquad \text{E2.4-3}$$

where

ε_1 is the deviation between a storm at a random tide phase and a zero tide level;

ε_2 is the deviation created by variation of the Holland B parameter;

ε_3 is the deviation created by variations is tracks approaching the coast; and

ε_4 is the deviation created primarily by errors in models and grids.

Three of the terms ε_1, ε_3 and ε_4 are treated here as though they are approximately independent of the magnitude of the surge, while the remaining term, ε_2 has been found to depend essentially linearly with the magnitude of the surge. For a monochromatic tide, the tidal elevation distribution, ε_1, is known to be bimodal distributed around its zero value; however, in nature, the effect of combining several tidal components with varying phases is to force the distribution toward a unimodal distribution. The probabilities of terms ε_3 and ε_4 are assumed to be normally distributed; thus, the probability distribution of the sum of these two terms will also be a normal distribution with the variance given by the sums of the individual variances of the two terms.

Figure 2.4-6 gives a numerical example of the combination of all four terms assuming a storm surge of 15 ft, as might be associated with a particular deterministic model execution based on a set of track and PBL parameters. As can be seen in this figure, the overall magnitude of these effects can add or subtract substantially to the total water depth. In this case, the distribution appears similar to a Gaussian distribution, since it is dominated by the term with the largest variance (deviations due to the omission of the Holland B parameter); however, the other terms have been included within the integral for $p(\varepsilon)$. Table 2.4-1 shows an example of the effect of adding this term on expected surge levels for selected return periods. In this example, a Poisson frequency of 1/16 was used in combination with a Gumbel distribution, with parameters $a_0 = 9.855$ and $a_1 = 3.63$. For this example, the effect of adding the ε-term is less than ½ ft for return periods up to 175 years and only exceeds1 ft at return periods greater than 400 years. However, for risk-based calculations which often include very large return periods (1000-10000 years), this term can become as large as 2-3 ft, even for the case where the effects of all neglected factors are assumed to be distributed around a mean deviation of zero. The effect could of course be larger if the deviations were biased.

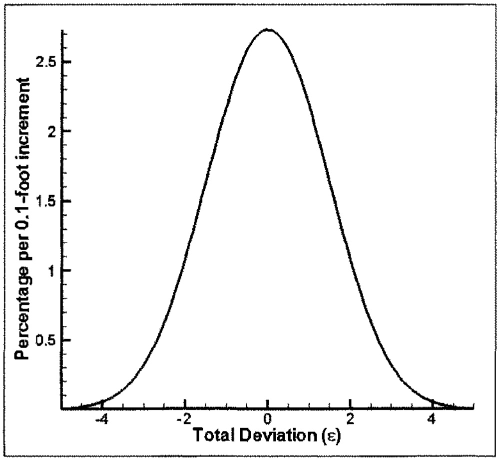


Figure 2.4-6. Percentage of deviations per 0.1-foot class as a function of deviation in feet

Table 2.4-1.
Example of Expected Surge Values as a Function of Return Period With and Without ε-Term

Return Period (years)	Without ε-Term (ft)	With ε-Term (ft)
50	11.98	12.06
100	14.82	15.21
200	17.67	18.35
300	19.33	20.18
400	20.52	21.49
500	21.43	22.50

From Table 2.4-1 and the above discussion, we see that the effect of the ε-term becomes much more pronounced at large return periods. Thus, older applications of the JPM that neglected this term were probably reasonably accurate at the 100-year return period, but were likely to have been progressively biased low at higher return periods. The important points to stress here are twofold. First, any neglect or suppression of natural variability in a procedure to estimate extremes will lead to some degree of underestimation of the estimated extremes; therefore, it is important to recognize and attempt to quantify all significant factors affecting surge heights at the coast. Second, to avoid making the number of dimensions in the JPM unmanageable, the estimated effects of the neglected factors contributing to extreme surges should be addressed statistically, such as done here via the addition of the ε-term to the JPM integral.

2.4.1.2 Sampling of Storm Parameters for the JPM-OS

In the conventional JPM, each simulation was typically treated as representative of its entire discrete probability range (i.e. all of the probability for each multi-dimensional box centered on its mean position). In these applications, the computational burden was considerably less than what is considered appropriate for surge simulations. Even in the original JPM, however, a scaling relationship between the pressure differential of a storm and computed surge levels was used to reduce the number of computer runs. This relationship, based on theoretical considerations and confirmed numerically in several studies, shows that surges are linearly proportional to the pressure differential of a storm at all areas close to the area of maximum storm impact. This information can be used effectively to interpolate between two different numerical results within the JPM integral. Such an interpolation provides added resolution along the pressure differential axis in this integral, which is very important due to the highly nonlinear characteristics of the probability of pressure differentials [$p(\Delta P)$].

In addition to the scaling relationship between surge levels and pressure differentials, the JPM-OS attempts to sample the parameter space in a fashion that can be used to estimate surges (develop the response surface) in an optimal manner. This method has been developed via hundreds of simulations on relatively straight coasts, as well as on coasts with other simple geometries, and is in the process of being extended to more complex coasts. It attempts to alleviate the need for very closely spaced parameter values in numerical simulations (essentially track spacing and number of storm sizes, forward speeds, and track angles considered); thereby potentially greatly reducing the total number of computer runs required for JPM execution. The storm suite for this study is discussed in section 2.4.2.

2.4.1.3 Specification of Variations in Pre-landfalling Hurricanes

Whereas the original JPM considered storm size, intensity, and wind field distribution to be constant in storms approaching the coast, the new JPM uses information from recent storms to estimate the rate of change of these parameters for pre-landfall conditions. In general these trends show that storms tend to fill by about 10-15 millibars, become slightly (15-30%) larger and have less peaked wind speed distributions (Holland B parameter decreasing from about 1.27 to around 1.0) over the last 90 nautical miles of coastal water before landfall. Since all of our probabilities have been developed based on landfalling characteristics, the offshore characteristics must be estimated from a generalized transform

$$p(\Delta P, R_p, v_f, \theta_l, x)_{offshore} = p(\Delta P, R_p, v_f, \theta_l, x)_{landfall} J^{-1} \qquad \text{E2.4-4}$$

where J is the Jacobian for the transform from nearshore to offshore conditions. However, since 1) storm heading during approach to the coast is relatively constant, 2) the forward speeds are assumed to be constant during approach to land and 3) the points of intersection (x) are identical for each offshore and landfall case, the transform can be viewed in only two dimensions, ΔP and R_p.

2.4.2 Storm Suite

Figures 2.4-7a to 2.4-7d show the synthesized primary tracks used in the study. The central tracks essentially mimic the behavior of intense landfalling historical storms in the record, while preserving the geographic constraints related to land-sea boundaries. These storms preserve the historical pattern of the tracks better than simply shifting the same storm tracks east or west along the coast, since they capture the observed variations in mean storm angles along the coast.

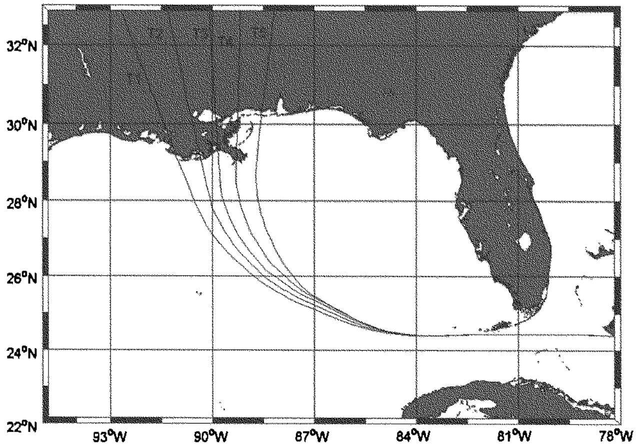


Figure 2.4-7a. Synthesized Tracks Used in the Study

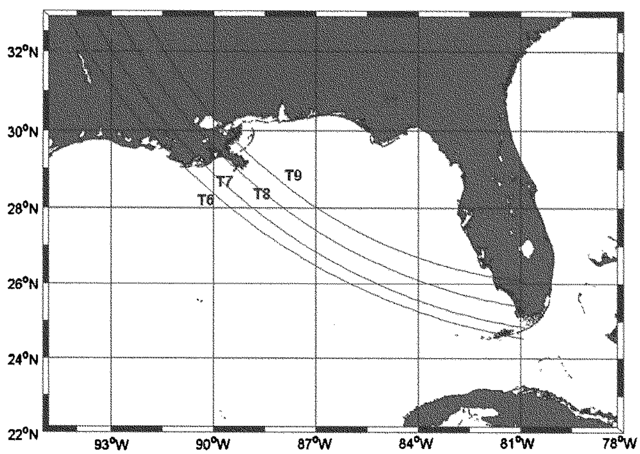


Figure 2.4-7b. Synthesized Tracks Used in the Study

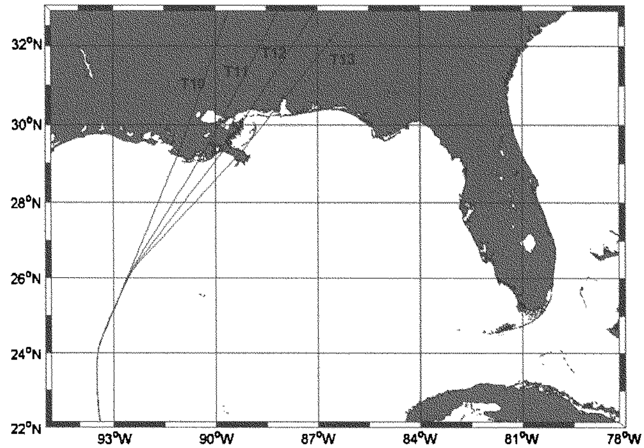


Figure 2.4-7c. Synthesized Tracks Used in the Study

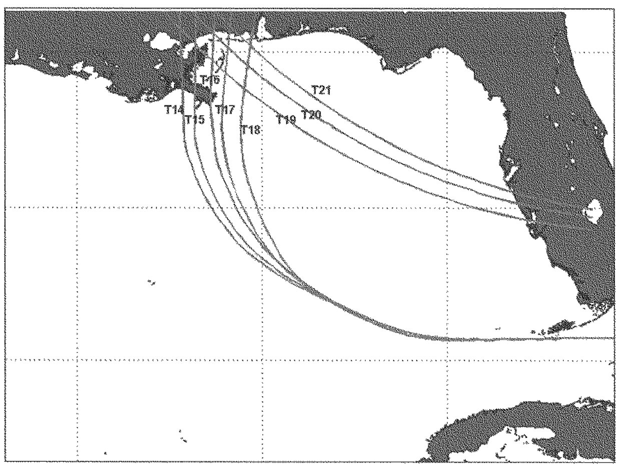


Figure 2.4-7d. Synthesized Tracks Used in the Study

Along each of the tracks modeled, the central pressure is allowed to vary during a simulated intensification interval until its intensity reaches a plateau. This plateau is maintained until the storm comes within 90 nautical miles of the coast at that time, the pressures decay according to the (linear interpolation) relationship

$$C_p(s) = \lambda_0 C_p(s_0) - (1-\lambda_0)\Delta P_{decay} \tag{E2.4-5}$$

where

C_p is the central pressure at s

s is the distance along the storm track, with s_0 located 90 nm from landfall

λ_0 is an interpolation multiplier (=1 at 90 nm from landfall and =0 at landfall)

ΔP_{decay} is the total change in central pressure over 90 nm approach to landfall

The pressure decay term is somewhat dependent on storm size, so the following relationship was used to represent this term

$$\Delta P'_{decay} = R_p - 6 \quad \text{(with } R_p \text{ given in nautical miles)}$$
$$\text{constrained by } \Delta P_{decay} = Max(\Delta P'_{decay}, 18); Min(\Delta P'_{decay}, 5) \tag{E2.4-6}$$

Once a storm is one hour past landfall the pressure decay factor according to Vickery is applied

$$C_p = P_\infty - \delta P \tag{E2.4-7}$$

where

$$\delta P = \delta P_0 e^{-a\Delta t}$$

where

δP is the local pressure differential

δP_0 is the pressure differential one hour after landfall

a is an empirical constant

Δt is time after landfall minus 1 hour

Rmax and the Holland B parameter are allowed to vary linearly over the same distance as Cp for all storms except the smallest storm class used in this application. For that class (Rmax = 6 nm), the storm is assumed to retain its intensity, its size, and its Holland B parameter all the way to landfall. Table 2.4-2 summarizes the central pressure / size scaling radius combinations used to define the storm suite.

Table 2.4-2.
Central Pressure/Size Scaling Radius Combinations

Central Pressure (mb)	Rmax (nm)					
900	6.0	12.5	14.9	17.7	18.4	21.8
930	8.0	17.7	25.8			
960	11.0	17.7	18.2	21.0	24.6	35.6

Defining three angles covers the important range for estimating the response surface of the surges. With the secondary variables (tidal phases, Holland B variations, wind field variations around the PBL central estimate, etc.) added to the integral, this provides a reasonable estimate of the surge CDF. The tracks approaching the Mississippi/Louisiana coast from the southeast are similar to the tracks of the 1947 Hurricane, Betsy, and Andrew. During the 1941-2005 interval, no tracks approached from the southwest; however, other storms such as the 1893 storm did approach eastern Louisiana from this direction. The 1893 track is fairly similar to one of the hypothetical tracks out of the southwest. A track from this direction represents the fact that these storms have to become caught up in the more westerly flow (winds blowing toward the east). For a storm to maintain its strength it cannot move too far west or too close to land; consequently, the track of a major storm is constrained somewhat to come from the region from which all the hypothetical (+45 degree) tracks emerge in order for these storms to strike the Mississippi coast.

The effect of storm heading angle on surges at the coast appears to be twofold. First, the overall along-coast pattern is broadened; since the storm moves along the coast at the same time that it moves toward landfall. Second, there is a relatively slow variation in the maximum surges produced by a storm as a function of the angle of the storm track with the coast. Sensitivity studies have shown that the maximum surge is relatively weakly dependent on the angle of storm intersection with the coast. In general, the hurricane approaching slightly (15-30 degrees) from west of perpendicular to a straight east-west coast produces a somewhat higher surge (5% or so) than hurricanes moving perpendicularly to the coast. On the other hand, hurricanes approaching the straight east-west coast from a more easterly direction will tend to produce lower surges than hurricanes moving perpendicular to such a coast. This appears to be a fairly broad pattern that can be represented via interpolation.

The effect of forward storm speed is addressed by considering three different forward velocities Vf=(11,6,17) knots, where 11 is around the mean and the 6-kt and 17-kt speeds span almost the entire range of Vf values at landfall for storms with Cp's less than 950. Increased forward storm speed contributes to higher wind speeds in the hurricane PBL model. Consequently, one effect of increasing forward storm velocity is to increase the surge at the coast by a factor, which is similar to increasing the wind speeds within the hurricane, i.e.

$$\eta_1 = \eta_2 \left(\frac{v_{\max} + 0.5 v_{f_1}}{v_{\max} + 0.5 v_{f_2}} \right)^2 \qquad \text{E2.4-8}$$

where

η_1 is the surge at the coast in storm 1, with forward speed = v_1

η_2 is the surge at the coast in storm 2, with forward speed = v_2

$v_{\max}$ is the maximum wind speed of a stationary storm

v_{f_i} is the forward storm velocity of the i^{th} storm

A second effect of storm speed is to change the duration that a flood wave has to propagate inland. Thus, a slowly moving storm may produce more extensive inland flooding than a faster moving storm. By covering essentially the entire range of forward storm speeds observed in major storms within the Gulf (see Figures 2.4-5a and 2.4-5b), the range of the effects of storm speed on surges can be quantified. Table 2.4-3 identifies the various parameters for the entire 197-storm suite. Tracks denoted with a and b are secondary tracks that fall between the primary tracks plotted in Figure 2.4-7.

Table 2.4-3.
Storm Suite

Run Number	Central Pressure (mb)	Rmax (nm)	Track (see Figure 1-7)	Forward Speed (knots)
Run001	960	11	1	11
Run002	960	21	1	11
Run003	960	35.6	1	11
Run004	930	8	1	11
Run005	930	17.7	1	11
Run006	930	25.8	1	11
Run007	900	6	1	11
Run008	900	14.9	1	11
Run009	900	21.8	1	11
Run010	960	11	2	11
Run011	960	21	2	11
Run012	960	35.6	2	11
Run013	930	8	2	11
Run014	930	17.7	2	11
Run015	930	25.8	2	11
Run016	900	6	2	11
Run017	900	14.9	2	11
Run018	900	21.8	2	11
Run019	960	11	3	11
Run020	960	21	3	11
Run021	960	35.6	3	11
Run022	930	8	3	11
Run023	930	17.7	3	11
Run024	930	25.8	3	11
Run025	900	6	3	11
Run026	900	14.9	3	11
Run027	900	21.8	3	11
Run028	960	11	4	11
Run029	960	21	4	11
Run030	960	35.6	4	11
Run031	930	8	4	11
Run032	930	17.7	4	11
Run033	930	25.8	4	11
Run034	900	6	4	11
Run035	900	14.9	4	11
Run036	900	21.8	4	11
Run037	960	11	5	11
Run038	960	21	5	11
Run039	960	35.6	5	11
Run040	930	8	5	11
Run041	930	17.7	5	11
Run042	930	25.8	5	11
Run043	900	6	5	11
Run044	900	14.9	5	11

Table 2.4-3.
Storm Suite (continued)

Run Number	Central Pressure (mb)	Rmax (nm)	Track (see Figure 1-7)	Forward Speed (knots)
Run045	900	21.8	5	11
Run046	960	18.2	6	11
Run047	960	24.6	6	11
Run048	900	12.5	6	11
Run049	900	18.4	6	11
Run050	960	18.2	7	11
Run051	960	24.6	7	11
Run052	900	12.5	7	11
Run053	900	18.4	7	11
Run054	960	18.2	8	11
Run055	960	24.6	8	11
Run056	900	12.5	8	11
Run057	900	18.4	8	11
Run058	960	18.2	9	11
Run059	960	24.6	9	11
Run060	900	12.5	9	11
Run061	900	18.4	9	11
Run066	960	18.2	10	11
Run067	960	24.6	10	11
Run068	900	12.5	10	11
Run069	900	18.4	10	11
Run070	960	18.2	11	11
Run071	960	24.6	11	11
Run072	900	12.5	11	11
Run073	900	18.4	11	11
Run074	960	18.2	12	11
Run075	960	24.6	12	11
Run076	900	12.5	12	11
Run077	900	18.4	12	11
Run078	960	18.2	13	11
Run079	960	24.6	13	11
Run080	900	12.5	13	11
Run081	900	18.4	13	11
Run082	960	17.7	1	6
Run083	900	17.7	1	6
Run084	960	17.7	2	6
Run085	900	17.7	2	6
Run086	960	17.7	3	6
Run087	900	17.7	3	6
Run088	960	17.7	4	6
Run089	900	17.7	4	6
Run090	960	17.7	5	6
Run091	900	17.7	5	6

Table 2.4-3.
Storm Suite (continued)

Run Number	Central Pressure (mb)	Rmax (nm)	Track (see Figure 1-7)	Forward Speed (knots)
Run092	930	17.7	6	6
Run093	930	17.7	7	6
Run094	930	17.7	8	6
Run095	930	17.7	9	6
Run097	930	17.7	10	6
Run098	930	17.7	11	6
Run099	930	17.7	12	6
Run100	930	17.7	13	6
Run101	930	17.7	1	17
Run102	930	17.7	2	17
RuN103	930	17.7	3	17
Run104	930	17.7	4	17
Run105	930	17.7	5	17
Run106	930	17.7	6	17
Run107	930	17.7	7	17
Run108	930	17.7	8	17
Run109	930	17.7	9	17
Run111	930	17.7	10	17
Run112	930	17.7	11	17
Run113	930	17.7	12	17
Run114	930	17.7	13	17
Run115	960	17.7	1b	11
Run116	900	17.7	1b	11
Run117	960	17.7	2b	11
Run118	900	17.7	2b	11
Run119	960	17.7	3b	11
Run120	900	17.7	3b	11
Run121	960	17.7	4b	11
Run122	900	17.7	4b	11
Run123	960	17.7	6b	11
Run124	960	17.7	7b	11
Run125	960	17.7	8b	11
Run126	900	17.7	6b	11
Run127	900	17.7	7b	11
Run128	900	17.7	8b	11
Run131	960	17.7	10b	11
Run132	900	17.7	10b	11
Run133	960	17.7	11b	11
Run134	900	17.7	11b	11
Run135	960	17.7	12b	11
Run136	900	17.7	12b	11
Run137	960	17.7	1	6
Run138	900	17.7	1	6
Run139	960	17.7	2	6

Table 2.4-3.
Storm Suite (continued)

Run Number	Central Pressure (mb)	Rmax (nm)	Track (see Figure 1-7)	Forward Speed (knots)
Run140	900	17.7	2	6
Run141	960	17.7	3	6
Run142	900	17.7	3	6
Run143	960	17.7	4	6
Run144	900	17.7	4	6
Run145	930	17.7	6b	6
Run146	930	17.7	7b	6
Run147	930	17.7	8b	6
Run149	930	17.7	11b	6
Run150	930	17.7	12b	6
Run151	930	17.7	13b	6
Run152	930	17.7	1	17
Run153	930	17.7	2	17
Run154	930	17.7	3	17
Run155	930	17.7	4	17
Run156	930	17.7	6	17
Run157	930	17.7	7	17
Run158	930	17.7	8	17
Run160	930	17.7	10b	17
Run161	930	17.7	11b	17
Run162	930	17.7	12b	17
Run801	960	11	18	11
Run802	960	21	18	11
Run803	960	35.6	18	11
Run804	930	8	18	11
Run805	930	17.7	18	11
Run806	930	25.8	18	11
Run807	900	6	18	11
Run808	900	14.9	18	11
Run809	900	21.8	18	11
Run810	960	11	14	11
Run811	960	21	14	11
Run812	930	8	14	11
Run813	930	17.7	14	11
Run814	900	6	14	11
Run815	900	14.9	14	11
Run816	960	11	15	11
Run817	960	21	15	11
Run818	930	8	15	11
Run819	930	17.7	15	11
Run820	900	6	15	11
Run821	900	14.9	15	11
Run822	960	11	16	11
Run823	960	21	16	11

Table 2.4-3.
Storm Suite (continued)

Run Number	Central Pressure (mb)	Rmax (nm)	Track (see Figure 1-7)	Forward Speed (knots)
Run824	930	8	16	11
Run825	930	17.7	16	11
Run826	900	6	16	11
Run827	900	14.9	16	11
Run828	960	11	17	11
Run829	960	21	17	11
Run830	930	8	17	11
Run831	930	17.7	17	11
Run832	900	6	17	11
Run833	900	14.9	17	11
Run846	960	18.2	19	11
Run847	960	24.6	19	11
Run848	900	12.5	19	11
Run849	900	18.4	19	11
Run850	960	18.2	20	11
Run851	960	24.6	20	11
Run852	900	12.5	20	11
Run853	900	18.4	20	11
Run854	960	18.2	21	11
Run855	960	24.6	21	11
Run856	900	12.5	21	11
Run857	900	18.4	21	11

2.4.3 Measure Evaluation

To evaluate the lines of defense 3 and 4, a subset of the 197-storm suite was simulated with the structures in place. Storms 019 to 045 were selected for this purpose. The deviation of the surge and wave response from the no project condition with the lines of defense in place was computed for each storm in the measure evaluation suite. It is assumed that the rank order of the storms does not change from the no project condition such that for a given station location

$$\eta'(T)= \eta(T)+\zeta(T) \qquad \text{E2.4-9}$$

where η' is the surge/waves with the line of defense in place, T is return period, η is surge/waves for the no project condition, and ζ is the deviation from the no project condition. The deviation as a function of return period ($\zeta(T)$) is computed from the subset of 27 storms. Figure 2.4-8 is an example plot showing the deviation between line 3 and the no project condition for a save station in St. Louis Bay. With a shape preserving interpolation, the deviation at each return period is computed and applied to adjust the stage frequency relationships for the proposed lines of defense.

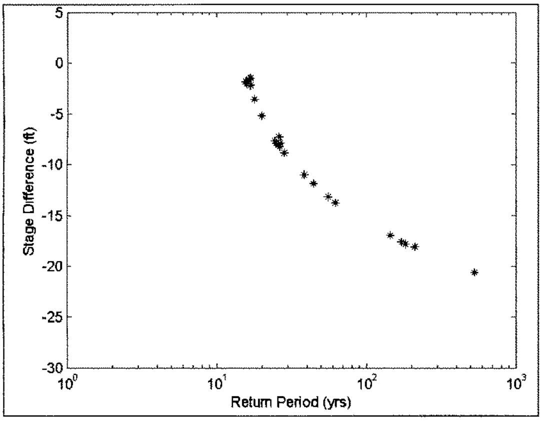


Figure 2.4-8. Plot of difference in storm surge between line of defense 3 and the no project condition as a function of return period at a save location in St. Louis Bay.

2.4.4 References

Interagency Performance Evaluation Task Force, 2007a, "Performance Evaluation of the New Orleans and Southeast Louisiana Hurricane Protection System, Volume IV – The Storm," U.S. Army Corps of Engineers, Washington, D.C., https://ipet.wes.army.mil/

Interagency Performance Evaluation Task Force, 2007b, "Performance Evaluation of the New Orleans and Southeast Louisiana Hurricane Protection System, Volume VIII – Engineering and Operational Risk and Reliability Analysis, Appendix 8" U.S. Army Corps of Engineers, Washington, D.C., https://ipet.wes.army.mil/

2.5 Wind and Atmospheric Pressure Modeling

Accurate modeling of wave and storm surge levels requires accurate wind and pressure field input to the model. This section describes the methodology to generate wind and pressure fields for the 197 storms in the JPM-OS suite. The wind fields specified with this methodology drive the storm surge simulations and the offshore and nearshore wave simulations.

2.5.1 Computational Model

The wind and pressure fields are generated with an Oceanweather Inc (OWI) highly refined meso-scale moving vortex formulation developed originally by Chow (1971) and modified by Cardone et al. (1992). The model is based on the equation of horizontal motion, vertically averaged through the depth of the planetary boundary layer. The numerical modeling grid is represented by a series of nests defined on a rectangular system; the highest resolution residing in the center of the vortex (about 2-km) decreasing in resolution by a factor of two to the outer extremities. It is assumed a tropical system changes structure relatively slowly (over a period of one or more hours). Hence, the spatial and temporal evolution of this system can be represented by a series of *snapshots* representing distinct phases in the storm's process. One added feature of this model is to conserve the integrity in storm's structure so that the horizontal velocity components can be linearly interpolated without loss in energy.

This model computes the surface wind and pressure field in tropical cyclones and is referred to as the Planetary Boundary Layer Model, or TC-96 (Thompson and Cardone, 1996). For each simulation in the suite a unique set of input conditions is defined. The data file includes the track position in space and time, the forward speed (V_f) and direction, central pressure, pressure scale radius (R_p), a rotation angle and a pressure profile peakedness parameter termed the *Holland B* factor (Holland, 1980). The wind and pressure field is generated and positioned on a fixed longitude/latitude grid system covering the Gulf of Mexico. Using continuity of the storm center, these snapshots are placed in time generating a complete account of the temporal and spatial evolution of a given hurricane. It should be noted that all storm simulations are synthetic conditions based on input criteria of the TC-96 model. Hence, no validation of the results can be pursued. This method has been used successfully for the past decade over a wide range of tropical storm scenarios for a number of studies (Cox and Cardone, 2000). Replacing the validation of the final wind and pressure fields, extensive quality control products (QA/QC) were generated to assure consistency and correctness of the forcing functions used for the wave and surge modeling efforts.

2.5.2 Methodology

The final wind and pressure fields resulting from TC-96 are targeted on a grid domain covering the entire Gulf of Mexico. The lateral boundaries are at -98° to -80° Longitude; 18° to 31° Latitude with a grid resolution of 0.05° (or 3'). The temporal variation in these fields is set to 1800-s, (30-min average wind) with lengths of storms ranging from 47- to 144-hr. All wind-fields are *marine-exposure* (no effective roughness variations for land/sea changes), generated at a 10-m elevation. The marine-exposure assumption will have implications as each of the tropical systems make landfall altering their state because of differences in the roughness lengths between open water and vegetated states. Each simulation retained consistent time of landfall at the identical date-time stamp of 080100 (month, day, hour). This effectively assured the surge and nearshore wave modeling efforts were synchronized in time. In addition each simulation has a unique name and internally a unique date-time stamp (incrementing the year for each run). The wind and pressure fields were generated for the entire 197-storm suite.

2.5.3 Results

The 197-storm suite was simulated with the TC-96 PBL model and the results were applied as forcing for the surge and wave modeling. Example results for storm 821 of the wind and pressure field generation are given in Figures 2.5-1 to 2.5-5. A series of seven individual graphical products are used in the evaluation of the wind and pressure fields. These identify any inconsistencies that would be attributed to incorrect input conditions to TC-96 since the model itself is very robust. These products include track position and maximum wind speed; maximum (wind magnitude) and minimum (pressure) field conditions over the entire simulation duration; wind and pressure field snapshot at landfall, wind field snapshot at the overall maximum speed in the simulation; and time variation of input.

Figure 2.5-1 plots the maximum wind speed found at each snapshot and the storm track position. For each individual snapshot (at 1800-s time step intervals) the maximum wind speed is determined. In general the wind maxima must be to the right of the storm track. If at any time the maximum wind speed location falls to the left of the track a potential error in the input to TC-96 is flagged. As in the case of storm 821 the locations of all maxima are to the right of the storm track. As this storm approaches the coastline and makes landfall, the wind speed decreases from nearly 60-m/s at its maximum to around 40-m/s indicative of filling of the pressure field.

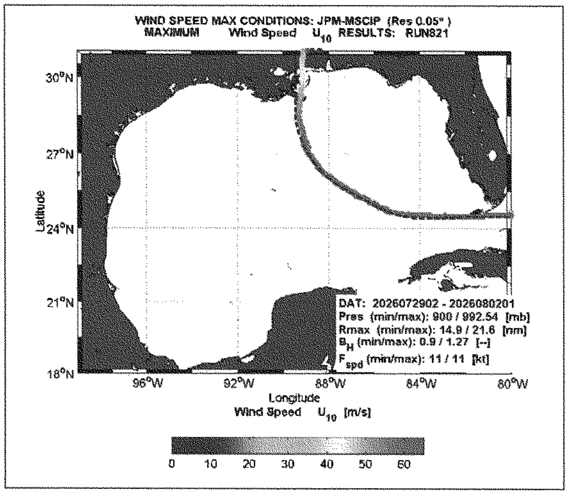


Figure 2.5-1. Location and value of maximum individual wind magnitude at every snapshot along with the storm track position for storm 821

Figure 2.5-2 represents the spatial variation of the maximum wind speed, and Figure 2.5-3 is the minimum overall pressure distribution. The wind field product (Figure 2.5-2) reflects the storm's path and displays the spatial coverage of high winds (for this case above 50-m/s), an indication of the breadth in the hurricane core. Figure 2.5-2 also shows the decay in the wind speed magnitude as it makes landfall. The minimum pressure distribution (Figure 2.5-3) clearly shows the storm track position, R_{max}, and where the filling of the pressure field occurs.

An example plot of the wind speed and wind direction vectors is shown in Figure 2.5-4. The wind direction vectors have been sub-sampled every 4 grid points, and are pointing toward which the winds are blowing. The directions also tend to reflect the base vortex in the TC-96 methodology. This is clearly evident as you move from the extremities of the storm to its center. The wind speed contouring clearly shows near continuous lines from the land to sea. This is indicative of generating an exclusive set of marine exposure wind fields. The wind speed maximum is found in the right front quadrant of the storm rotated about 45° counterclockwise from the orthogonal to the storm track.

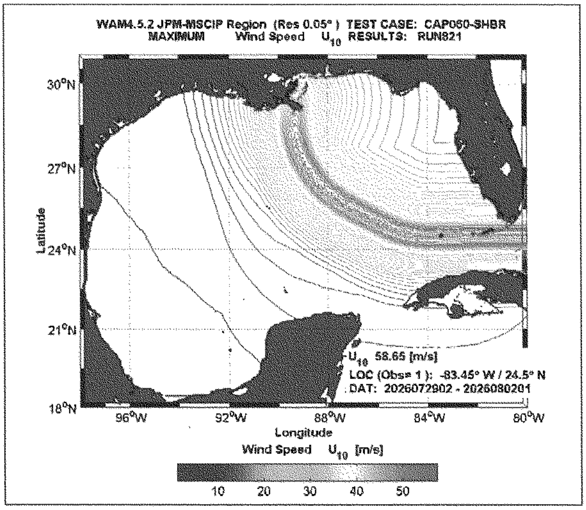


Figure 2.5-2. Maximum overall wind speed color contour for storm 821

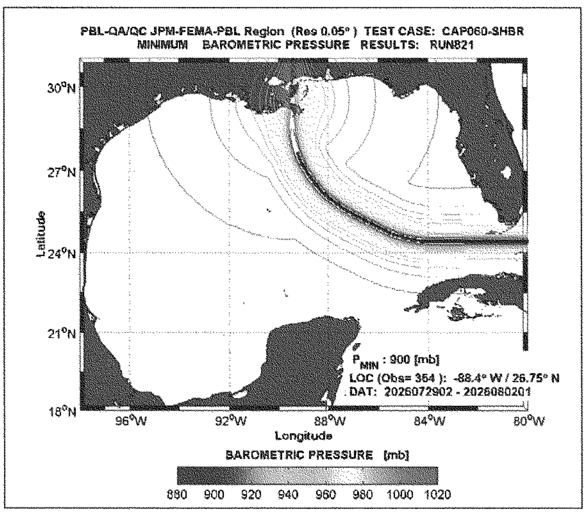


Figure 2.5-3. Minimum overall pressure field color contour for storm 821

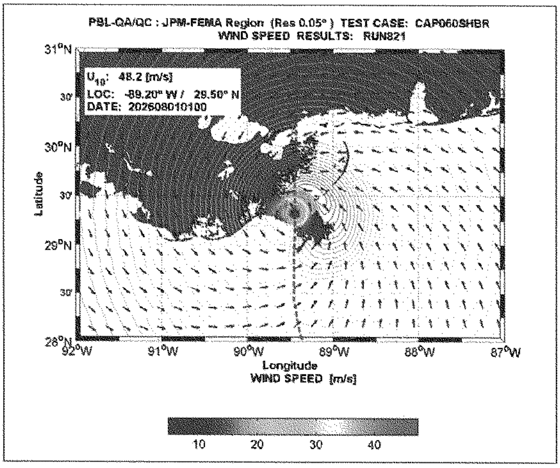


Figure 2.5-4. Snapshot of the wind speed (color contoured) and wind direction at the landfall time for storm 821

Figure 2.5-5 displays time plots and comparisons between the input files used to build the wind and pressure fields for TC-96 and results obtained from the resulting fields. It displays the minimum pressure from the input and output, the maximum wind speed (only from the output wind fields to check consistency); a comparison between R_p and a computed radius to maximum wind speed (R_{max}); the input Holland B (for consistency checks); and a comparison between the input forward speed and one computed from the field information. There are a few identifiable differences and similarities found in this product. The top panel of Figure 2.5-5 shows a large difference between the input and output minimum pressures. These differences will not influence any of the surge modeling efforts since they lie outside of the ADCIRC simulation times. These differences are attributed to the input file containing minimum pressures that are located outside of the defined grid domain. This also holds true for the comparison between the pressure scale radius (R_p) and the computed R_{max} at the start and end of the simulation. One must also note that R_p and R_{max} are not equivalent variables, but are relatively similar. In addition, the estimate of R_{max} is dependent on the modeled grid resolution of 0.05° or roughly 5.5-km. The value of R_p is a defined finite input value. In general though, despite these differences, any large deviation (more than 20-percent of the value) would be considered as questionable. The fourth panel displays the time variation in Holland B parameter analyzed directly from the input file. This variable is either constant (a value of 1.0) over time, or decreases as it does in this example just prior to landfall. This reflects the filling in the pressure field, as well as a decrease in the wind maximum. For all no constant cases, the Holland B is equal to 1.0 at landfall. The lower panel checks for the proper forward speed. The solid line is derived from the input file, while the symbols represent a computed forward speed derived from the output results. The noted oscillations result from the specified grid resolution used with accuracy levels on the order of about 5.5-km. Strong deviations from the input would suggest a phase error in the resulting wind fields and subject to either further testing or evaluation.

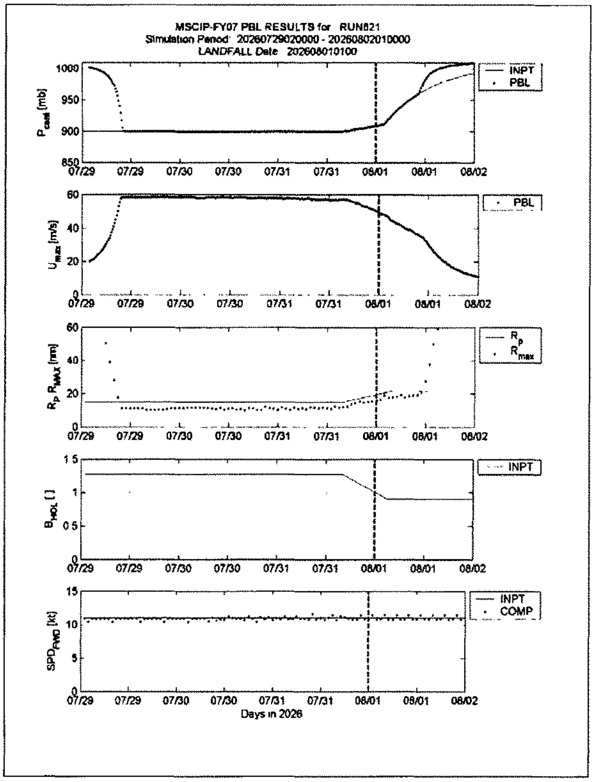


Figure 2.5-5. Time plot of input to TC-96 and output derived from the wind and pressure field files for storm 821

2.6 Offshore Wave Modeling

Offshore waves are required as a boundary condition for the nearshore wave modeling. This section describes the methodology to generate the offshore waves for the 197 storms in the JPM-OS suite. The offshore wave model is forced with the wind fields discussed in section 2.5.

2.6.1 Computational Model

The generation of the wave field and directional wave spectra for the various hurricane storm tracks is based on the implementation of a third generation discrete spectral wave model called WAM (Komen et al, 1994). This model solves the action balance equation:

$$\frac{\partial N}{\partial t} + \vec{c_G} \cdot \frac{\partial N}{\partial \vec{x}} = \omega^{-1} \cdot \sum_i S_i \qquad \text{E2.6-1}$$

where N is the action density defined by $F(f,\theta,x_i,t)/\omega$, where F is the energy density spectrum defined in frequency, (f) direction (θ) over space, (x_i)and time, (t) and the radial frequency ω is equal to $2\pi f$. S_i represent the source-sink terms:

$$\sum_i S_i = S_{in} + S_{nl} + S_{ds} + S_{w-b} + S_{bk} \qquad \text{E2.6-2}$$

S_{in} is the atmospheric input, S_{nl} represents the nonlinear wave-wave interactions, S_{ds} is the high frequency breaking (white-capping), S_{w-b} is wave bottom effects (bottom friction), and S_{bk} is depth limited wave breaking. The solution is solved for the spatial and temporal variation of action in frequency and direction, over a fixed grid defined in x_i (generally a fixed longitude latitude geospatial grid).

Computationally E2.6-1 is solved in two steps. The advection term (second term in E2.6-1) is solved first accounting for the propagation of wave energy. Each packet of energy in frequency and direction is moved based on the group speed of that particular frequency band and water depth. This assumes linear theory and superposition of wave packets. In a fixed longitude latitude grid system curvature effects are resolved where the energy is propagated in a spherical coordinate system. As the water depth decreases, the full dispersion relationship is applied. Wave shoaling and refraction effects the propagation of the energy packets.

After every propagation step the solution to the time rate change of the action density is solved including the source term integration. The wind field is read, and the atmospheric input source (S_{in}) is applied. The nonlinear wave-wave interaction source term is the mechanism that self-stabilizes the spectral energy, transferring portions of the energy to the forward face and high frequency tail. Dissipation (S_{ds}) removes portions of energy that become too energetic for the given frequency band. For application in arbitrary depths energy is removed via the wave-bottom sink (S_{w-b}) and ultimately in very shallow water the spectrum releases much of its available energy due to breaking (S_{bk}). A more complete theoretical derivation and formulation of the source terms can be found in Komen et al. (1994).

2.6.2 Methodology

The goal of the offshore wave modeling was to provide two-dimensional wave spectra in the coastal area to be used as input boundary condition to the nearshore wave modeling (STWAVE, Smith et al. 2001). The spectral estimates contain all energy derived from the synthetic storm simulations.

Initial sensitivity tests (and past hurricane simulations) indicated that only one grid at a nominal resolution of 0.05° was required to provide quality wave estimates. The target domain is shown in Figure 2.6-1. Figure 2.6-2 identifies the save locations for the boundary conditions for the nearshore transformation modeling STWAVE (Smith et al 2001). Two sets are used in this study. The Alabama-Mississippi set (AL-MS, ST001-ST025) consist of the line parallel to the Alabama and Mississippi coastline. The second set is the diagonal line running from the northeast to southwest intersecting the AL-MS boundary at ST011 and ending at ST046. There are many distinct features that can affect the incoming wave energy, however most all, with exception to the Mississippi Canyon are landward of the defined output boundary for STWAVE. The Mississippi Canyon because of its deep water acts as a filter, attenuating wave energy.

Two time steps are applied in the wave model simulations. The propagation time step is set so that numerical stability is attained. The second time step the source term integration is set to the physical processes and relaxation times of S_{in} , S_{nl} , S_{ds} , $S_{w\text{-}b}$. In addition the time steps are required to be integer multiples of the wind input, and for the fine-scale grid also evenly divisible of the basin-scale propagation time step.

All simulations are initiated from simple fetch laws using the first wind field. Wave field information files are built for quality assurance, quality control graphical products displaying the temporal and spatial evolution of various wave related parameters for each of the 197 storms. The offshore WAM wave simulations supply the nearshore wave modeling effort supported by STWAVE (Smith, et al, 2001). The WAM directional wave spectra are output every 15-min at 28 discrete frequency bands (exponential distribution where $f_{n+1} = 1.1 \cdot f_n$ and $f_0 = 0.031384$), and 24 direction bands centered every 15-deg starting at $\theta_0 = 7.5$). The location of these special output locations are found in Figure 2.6-2.

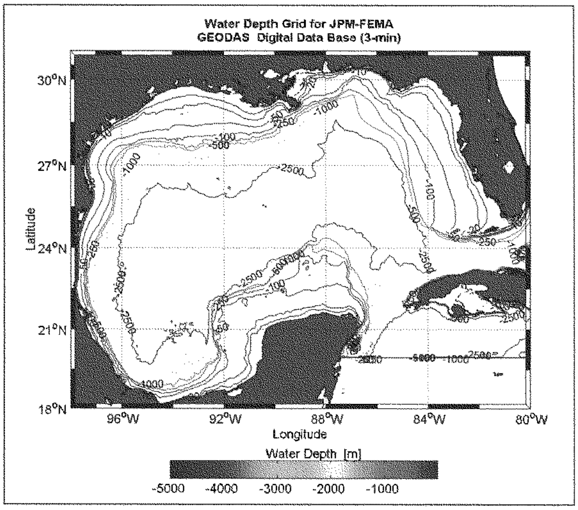


Figure 2.6-1. Water depth contours for offshore wave model simulations. Depths are in meters.

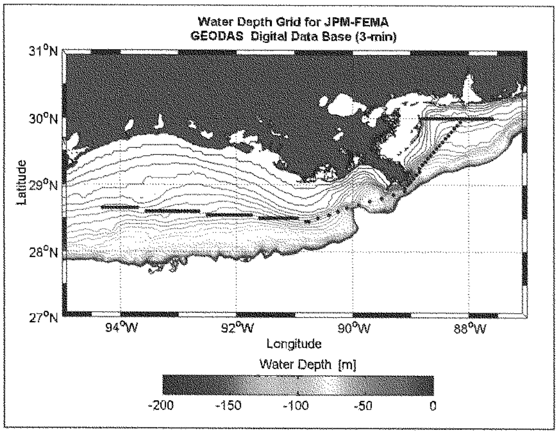


Figure 2.6-2. Refined version of the water depth grid used in offshore wave model simulations. Boundary points closed symbols, and depths are in meters.

2.6.3 Results

Generation of wave estimates based on synthetic storm simulations must be substantiated with verification/validation of the modeling results based on not only the technology used, but also the methods applied. This effort has been documented in previous studies (Interagency Performance Evaluation of the New Orleans and Southeast Louisiana Hurricane Project (IPET), https://ipet.wes.army.mil/) and more recently a Joint Coastal Surge Modeling Effort for the New Orleans District. These two reports focus on the verification of the WAM results using highly defined wind fields and also the PBL methods. A series of historical storms (Betsy, 1965, Rita 2005, Ivan 2004, Camille 1969, Katrina 2005 and Andrew 2002) were selected and analyzed.

Two-dimensional wave spectra in the coastal area were calculated and output by WAM to be applied as the input boundary condition to the nearshore wave model STWAVE for the entire 197-storm suite. Example results of the maximum total significant wave height field for RUN801 are given in Figure 2.6-3. The envelope of high waves coincides with that of the wind core (see Figure 2.5-2). The maximum overall H_{mo} for this simulation is 17-m and falls far south of any of the boundary points. However, there is an area of 10-m maxima running all along the SE-LA boundary extending well into the Mississippi coastline. The distribution is skewed toward the east sending what appears to be more energy into the coastline. In the nearshore area, the H_{mo} results diminish to a range near 8-m.

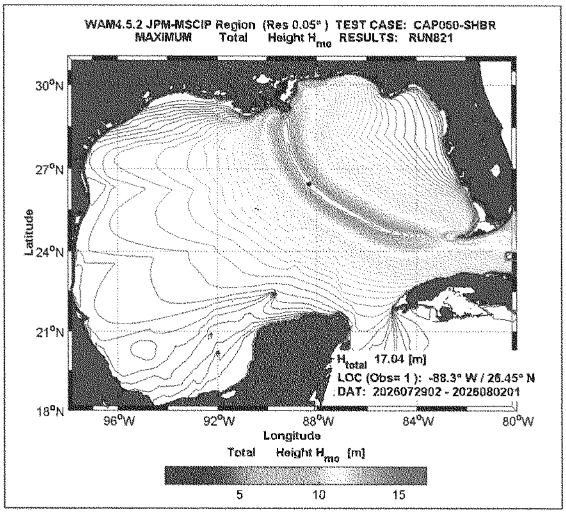


Figure 2.6-3. Maximum overall total significant wave height (in meters) color contour for storm 821

Figure 2.6-4 is an example color contour plot generated to depict the spatial (x axis) and temporal (y-axis) variation of the significant wave heights at each of the 119 output locations designated for STWAVE input boundary information. ST001 through ST046 are the points located along the Mississippi coast. Figure 2.6-4 represents the significant wave heights (integrated from the directional wave spectra of the STWAVE boundary conditions) for storm 821. Rather than isolate only station information (ST001 through ST046) along the Mississippi coast, all 119 output locations are contoured. This aids in the overall evaluation of the wave model's performance, and isolates any potential problems, not only in the local domain (along the Mississippi-Alabama coastline) but the entire shoreline reach. The well defined discontinuity around ST025 requires some explanation. The location of ST001 through ST025 represented in Figure 2.6-2 as the horizontal line seaward Mississippi Sound and extending to the west to the Chandelier Islands. The water depth decreases to about 5-m at the western extent. This causes the wave heights to diminish to near zero. ST026 is the start of the SE-LA boundary (Figure 2.6-2) and starts just offshore of ST012, and is oriented in a NE/SW direction extending to the tip of Louisiana. For storm 821, there is a distinct lobe of high energy values (upwards of nearly 16-m) along the SE-LA boundary. Along the Mississippi coast the wave climate is diminished to 10-m. Despite this reduction in energy level the duration of these high waves occurs over a 12-hour time span. One must realize some of the energy contained in the spectrum may not reach the coast, propagating outside of a ±90° directional plane at the boundary. These conditions emulate that found in the maximum wave height graphic (Figure 2.6-3). The skewed nature of the maximum H_{mo} distribution is evident in this plot, where the Mississippi coastline is affected despite the landfall being located well to the west.

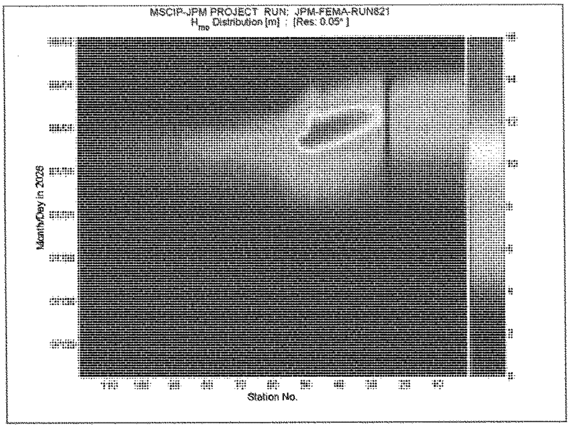


Figure 2.6-4. Spatial and temporal variation in the H_{mo} (in meters) for the 119 boundary output locations for storm 821

Directional spectral wave estimates were generated based on the 28 frequency and 24 direction bands at the 46 nearshore locations in the WAM grid domain for the entire 197-storm suite. This information consists of time (900-s) and spatial (0.05-deg) varying energy density (defined here as m^2-s) for the entire storm simulation period. This information is used as input criteria for STWAVE to estimate the nearshore wave environment.

2.7 Nearshore Wave Modeling

This section describes the numerical modeling of nearshore wave transformation and generation. Nearshore waves are required to calculate wave runup and overtopping on structures, and the wave momentum (radiation stress) contribution to elevated water levels (wave setup). First the nearshore wave model STWAVE and the Boussinesq wave model COULWAVE are briefly described, then the modeling methodology is outlined. Finally, example results are presented.

2.7.1 Computational Models

2.7.1.1 STWAVE

The numerical model STWAVE (Smith 2000; Smith, Sherlock, and Resio 2001; Smith and Smith 2001; Thompson, Smith, and Miller 2004; Smith and Zundel 2006; Smith and Sherlock in publication) was used to generate and transform waves to the shore. STWAVE numerically solves the steady-state conservation of spectral action balance along backward-traced wave rays:

$$(C_{ga})_x \frac{\partial}{\partial x}\frac{C_a C_{ga}\cos(\mu-\alpha)E(f,\alpha)}{\omega_r}+(C_{ga})_y \frac{\partial}{\partial y}\frac{C_a C_{ga}\cos(\mu-\alpha)E(f,\alpha)}{\omega_r}=\sum\frac{S}{\omega_r} \qquad \text{E2.7-1}$$

where

C_{ga} = absolute wave group celerity

x,y = spatial coordinates, subscripts indicate x and y components

C_a = absolute wave celerity

μ = current direction

α = propagation direction of spectral component

E = spectral energy density

f = frequency of spectral component

ω_r = relative angular frequency (frequency relative to the current)

S = energy source/sink terms

The source terms include wind input, nonlinear wave-wave interactions, dissipation within the wave field, and surf-zone breaking. The terms on the left-hand side of E2.7-1 represent wave propagation (refraction and shoaling), and the source terms on the right-hand side of the equation represent energy growth and decay in the spectrum.

The assumptions made in STWAVE include mild bottom slope and negligible wave reflection; steady waves, currents, and winds; linear refraction and shoaling, and depth-uniform current. STWAVE can be implemented as either a half-plane model, meaning that only waves propagating toward the coast are represented, or a full-plane model, allowing generation and propagation in all directions. Wave breaking in the surf zone limits the maximum wave height based on the local water depth and wave steepness:

$$H_{mo_{max}} = 0.1L \tanh kd \qquad \text{E2.7-2}$$

where

H_{mo} = zero-moment wave height

L = wavelength

k = wave number

d = water depth

STWAVE is a finite-difference model and calculates wave spectra on a rectangular grid. The model outputs zero-moment wave height, peak wave period (T_p), and mean wave direction (α_m) at all grid points and two-dimensional spectra at selected grid points. Recent upgrades to STWAVE include an option to input spatially variable wind and surge fields. The surge significantly alters the wave transformation and generation for the hurricane simulations in shallow areas (such as Lake Pontchartrain) and where low-laying areas are flooded.

The inputs required to execute STWAVE include the bathymetry grid (including shoreline position and grid size and resolution); incident frequency-direction wave spectra on the offshore grid boundary; current field (optional), surge and/or tide fields, wind speed, and wind direction (optional); and bottom friction coefficients (optional). The outputs generated by STWAVE include the fields of energy-based, zero-moment wave height, peak spectral wave period, and mean direction; wave spectra at selected locations (optional); fields of radiation stress gradients to use as input to ADCIRC (optional).

2.7.1.2 COULWAVE

Numerical results based on the standard Boussinesq equations or the equivalent formulations have been shown to give predictions that compared quite well with field data (Elgar and Guza 1985) and laboratory data (Goring 1978, Liu *et al.* 1985). COULWAVE (Cornell University Long and Intermediate Wave model) is based on the Boussinesq-type equations, which are known to be accurate for inviscid wave propagation from fairly deep water (wavelength/depth ~2) all the way to the shoreline (Wei *et al*, 1995).

The model consists of a fairly complex set of partial differential equations that are integrated in time to solve for the free surface elevation. Fundamentally, the Boussinesq equations solved by COULWAVE are inviscid. To accommodate frictional effects, viscous submodels are integrated. To simulate the effects of wave breaking, the eddy viscosity model of Kennedy *et al* (2000) is used here with some modification as given in Lynett (2006b). Energy dissipation is added to the momentum equation when the wave slope exceeds some threshold value, and continues to dissipate until the wave slope reaches some minimum value when the dissipation is turned off.

The moving shoreline condition has been shown to capture shoreline motion due to a wide range of wave frequencies, wave heights, and beach slopes. The shoreline algorithm has been extensively compared with empirical runup laws and existing experimental data for runup due to regular waves. (Korycansky & Lynett, 2005). The model results have also been compared to time-averaged experimental data of overtopping of sloping structures (e.g. Kobayashi & Wurjanto, 1989; Dodd, 1998; Hu et al, 2000) with good agreement. The Boussinesq model results were compared with well-established empirical formulas such as those given by Owen (1984) and Van der Meer & Janssen (1995). A noteworthy result of these comparisons is the conclusion that, when using the wave height and water level at the toe of the last simple slope of the structure, there is no accuracy preference between the empirical formulas and the detailed hydrodynamics (Boussinesq). Thus, for relatively simple profiles where the wave height at the structure toe can be estimated with high confidence, the empirical formulas provide the same level of accuracy as the Boussinesq with significantly less computational expense. On the other hand, if the levee is fronted by a series of slopes or an arbitrary shaped protecting structure, some method must be used to provide the wave height at the toe of the last simple slope. For this situation, the Boussinesq can be used to provide this wave height; however the Boussinesq can also provide the overtopping for such a configuration and would be the logical choice for estimating overtopping, provided the computational resources and expertise required by the modeling are available.

2.7.2 Methodology

STWAVE was applied on two grids with 200 m resolution for the Mississippi coast: Eastern Mississippi/Alabama grid and Western Mississippi/Eastern Louisiana grid. The input for each grid includes the bathymetry (interpolated from the ADCIRC domain), surge fields (interpolated from ADCIRC output), and wind (interpolated from ADCIRC output). The wind applied in STWAVE is spatially and temporally variable for all domains. STWAVE was run at 30-min intervals for 93 quasi-time steps (46.5 hrs). The model output includes wave parameters (height, peak wave period, and mean direction) to provide wave parameters for the calculation wave runup and overtopping on structures and radiation stresses to be applied as forcing in ADCIRC to calculate wave setup.

The bathymetry grids cover the entire Gulf of Mexico coastline of Mississippi and extend east into Alabama and west into Louisiana at a resolution of 656 ft (200 m). The East MS-AL grid domain covers Eastern Mississippi and Alabama The domain is approximately 70 by 75 miles (112.6 by 121 km). The West MS-Southeast LA grid is approximately 85 by 92 miles (136.6 by 148.8 km) and extends from Mississippi Sound to the Mississippi River. The domain was broken into two parts to capture the transformation of offshore waves from approximately the 100 ft (30 m) depth contour to the shoreline. Figure 2.7-1 shows the bathymetry for the MS-AL grid and Figure 2.7-2 shows the bathymetry for the MS-SE LA grid. Brown areas in the bathymetry plots indicate land areas at 0 ft or higher elevation. These simulations are forced with both the local winds interpolated from ADCIRC and waves interpolated on the offshore boundary from the regional WAM model. The simulations were run with the half-plane version of STWAVE for computational efficiency.

Levees and other barriers such as seawalls and roadways are included in the STWAVE and COULWAVE grids as bathymetric/topographic features. The STWAVE grids bathymetry/topography was updated to include the lines of defense 3 and 4. However, the STWAVE model cannot resolve the wave setup that occurs near structures such as levees and seawalls due to the resolution of the grid and the assumption of negligible wave reflection. Local wave setup very near structures such as levees and seawalls can increase the water level at the structure. To capture the additional wave setup near the line of defense structures, COULWAVE was applied. COULWAVE was used to generate a lookup table that, given input wave boundary condition information from STWAVE and a representative profile, computes the additional wave setup and wave height at the toe of the structure.

Representative profile data was collected at Hancock, west Harrison, east Harrison, and Jackson counties. Profile data that extended from the mainland into Mississippi Sound at locations near Waveland, Pass Christian, Harrison County just west of the western end of Deer Island, and in the Pascagoula area were used to develop the representative profiles for the Mississippi coast. To evaluate lines of defense 3 and 4, which include both a levee and seawall structure , the structures were incorporated into the 4 representative profiles, giving a total of 8 profiles to be simulated. The seawall had a 15 ft (NAVD88 2004.65) elevation for all four profiles. The levee was modeled with a 30 ft elevation for the Waveland, Pass Christian, and west of Deer Island profiles; and modeled with a 15 ft elevation on the Pascagoula profile.

To develop the lookup table a set of independent parameters and their ranges were specified. The independent parameters are levee slope, levee crest height, incident wave height, peak wave period, and surge water elevation. All of the hydrodynamic parameters are specified at 600 ft from the levee toe, and represent information provided from STWAVE and ADCIRC runs. The levee slope evaluated was 1:3. The seawall was approximated as a very steep slope (5:1). The other parameters used to develop the lookup table are given in Table 2.7-1. For each parameter combination, a Boussinesq simulation was run for the 8 profiles. Save stations near proposed structures were associated with the most appropriate representative profile. For the Mississippi coast, a total of 8 x 3 x 3 X 3 = 216 simulations were run to create the lookup table.

For each simulation, time series of free surface elevation, depth-averaged velocity, and mass flux are recorded. Each time series is distilled to a significant wave height, a mean water level (from which the local wave setup is obtained), and a mean flux. Note that mean flux, when measured on the crest of a levee, is identical to the overtopping rate in units of water volume/time per unit length of crest. Using interpolation routines, the wave height, wave setup, and overtopping values for any combination of input conditions bracketed by the independent parameter ranges shown above can be obtained. The lookup table script outputs the wave setup at the structure toe, the wave height at the toe, and the overtopping rate predicted by COULWAVE.

The entire 197 storm suite was simulated with STWAVE forced with input boundary conditions calculated by the offshore wave model WAM and water level supplied by the surge model. All storms were run on both STWAVE grids. STWAVE was run for approximately a two-day period for each storm to capture the peak wave conditions. Radiation stress gradients were calculated and applied as a forcing condition to the surge model. To provide the wave height and period for boundary conditions to COULWAVE, the STWAVE output was processed to extract the significant wave height at the surge peak for save stations near the proposed structures.

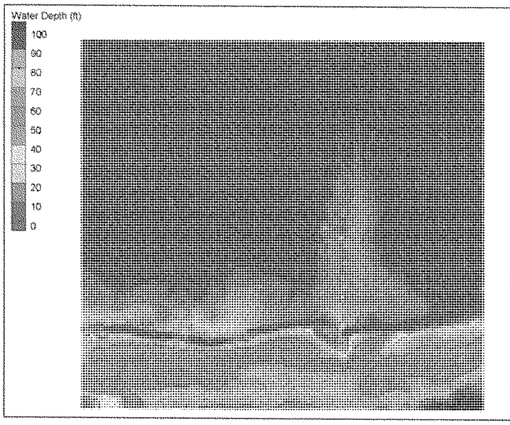


Figure 2.7-1. MS-AL Bathymetry Grid (depths in feet)

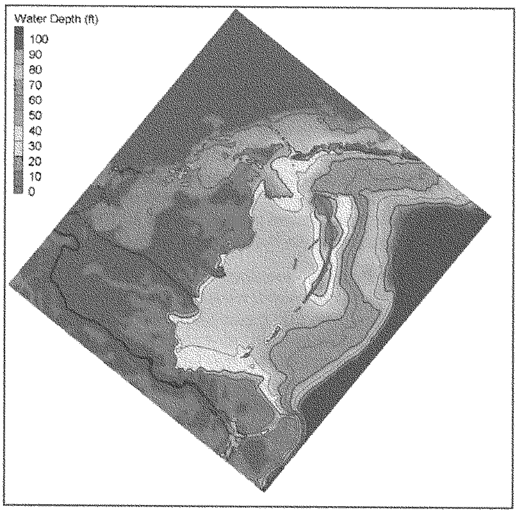


Figure 2.7-2. West MS-SE LA Bathymetry Grid (depths in feet)

Table 2.7-1.
Water Levels and Wave Parameters Modeled with COULWAVE

Water Level Relative to Structure Crest (ft)	Wave Heights (ft)	Peak Periods (sec)
0	2, 5, 8	8, 12, 16
-2	2, 5, 8	8, 12, 16
-4	2, 5, 8	8, 12, 16

2.7.3 Results

Example output generated from the STWAVE model results are provided in Figures 2.7-3 to 2.7-6. Figures 2.7-3 to 2.7-4 show the maximum significant wave height and coincident direction produced by storm 027 for the MS-AL and MS-SE LA grids, respectively. Figures 2.7-5 to 2.7-6 are the peak wave periods at the time of maximum wave height. The maximum significant wave heights and periods in representative sections can be selected as boundary conditions for calculating wave runup and overtopping, wave forcing on structures, or other design purposes.

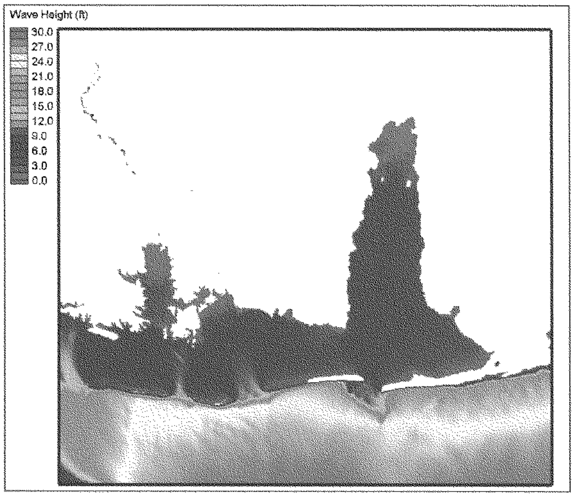


Figure 2.7-3. Maximum significant wave height for the MS-AL grid for storm 027

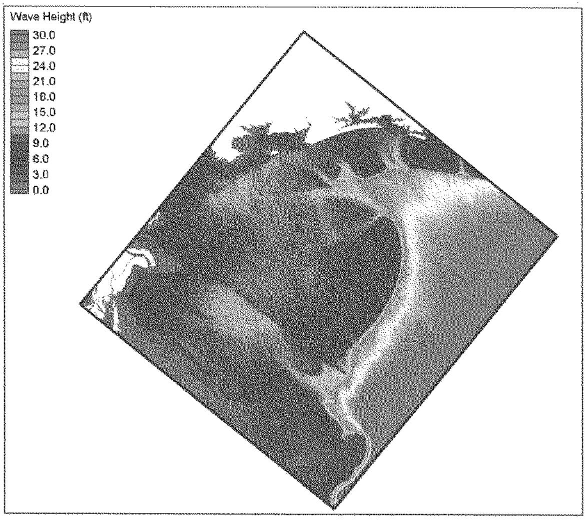


Figure 2.7-4. Maximum significant wave height for the MS-SE LA grid for storm 027

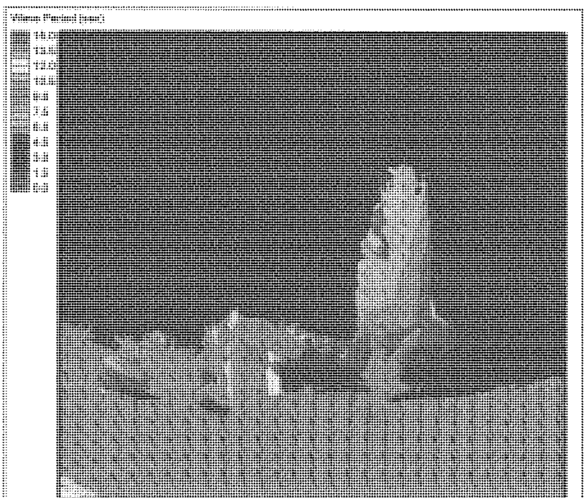


Figure 2.7-5. Peak wave period and direction at the time of maximum wave height for the MS-AL grid for storm 027

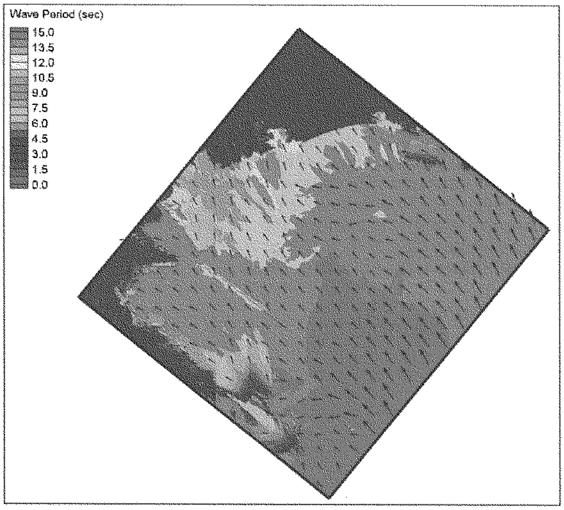


Figure 2.7-6. Peak wave period and direction at the time of maximum wave height for the MS-SE LA grid for storm 027

For storm 027 at a save location near a proposed ring levee in the Pascagoula area, the wave height and period calculated by STWAVE at the peak of the storm was approximately 3.5 ft and 13.5 sec, respectively. With these input parameters, the wave setup at the toe of the structure obtained from the COULWAVE generated lookup table was about 1.3 ft. These calculations were made for all 27 storms in the measure evaluation storm suite and the local wave setup was added to the water level. In general, the additional wave setup calculated near the structure was less than 1 ft, but occasionally was calculated to be as much as approximately 1.75 ft. Note that this additional wave setup was only applied to estimate water levels at the proposed lines of defense to assist in preliminary cost estimation.

2.8 Storm Surge Modeling

The Advanced CIRCulation Model (ADCIRC) was selected as the basis for the surge modeling effort. The domain and geometric/topographic description and resulting computational grid provides for a common domain and grid from the Sabine River to Mobile Bay which extends inland across the floodplains of Southern Louisiana and Mississippi (to the 30 to 75 ft contour NAVD88 2004.65) and extends seaward to the deep Atlantic Ocean. The grid, referred to as SL15, domain boundaries were selected to ensure the correct development, propagation and attenuation of storm surge without necessitating nesting solutions or specifying ad hoc boundary conditions for tides or storm surge. The grid will be used for all coastal analysis for Louisiana and Mississippi to ensure consistency and matching solutions at state line/region boundaries.

2.8.1 Computational Model

ADCIRC-2DDI, the two-dimensional, depth-integrated implementation of the ADCIRC coastal ocean model, was used to perform the hydrodynamic computations in this study (Luettich et al. 1992, Westerink et al. 1992, Westerink et al. 1993, Luettich and Fulcher 2004, Luettich and Westerink 2004). Imposing the wind and atmospheric pressure fields, the ADCIRC model can replicate tide induced and storm-surge water levels and currents. In two dimensions, the model is formulated with the depth-averaged shallow water equations for conservation of mass and momentum. Furthermore, the formulation assumes that the water is incompressible, hydrostatic pressure conditions exist, and that the Boussinesq approximation is valid. Using the standard quadratic parameterization for bottom stress and neglecting baroclinic terms and lateral diffusion/dispersion effects, the following set of conservation equations in primitive, nonconservative form, and expressed in a spherical coordinate system, are incorporated in the model (Flather 1988; Kolar et al. 1993):

$$\frac{\partial U}{\partial t} + \frac{1}{r\cos\phi} U \frac{\partial U}{\partial \lambda} + \frac{1}{R} V \frac{\partial U}{\partial \phi} - \left[\frac{\tan\phi}{R} U + f\right] V =$$

E2.8-1

$$-\frac{1}{R\cos\phi}\frac{\partial}{\partial \lambda}\left[\frac{p_s}{\rho_0} + g(\zeta - \eta)\right] + \frac{\tau_{s\lambda}}{\rho_0 H} - \tau_* U$$

$$\frac{\partial V}{\partial t} + \frac{1}{r\cos\phi} U \frac{\partial V}{\partial \lambda} + \frac{1}{R} V \frac{\partial V}{\partial \phi} - \left[\frac{\tan\phi}{R} U + f\right] U =$$

E2.8-2

$$-\frac{1}{R}\frac{\partial}{\partial \phi}\left[\frac{p_s}{\rho_0} + g(\zeta - \eta)\right] + \frac{\tau_{s\lambda}}{\rho_0 H} - \tau_* V$$

$$\frac{\partial \zeta}{\partial t} + \frac{1}{R\cos\phi}\left[\frac{\partial UH}{\partial \lambda} + \frac{\partial (UV\cos\phi)}{\partial \phi}\right] = 0 \qquad \text{E2.8-3}$$

where

t = time,

λ and φ = degrees longitude (east of Greenwich is taken positive) and degrees latitude (north of the equator is taken positive),

ζ = free surface elevation relative to the geoid,

U and V = depth-averaged horizontal velocities in the longitudinal and latitudinal directions, respectively,

R = the radius of the earth,

$H = \zeta + h$ = total water column depth,

h = bathymetric depth relative to the geoid,

$f = 2\Omega \sin \varphi$ = Coriolis parameter,

Ω = angular speed of the earth,

p_s = atmospheric pressure at free surface,

g = acceleration due to gravity,

η = effective Newtonian equilibrium tide-generating potential parameter,

ρ_0 = reference density of water,

$\tau_{s\lambda}$ and $\tau_{s\varphi}$ = applied free surface stresses in the longitudinal and latitudinal directions, respectively, and

τ = bottom shear stress and is given by the expression $C_f(U^2 + V^2)^{1/2}/H$ where C_f is the bottom friction coefficient.

The momentum equations (Equations 1 and 2) are differentiated with respect to λ and τ and substituted into the time differentiated continuity equation (Equation 3) to develop the following Generalized Wave Continuity Equation (GWCE):

$$\frac{\partial^2\zeta}{\partial t^2} + \tau_0 \frac{\partial\zeta}{\partial t} - \frac{1}{R\cos\phi}\frac{\partial}{\partial\lambda}\left[\frac{1}{R\cos\phi}\left(\frac{\partial HUU}{\partial\lambda} + \frac{\partial(HUV\cos\phi)}{\partial\phi}\right) - UVH\frac{\tan\phi}{R}\right]$$

$$\left[-2\omega\sin\phi\, HV + \frac{H}{R\cos\phi}\frac{\partial}{\partial\lambda}\left(g(\zeta - \alpha\eta) + \frac{p_s}{[}p_0\right) + \tau_* HU - \tau_0 HU - \tau_{s\lambda}\right]$$

$$-\frac{1}{R}\frac{\partial}{\partial\phi}\left[\frac{1}{R\cos\phi}\left(\frac{\partial HVV}{\partial\lambda} + \frac{\partial HVV\cos\phi}{\partial\phi}\right) + UUH\frac{\tan\phi}{R} + 2\,\omega\sin\phi\, HU\right] \qquad \text{E2.8-4}$$

$$+\frac{H}{R}\frac{\partial}{\partial\phi}\left(g(\zeta - alfa\eta) + \frac{p_s}{\rho_0}\right) + \tau_* - \tau_0 HV - \frac{\tau_{s\lambda}}{\rho_0}]$$

$$-\frac{\partial}{\partial t}[\frac{VH}{R}\tan\phi] - \tau_0[\frac{VH}{R}\tan\phi] = 0$$

The ADCIRC model solves the GWCE in conjunction with the primitive momentum equations given in Equations 1 and 2. The GWCE-based solution scheme eliminates several problems associated with finite-element programs that solve the primitive forms of the continuity and momentum equations, including spurious modes of oscillation and artificial damping of the tidal signal. Forcing functions include time-varying water-surface elevations, wind shear stresses, and atmospheric pressure gradients.

The ADCIRC model uses a finite-element algorithm in solving the defined governing equations over complicated bathymetry encompassed by irregular sea/ shore boundaries. This algorithm allows for extremely flexible spatial discretizations over the entire computational domain and has demonstrated excellent stability characteristics. The advantage of this flexibility in developing a computational grid is that larger elements can be used in open-ocean regions where less resolution is needed, whereas smaller elements can be applied in the nearshore and estuary areas where finer resolution is required to resolve hydrodynamic details.

2.8.2 Methodology

The ADCIRC grid utilized for this study is that which was calibrated and validated for IPET with Hurricane Katrina data and subsequently validated with data from Hurricane Rita for this and other coastal surge studies conducted by USACE. The development of an accurate unstructured grid storm surge model of Southern Louisiana and Mississippi requires appropriate selection of the model domain and optimal resolution of features controlling surge propagation. The SL15 model domain, shown in Figure 2.8-1, has an eastern open ocean boundary that lies along the 60° W meridian, extending south from the vicinity of Glace Bay in Nova Scotia, Canada to the vicinity of Coracora Island in eastern Venezuela (Westerink, Luettich and Muccino 1994, Blain et al. 1994, Mukai et al. 2002, Westerink et al., 2006, Ebersole et al., 2006). This domain has a superior open ocean boundary that is primarily located in the deep ocean and lies outside of any resonant basin. There is little geometric complexity along this boundary. Tidal response is dominated by the astronomical constituents and nonlinear energy is limited due to the depth. The boundary is not located near tidal amphidromes. Hurricane storm surge response along this boundary is essentially an inverted barometer pressure effect directly correlated to the atmospheric pressure deficit in the meteorological forcing; it can therefore be easily specified. This boundary allows the model to accurately capture basin-to-basin and shelf-to-basin physics. Hurricane forerunner and Gulf of Mexico resonant modes can be generated as the hurricane moves from the Atlantic into the Gulf.

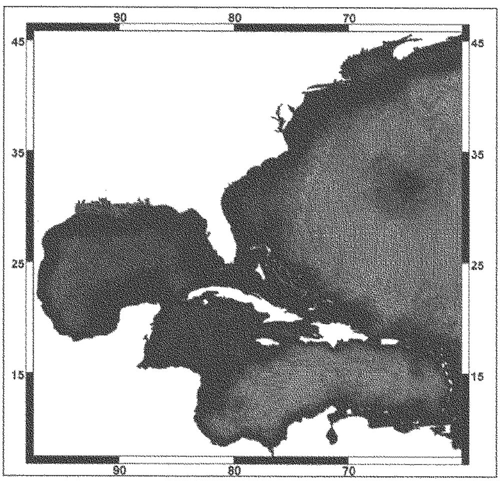


Figure 2.8-1. The ADCIRC SL15 Unstructured Grid

The grid design provides localized refinement of the coastal floodplains of Southern Louisiana and Mississippi and of the important hydraulic features. The level of detail in Southern Louisiana and Mississippi is unprecedented, with nodal spacing reaching as low as 100 ft in the most highly refined areas. Unstructured grids can resolve the critical features and the associated local flow processes with orders of magnitude fewer computational nodes than a structured grid, because the latter is limited in its ability to provide resolution on a localized basis and fine resolution generally extends far outside the necessary area. The SL15 grid is refined locally to resolve features such as inlets, rivers, navigation channels, levee systems and local topography/bathymetry. In addition, wave breaking zones have been identified based on local bathymetric gradients, and a swath of 150 to 700 ft grid resolution has been placed along the coast and over barrier islands to ensure that the grid scale of the flow model is consistent with that of the STWAVE models. The STWAVE forcing function is accommodated by adding a high level of resolution where significant gradients in the wave radiation stresses and forcing of surge through wave transformation and breaking are the largest. The high resolution zones allow for the strong wave radiation stress gradients to fully force the water body in these important regions and ensures that the resulting wave radiation stress induced set up is sufficiently accurate. Barrier islands were in particular very highly resolved to 150 to 250 ft due to the significant wave breaking and the resulting important wave radiations stresses as well as the very high currents that develop over the features. The SL15 computational grid contains 2,137,978 nodes and 4,184,778 elements. Grid resolution varies from approximately 12-15 mi in the deep Atlantic Ocean to about 100 ft in Louisiana and Mississippi. The high grid resolution required for the study region leads to a final grid with more than 90% of the computational nodes placed within or upon the shelf adjacent to Southern Louisiana and Mississippi, enabling sufficient resolution while minimizing the cost of including such an extensive domain. Geometry, topography and bathymetry in the SL15 model were all defined to replicate the prevailing conditions in August 2005 prior to Hurricane Katrina with the exceptions of some of the barrier islands and area between Lake Pontchartrain and Lake Borgne that were included as post Katrina September 2005 configurations. The bathymetric and topographic data was interpolated to the SL15 computational mesh by moving progressively from the coarsest and deepest to finest and shallowest areas of the computational domain.

Levee and road systems that are barriers to flood propagation are features that generally fall below the defined grid scale and represent a non-hydrostatic flow scenario. It is most effective to treat these structures as sub-grid scale parameterized weirs within the domain. ADCIRC defines these as barrier boundaries by a pair of computational nodes with a specified crown height (Westerink et al. 2001). Once water level reaches a height exceeding the crown height, the flow across the structure is computed according to basic weir formulae. This is accomplished by examining each node in the defined pair for their respective water surface heights and computing flow according to the difference in water elevation. The resulting flux is specified as a normal flow from the node with the higher water level to the node with the lower water level for each node pair. Lines of Defense 3 and 4, as described in Section 2.1, were incorporated into the ADCIRC grid as sub-grid scale weirs. Weir boundary conditions also are implemented for external barrier boundaries, which permit surge that overtops levee structures at the edge of the domain to transmit flow out of the computational area.

The entire JPM-OS synthetic storm suite was simulated for the no project condition forced with the wind and pressure fields discussed in section 2.5 and radiation stress gradients calculated by STWAVE (see section 2.7). The ADCIRC and STWAVE models were coupled in that wind and water levels computed by ADCIRC were applied as a boundary condition for STWAVE, STWAVE was run and the resulting radiation stress gradients were then applied as forcing to ADCIRC to compute the final water level.

2.8.3 Results

The primary goal of the ADCIRC simulations was to estimate overall peak water level for each storm in the JPM-OS suite for the calculation of stage-frequency curves for the no project condition and with proposed protection measures in place. This involved an examination of the entire spatial domain every 900 seconds (15 minutes) to determine if water levels exceeded the previous time steps maximum water level at any point in the domain. The result of this analysis is a maximum envelope of water level for a given simulation. Example output generated from the ADCIRC model results are provided in Figures 2.8-2 to 2.8-6 and discussed below. The peak surge elevations were saved at stations along the Mississippi coast for the entire JPM-OS storm suite and the computed water levels used as input for the JPM analysis.

Figure 2.8-2 is the envelope of maximum water level for storm 027 for the no project condition, Figure 2.8-3 is the envelope of maximum water level for the same storm with line of defense 3 in place, and Figure 2.8-4 is the difference between the line of defense 3 and the no project condition. For this particular storm, the maximum water level envelope for the no project condition (Figure 2.8-2) shows that the highest water levels are in the vicinity of Saint Louis Bay where the water level reaches 26 ft NAVD88 (2004.65). Approximately 25 miles to the east, Biloxi Bay water levels are at 18 ft NAVD88 (2004.65) and Pascagoula is at 10 ft NAVD88 (2004.65). The bays overflow their banks and the surrounding low-lying areas are inundated. The maximum water level envelope for the line of defense 3 (Figure 2.8-3) shows that the highest water levels are *seaward* of the line of defense 3 in the vicinity of Bay Saint Louis where the water level in the Gulf reaches 27 ft NAVD88 (2004.65) along the shoreline west of the entrance to Saint Louis Bay. Water within Saint Louis Bay is locally affected by the winds with water levels of 3-5 ft, but generally remains within its banks. Approximately 25 miles to the east, Biloxi Bay water levels are at 3 ft NAVD88 (2004.65) and Pascagoula remains at 10 ft NAVD88 (2004.65) since it is unprotected by the line of defense 3. The difference between the maximum water levels with line 3 of defense and the no project condition (Figure 2.8-4) shows areas in blue (Saint Louis Bay and Biloxi Bay) where water levels are reduced, indicating that the line of defense 3 provides protection to these regions. Water levels are reduced by 18-23 ft in St Louis Bay and 14 ft in Biloxi Bay. Figure 2.8-4 also shows slightly (~1-ft) higher water levels in the Gulf as indicated by the yellow and orange areas.

Figure 2.8-5 is the envelope of maximum water level for the storm 027 with line of defense 4 in place, and Figure 2.8-6 is the difference between the line of defense 4 and the no project condition. The results are very similar to the line of defense 3 results. The maximum water level envelope for the line of defense 4 (Figure 2.8-5) also shows that the highest water levels are *seaward* of the line of defense 4 in the vicinity of Bay Saint Louis where the water level in the Gulf reaches 27 ft NAVD88 (2004.65) along the shoreline west of the entrance to Saint Louis Bay. Water within Saint Louis Bay is again locally affected by the winds with water levels of 2-5 ft, but generally remains within its banks. Approximately 25 miles to the east, Biloxi Bay water levels are at 3 ft NAVD88 (2004.65) and Pascagoula remains at 10 ft NAVD88 (2004.65) since it is unprotected by the line of defense 4. The difference between the maximum water levels with line 4 of defense and the no project condition (Figure 2.8-6) shows areas in blue (Saint Louis Bay and Biloxi Bay) where water levels are reduced, indicating that the line of defense 4 provides protection to these regions. Water levels are reduced by 18-23 ft in St Louis Bay and 14 ft in Biloxi Bay. Figure 2.8-6 also shows slightly (~1-ft) higher water levels in the Gulf as indicated by the yellow and orange areas.

The peak surge elevations were saved at stations along the Mississippi coast for the entire JPM-OS storm suite and the computed water levels used as input for the JPM analysis. The peak surge elevations for the set of storms run with the lines of defense in place were also saved at stations along the coast and stage frequency curves developed with the methodology discussed in section 2.4.3. The resulting stage frequency relationships are given in section 2.9.

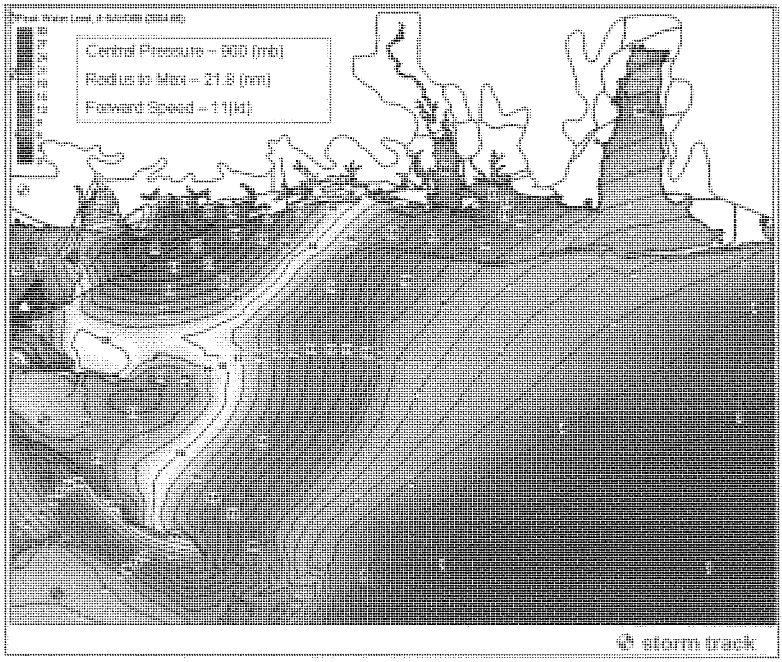


Figure 2.8-2. Envelope of maximum water level for storm 027 for the no project condition

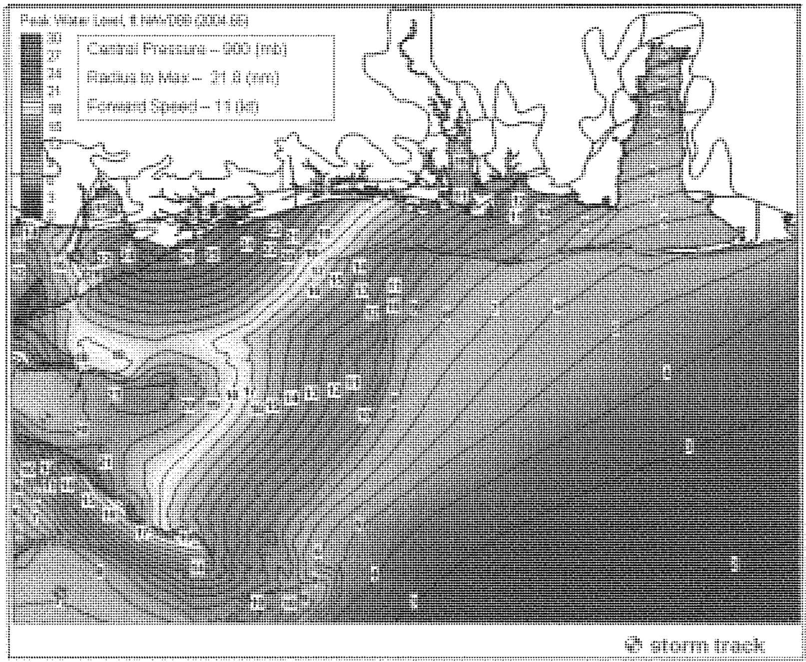


Figure 2.8-3. Envelope of maximum water level for storm 027 for the line of defense 3

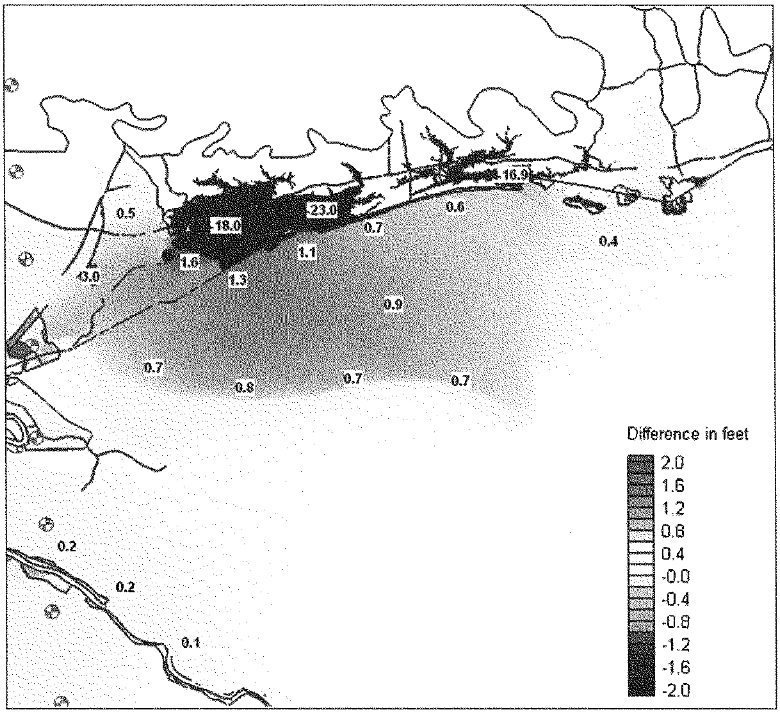


Figure 2.8-4. Difference in maximum water level between line of defense 3 and the no project condition for storm 027

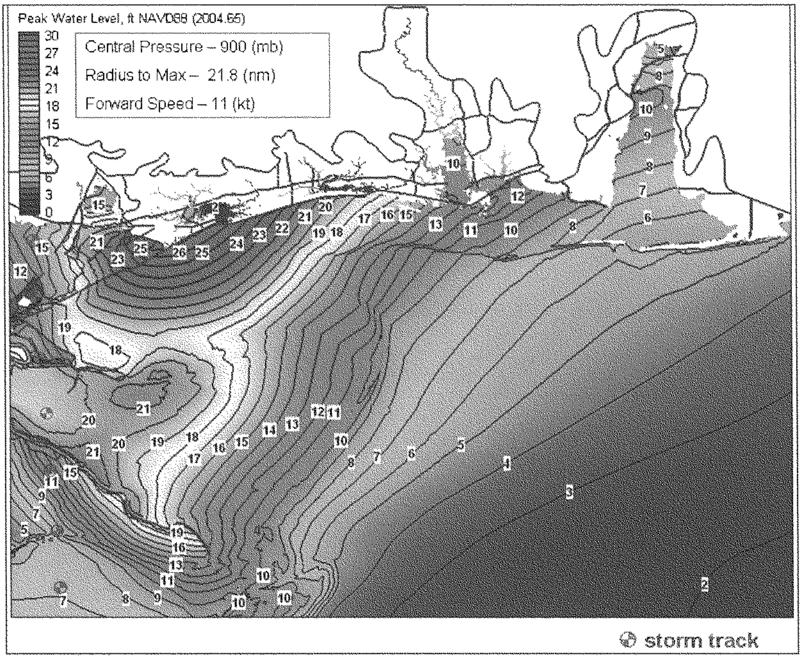


Figure 2.8-5. Envelope of maximum water level for storm 027 for the line of defense 4

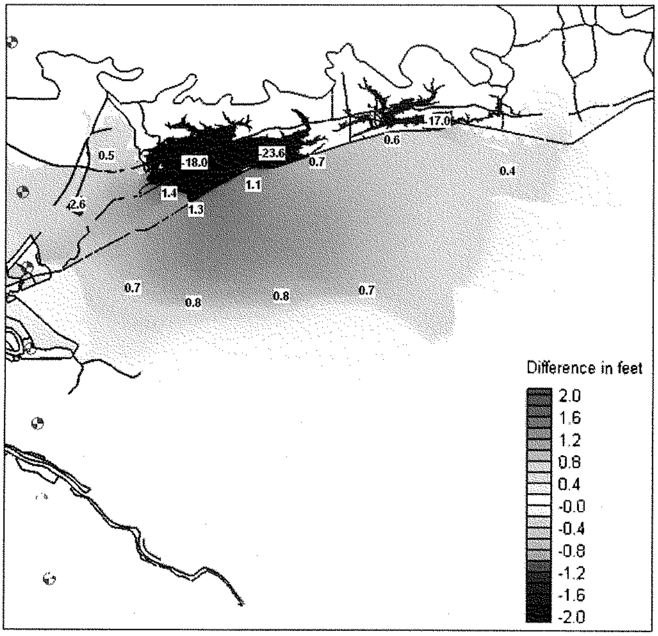


Figure 2.8-6. Difference in maximum water level between line of defense 4 and the no project condition for storm 027

2.8.4 Line of Defense 5 Results

Six maximum possible intensity (MPI) storms with landfall points along the Mississippi coast were simulated to determine inundation limits for the Mississippi coastline. These limits are used to establish line of defense 5. The six MPI storms made landfall at various points along the coast as shown in Figure 2.8-7. All MPI storms were defined at their most intense point as having a minimum central pressure of 880 mb, radius to maximum winds of 36 n mi, and a forward speed of 11 kt.

Peak water level envelopes from each of the six MPI simulations were computed. The six peak water level envelopes were then compared to compute the "peak of peaks", which is considered the inundation limit along the entire Mississippi coastline (Figure 2.8-8). The maximum water level along the Mississippi coastline was determined to be approximately 30 ft along the entire western half of the state and east of Pascagoula. The landward extent of the inundation indicates the storm surge reaches Interstate 10 for much of the western portion of the state. Lower peaks near Biloxi and Mobile Bay (24-27 ft) may be attributed to the protection afforded by the barrier islands.

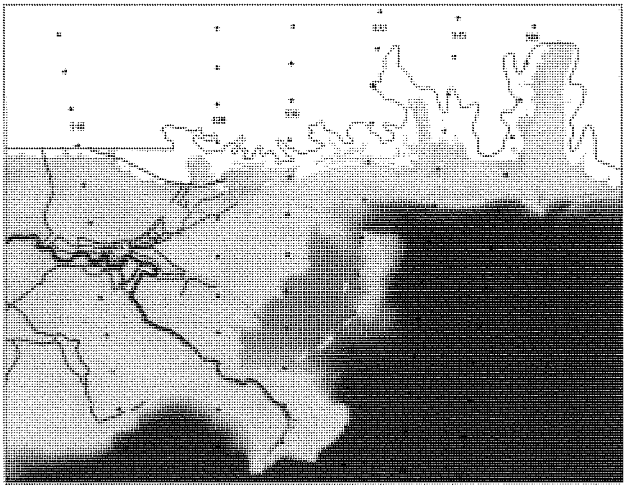


Figure 2.8-7. Storm Tracks for Maximum Possible Intensity Storms

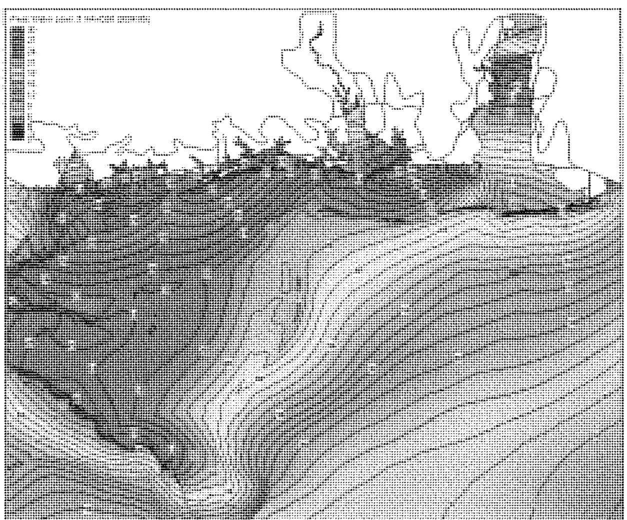


Figure 2.8-8. Envelope of Maximum Water Level for all MPI Storms

2.9 Stage Frequency Curves

The purpose of hydrodynamic modeling was to estimate the surge and wave conditions for the no project condition and with lines of defense 3 and 4 in place. The expected return periods for those surge and wave conditions is also required to quantify the risk for the existing condition and the level of protection that might be possible with the proposed protection measures. Sixty-two save locations were selected to evaluate damage reaches across Mississippi. The surge and wave conditions at these 62 locations, plus 18 additional locations in the Mississippi Sound and seaward of the barrier islands were saved and analyzed with the JPM-OS methodology described in section 2.4. The calculation of the hydrodynamic conditions has been detailed in sections 2.5 to 2.8. In this section, a description of the integrated modeling system is given and the location of the save stations identified. Finally, the frequency results for both the surge and waves are presented.

2.9.1 Integrated Modeling System

Section 2.4 described the statistical methodology and sections 2.5 to 2.8 detailed the models and methodologies applied for computing the surge and wave estimates for the Mississippi coast. Each component is part of an integrated modeling system. For completeness, the integrated system is presented. A schematic diagram of the system is shown in Figure 2.9-1.

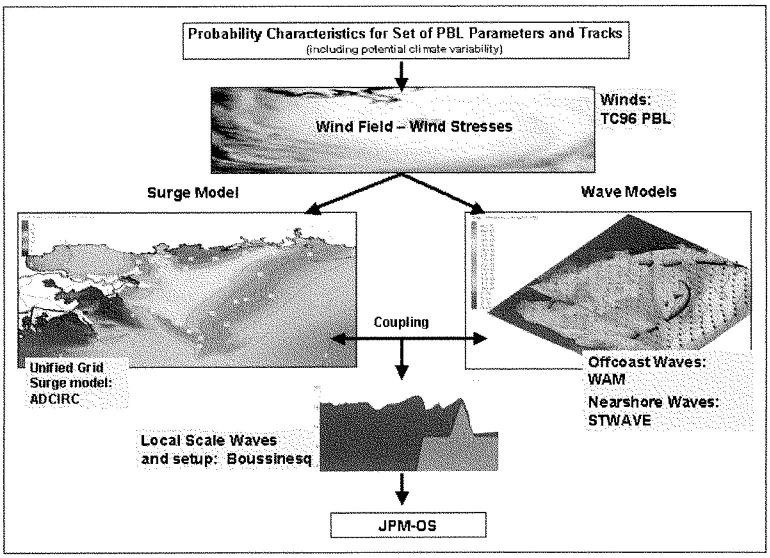


Figure 2.9-1. Diagram of Modeling System for Coastal Inundation Applications

First, for each defined storm (a track and its time-varying wind field parameters) the TC96 PBL model (Thompson and Cardone, 1996) is used to construct 15-minute snapshots of wind and pressure fields for driving surge and wave models. ADCIRC is then run to compute the wind-driven surge component. In parallel with the initial ADCIRC runs, the large-domain, discrete, time-dependent spectral wave model WAM is run to calculate directional wave spectra that serve as boundary conditions for local-domain, near-coast wave model STWAVE. Using initial water levels from ADCIRC, winds that include the effects of sheltering due to land boundaries, and spectral boundary conditions from the large-domain wave model, STWAVE is run to produce wave fields and estimated radiation stress fields. The radiation stress fields are added to the PBL-estimated wind stresses, and the ADCIRC model is run again for the time period during which the radiation stresses potentially make a significant contribution to the water levels.

For simulations with the proposed structures, a method based on Boussinesq modeling (using a lookup table based on interpolations from generic runs) is used to provide estimates of the incremental contribution to the water level at the structure. The water levels from the second ADCIRC run and waves from STWAVE in locations adjacent to structures are provided as the boundary conditions for driving the Boussinesq-based runs.

2.9.2 Save Stations

Sixty-two save stations were identified to evaluate damage reaches across Mississippi. The surge and wave conditions at these 62 stations, plus 18 additional stations in the Mississippi Sound and seaward of the barrier islands were saved and analyzed. Figure 2.9-2 shows the location of each station.

Figure 2.9-2. Save Station Locations

2.9.3 Results

2.9.3.1 Without-Project

The peak surge elevations, maximum wave heights, and peak wave periods were saved at stations along the Mississippi coast for the entire JPM-OS storm suite and used as input for the JPM analysis. The resulting frequency relationships are provided by save station in Tables 2.9-1 to 2.9-3 below for water level, wave height, and wave period, respectively. Note that there are no waves at some of the inland points.

Table 2.9-1.
Stage-Frequency Relationships – Without Project

Station Number	Water Level (ft)				
	25-yr	50-yr	100-yr	500-yr	1000-yr
1	8.1	11.3	14.2	19.1	20.8
2	10	13.8	16.3	20.1	21.3
3	10.8	14.9	17.9	23	24.6
4	10.4	14.4	17.3	22.3	23.9
5	10.4	14.4	17.3	22.4	24
6	8.9	12.4	15.4	20.3	22.1
7	8.8	12.3	15.4	20.3	22.1
8	9	12.6	15.6	20.6	22.4
9	9.2	12.9	16	21	22.9
10	8.1	11.2	13.9	18.7	20.4
11	7.7	11.2	13.8	18.3	19.8
12	7.4	10.9	13.6	17.9	19.4
13	7.6	11.3	14	18.3	19.7
14	7.1	9.9	12.1	16.3	17.8
15	9	12.5	15.5	20.3	22.1
16	2.6	3.3	3.8	4.5	4.8
17	3.2	4.2	4.8	6.1	6.5
18	4.2	5.5	6.6	8.5	9.3
19	5.6	7.4	8.9	11.8	13
20	5.9	7.9	9.6	12.9	14.2
21	6.3	8.6	10.6	14.5	15.9
22	7.7	11.2	13.9	18.2	19.8
23	5.8	7.7	9.3	12.4	13.6
24	5.7	7.5	9	12	13.5
25	6.1	8.1	9.8	12.6	13.7
26	6.3	8.4	10.2	13.8	15.1
27	8.1	11.4	13.9	18.7	20.3
28	7.1	9.7	11.6	15	16.3
29	6.9	9.3	11.2	14.4	15.5
30	8.2	11.6	14.2	19	20.7
31	8.1	11.3	14.2	19.1	20.8
32	8.4	11.8	14.8	19.8	21.6
33	8.8	12.3	15.4	20.4	22.3
34	8.7	12.2	15.2	20	21.8
35	8.3	11.3	13.5	17.2	18.5
36	8.3	11.3	13.5	17.2	18.5
37	8.7	11.8	14.1	17.9	19.2
38	9.1	12.6	15.5	20.1	21.8
39	9.7	13.5	16.4	21.2	23
40	9	12.1	14.4	18.3	19.7
41	9.1	12.8	15.7	20.5	22.3

Table 2.9-1.
Stage-Frequency Relationships – Without Project (continued)

Station Number	Water Level (ft)				
	25-yr	50-yr	100-yr	500-yr	1000-yr
42	9.5	13.3	16.2	21	22.8
43	8.9	12	14.3	18.3	19.6
44	9.1	12	14.1	17.7	18.8
45	8.8	11.6	13.7	17.2	18.3
46	10.2	13.9	16.7	21.6	23.4
47	10.7	14.2	17	22.1	23.9
48	10.4	14.3	17.2	22.2	23.8
49	10.5	14.3	17.3	22.6	24.3
50	10.8	14.3	17.2	22.6	24.4
51	10.5	14.4	17.1	21.6	23
52	10.4	14.3	17.3	22.4	24
53	10.3	14.1	17.1	22.2	23.8
54	6.8	9.7	11.6	14.6	15.6
55	10.9	15.1	18.1	22.9	24.3
56	10.7	14.8	17.8	22.8	24.4
57	8.9	12.1	14.3	18.2	19.4
58	10.1	13.7	16.3	20.4	21.6
59	6.9	9.9	11.8	14.9	16
60	10.6	14.5	17.2	21.6	23
61	10.6	14.5	17.5	22.4	24
62	9.6	13.5	16	20.1	21.4
63	10.1	14.1	16.5	20.3	21.5
64	10.3	14.2	16.9	21.2	22.5
65	10.6	14.7	17.6	22.5	24
66	10.6	14.2	17.1	22.4	24.2
67	10.6	14.1	16.8	22	23.8
68	10	13.7	16.5	21.4	23.1
69	9.1	12.7	15.7	20.4	22.2
70	8.5	12	14.9	19.6	21.3
71	8	11.1	13.8	18.5	20.2
72	7.9	11.2	13.7	18.4	20
73	7.5	10.8	13.3	17.7	19.2
74	7	10.3	13.2	17.4	18.8
75	6.9	10.3	14	18.7	20.2
76	9.4	12.2	14.3	17.8	19.1
77	8	11	13.2	16.8	18
78	6.7	9.6	12.1	15.9	17.3
79	5.8	8.7	11.7	15.7	17
80	5.6	8.3	11.7	16.1	17.3

Table 2.9-2.
Wave Height-Frequency Relationships – Without Project

Station Number	Significant Wave Height (ft)				
	25-yr	50-yr	100-yr	500-yr	1000-yr
1	3.5	4.9	5.9	7.3	7.7
2	1.3	2.7	3.8	6	6.8
3	2.4	3.3	4	5.5	6
4	2	3.4	4.6	7.3	8.1
5	2.8	4.2	5.6	8	8.7
6	2.9	4.6	5.9	8.1	8.8
7	3.4	5.2	6.7	9.1	9.9
8	2.6	4.4	5.7	8	8.7
9	1.8	3.1	4	5.5	6
10	4.4	5.6	6.6	8	8.3
11	2.1	3.2	4.1	6.1	6.5
12	5	6.4	7.5	9.5	10
13	0.2	0.5	0.9	1.3	1.5
14	0.4	0.8	1.3	2.2	2.5
15	2.2	4.1	5.3	7.3	8
16	0	0	0	0	0
17	0	0	0	0	0
18	0	0	0	0	0
19	0	0	0	0	0
20	0.1	0.2	0.3	0.6	0.7
21	0.6	1.3	1.9	3.1	3.3
22	4.3	6	7.3	9.5	10.2
23	0.5	1	1.4	2.2	2.6
24	0	0	0	0	0
25	0	0	0	0	0
26	0.8	1.6	2.3	3.4	3.7
27	3.3	4.4	5.6	7.2	7.6
28	0	0	0	0	0
29	0	0	0	0	0
30	4.4	5.8	6.7	8.3	8.9
31	3.8	5.1	6.1	7.4	7.8
32	0.3	0.8	1.3	2.3	2.7
33	2.7	4.4	5.8	7.8	8.5
34	0	0.1	0.1	0.2	0.3
35	0	0	0	0	0
36	0	0	0	0	0
37	0	0	0	0	0
38	0.8	1.2	1.6	2.3	2.7
39	5.1	6.2	7	8.1	8.6
40	1	1.4	1.8	2.6	2.9
41	4.6	6.1	7.2	8.9	9.4
42	5.5	6.7	7.4	8.6	9.1
43	0	0	0	0	0
44	0	0	0	0	0

Table 2.9-2.
Wave Height-Frequency Relationships – Without Project (continued)

Station Number	Significant Wave Height (ft)				
	25-yr	50-yr	100-yr	500-yr	1000-yr
45	0	0	0	0	0
46	4.5	5.5	6.4	8	8.5
47	4.4	5.8	6.5	7.8	8.4
48	0.5	1.1	1.8	4	4.7
49	3.1	4.4	5.6	8.2	8.9
50	0.5	1.8	3.9	7.3	8.5
51	0	0	0	0	0
52	0	0.1	0.1	0.2	0.3
53	0.1	0.2	0.3	0.6	0.7
54	0	0	0	0	0
55	2.7	4	5.3	7.4	8.1
56	3	4.4	5.8	8.4	9.1
57	0	0	0	0	0
58	0	0	0	0	0
59	0	0	0	0	0
60	0.6	1.2	1.8	2.6	3
61	2	3.1	4	5.7	6.3
62	0.5	1.2	1.8	3.8	4.5
63	2.5	4.1	5.5	8.1	9.2
64	3	4.2	5.2	7.6	8.4
65	3.7	5.1	6.3	9	9.8
66	4.2	5.1	6.1	8.4	9.2
67	5.1	6.1	6.7	8.1	8.7
68	4.4	5.5	6.4	8	8.4
69	6.3	7.6	8.4	9.8	10.2
70	5.5	6.9	8	9.6	10.2
71	5	6.1	7	8.3	8.7
72	5.2	6.6	7.7	9.8	10.5
73	4.8	6	6.8	8.3	8.8
74	4.7	6	6.8	8.1	8.4
75	6.4	7.7	9.6	11.3	11.7
76	8.3	9.9	11	13	13.6
77	10.6	12.4	13.6	15.5	16.1
78	10.4	12.2	13.6	16	17
79	11.9	13.6	15.1	17	17.5
80	10	11.5	13.3	15.4	15.9

Table 2.9-3.
Wave Period-Frequency Relationships

Station Number	Peak Wave Period (sec)				
	25-yr	50-yr	100-yr	500-yr	1000-yr
1	8.4	11.6	13.9	16.3	16.3
2	3.4	6.3	7.9	12.6	14.4
3	3.8	5.1	6.7	9.9	11.1
4	5.5	7.0	8.0	10.2	11.0
5	7.0	9.2	11.1	14.6	14.9
6	6.2	10.1	13.0	15.9	16.3
7	9.5	12.7	14.2	16.3	16.3
8	5.9	8.9	12.1	14.7	15.6
9	6.0	8.3	11.7	14.8	15.6
10	9.5	12.6	14.3	16.3	16.3
11	10.7	13.1	14.9	16.3	16.3
12	11.7	13.0	14.0	14.9	14.9
13	2.3	2.6	3.0	3.5	3.8
14	4.4	5.2	5.8	7.0	7.4
15	5.3	7.5	9.8	13.6	14.6
16	2.2	2.4	2.4	2.4	2.4
17	2.2	2.4	2.4	2.4	2.4
18	2.2	2.4	2.4	2.4	2.4
19	2.2	2.4	2.4	2.4	2.4
20	2.2	2.4	2.6	2.9	2.9
21	2.4	2.8	3.2	4.1	4.5
22	12.1	13.2	14.1	14.9	14.9
23	3.0	3.5	3.9	4.3	4.3
24	2.2	2.4	2.4	2.4	2.4
25	2.2	2.4	2.4	2.4	2.4
26	2.4	2.9	3.3	3.9	4.2
27	8.5	11.6	14.0	16.3	16.3
28	2.2	2.4	2.4	2.4	2.4
29	2.2	2.4	2.4	2.4	2.4
30	5.2	7.1	10.7	14.9	14.9
31	10.4	12.3	13.6	16.1	16.3
32	2.6	3.4	4.3	8.5	11.2
33	10.2	12.7	13.9	16.3	16.3
34	2.2	2.4	2.6	2.9	2.9
35	2.2	2.4	2.4	2.4	2.4
36	2.2	2.4	2.4	2.4	2.4
37	2.2	2.4	2.4	2.4	2.4
38	2.7	3.2	3.7	4.4	4.7
39	11.4	12.8	13.6	15.1	15.6
40	2.5	3.0	3.3	4.0	4.1
41	11.3	12.6	13.5	14.9	15.2
42	11.4	12.8	13.7	15.5	16.0
43	2.2	2.4	2.4	2.4	2.4
44	2.2	2.4	2.4	2.4	2.4

Table 2.9-3.
Wave Period-Frequency Relationships (continued)

Station Number	Peak Wave Period (sec)				
	25-yr	50-yr	100-yr	500-yr	1000-yr
45	2.2	2.4	2.4	2.4	2.4
46	11.4	13.0	14.1	16.3	16.3
47	10.2	12.7	13.9	15.8	16.3
48	2.6	3.4	4.4	6.2	6.8
49	7.1	9.6	11.3	15.5	16.3
50	2.8	6.5	10.3	13.5	13.5
51	2.2	2.4	2.4	2.4	2.4
52	2.4	2.8	3.2	3.8	3.9
53	2.2	2.4	2.6	2.7	2.7
54	0.0	0.0	0.0	0.0	0.0
55	8.0	10.8	12.4	15.3	16.3
56	7.0	8.9	10.3	12.7	13.8
57	2.2	2.4	2.6	2.7	2.7
58	2.2	2.4	2.4	2.4	2.4
59	0.0	0.0	0.0	0.0	0.0
60	2.3	2.8	3.2	3.9	4.2
61	3.7	6.0	7.7	10.8	12.2
62	2.6	3.6	4.9	7.5	8.3
63	5.4	6.7	7.7	9.3	9.9
64	7.0	8.6	10.0	12.0	12.7
65	6.1	7.7	9.0	10.8	11.4
66	6.1	9.7	12.4	14.9	14.9
67	10.7	13.7	14.9	14.9	14.9
68	11.3	12.9	13.9	14.9	14.9
69	11.5	13.2	14.5	16.3	16.3
70	11.3	12.9	14.0	14.9	14.9
71	5.3	8.8	13.1	16.2	16.3
72	5.7	8.9	12.6	14.9	14.9
73	11.6	13.3	14.3	14.9	14.9
74	7.2	10.6	12.9	16.3	16.3
75	12.1	13.9	14.9	14.9	14.9
76	12.4	14.1	15.1	16.3	16.3
77	12.0	13.3	14.3	14.9	14.9
78	12.4	13.8	14.6	14.9	14.9
79	12.7	14.0	14.7	14.9	14.9
80	12.4	13.8	14.6	14.9	14.9

2.9.3.2 Line of Defense 3

The peak water level, maximum wave height, and wave period for the set of storms run with the lines of defense in place were also saved at stations along the coast. The water level at save stations adjacent to the proposed structures was increased by the amount predicted from the Boussinesq modeling. The waves were not calculated for stations behind the proposed line of defense. The frequency relationships were estimated from the 27 storm subset and methodology discussed in section 2.4.3. The wave periods were not altered by the presence of the line of defense and thus are the same as for the no project condition. The frequency relationships for water level and wave height are provided by save station in Tables 2.9-4 and 2.9-5, respectively.

Table 2.9-4.
Stage-Frequency Relationships – LOD 3

Station Number	Water Level (ft)				
	25-yr	50-yr	100-yr	500-yr	1000-yr
1	8.5	12	15	19.8	21.6
2	10.2	14.3	16.8	21	22.3
3	1.3	1.3	1.5	2.5	2.6
4	1.2	1.2	1.4	1.8	2
5	11.9	15.5	18.3	23.9	25.5
6	9.2	13.2	16.4	21.5	23.4
7	9	12.8	16	21	22.9
8	9.3	13.2	16.3	21.5	23.4
9	1.3	1.3	1.4	1.4	1.5
10	8.1	11.4	14.3	18.9	20.7
11	8.1	11.5	14.3	18.9	20.4
12	8	11.1	14.3	18.5	20
13	8.2	12	14.9	19	20.4
14	7.1	9.9	12.1	16.5	18
15	9.3	13.3	16.4	21.4	23.3
16	2.6	3.2	3.8	4.5	4.8
17	3	4.3	4.9	6.2	6.6
18	4.2	5.6	6.7	8.5	9.3
19	5.6	7.6	9.1	12	13.1
20	6	7.9	9.8	13.1	14.3
21	6.6	9	11.1	14.9	16.3
22	8.2	11.8	14.6	18.8	20.4
23	6	7.9	9.5	12.6	13.7
24	5.8	7.6	9.1	12.1	13.6
25	4.2	5.4	6.5	8	8.1
26	6.5	8.7	10.6	14.1	15.4
27	8.4	11.9	14.6	19.2	20.8
28	1.6	1.7	2	2.3	2.4
29	1.6	1.8	2.2	2.9	2.9
30	8.6	12.2	15	19.6	21.4
31	8.5	12	15	19.8	21.6
32	8.7	12.1	15.3	20.1	22
33	9.1	12.9	16.1	21.2	23.2
34	1.3	1.3	1.4	1.4	1.5
35	1.2	1.9	2	2.2	2.4
36	1.2	1.9	2	2.2	2.4
37	1.3	2	2.1	2.5	2.7
38	1.1	1.3	1.3	1.4	1.4
39	10	14	16.8	21.8	23.7

Table 2.9-4.
Stage-Frequency Relationships – LOD 3 (continued)

Station Number	Water Level (ft)				
	25-yr	50-yr	100-yr	500-yr	1000-yr
40	1.3	1.6	1.6	1.9	2
41	9.5	13.4	16.3	21.2	23.1
42	9.8	13.8	16.6	21.6	23.5
43	1.5	2.2	2.3	2.9	3.1
44	3	4.5	4.8	6.3	6.4
45	2.3	3.1	3.5	4.7	4.7
46	10.5	14.3	16.9	22.4	24.1
47	11	14.6	17.4	22.9	24.6
48	1.4	1.5	1.6	1.8	2
49	10.9	15.2	18.2	23.8	25.5
50	11	14.5	17.7	23.6	25.6
51	2.2	2.6	3.1	4.6	4.8
52	1.9	2	2.1	2.2	2.3
53	0	0	0.1	0.1	0.1
54	6.9	9.9	11.8	14.9	15.9
55	11.3	15.9	19.2	24.2	25.8
56	11.1	15.7	18.7	24.1	25.7
57	2.1	2.5	2.6	3.5	3.7
58	2.2	2.4	3.4	4.7	4.8
59	7	10.1	12.1	15.3	16.4
60	2.4	3.2	4	5.6	5.8
61	1.1	1.2	1.5	1.8	2
62	0	0	0	0	0
63	10.4	14.5	17.1	21.1	22.3
64	10.6	14.8	17.7	22.4	23.7
65	11	15.4	18.6	23.6	25.1
66	10.9	14.6	17.7	23.2	25
67	10.7	14.3	17.1	22.7	24.3
68	10.1	14	16.6	22	23.6
69	9.2	13	16.1	20.8	22.7
70	8.6	12.3	15.3	20	21.8
71	8	11.4	14.2	18.8	20.6
72	8	11.5	14	18.7	20.3
73	7.5	10.9	13.4	17.9	19.4
74	7	10.4	13.2	17.5	18.9
75	6.9	10.3	14	18.7	20.2
76	9.5	12.2	14.7	18.7	19.8
77	8	11.2	13.3	16.9	18.2
78	6.7	9.6	12.1	16	17.6
79	5.8	8.7	11.7	15.7	17
80	5.6	8.3	11.7	16.1	17.3

Table 2.9-5.
Wave Height-Frequency Relationships – LOD 3

Station Number	Water Level (ft)				
	25-yr	50-yr	100-yr	500-yr	1000-yr
1	3.6	4.9	6.1	7.8	8.3
2	1.4	2.9	4.0	6.2	7.0
5	2.8	4.4	5.9	8.4	9.1
6	3.0	4.8	6.2	8.4	9.1
7	3.5	5.2	6.9	9.7	10.7
8	2.8	4.5	5.9	8.4	9.2
10	4.6	5.7	6.7	8.2	8.6
11	2.1	3.2	4.2	6.4	6.9
12	5.0	6.4	7.5	9.4	9.9
13	0.2	0.5	0.8	1.0	1.1
14	0.4	0.7	1.1	1.8	2.0
15	2.5	4.0	5.6	7.6	8.3
16	0.0	0.0	0.0	0.0	0.0
17	0.0	0.0	0.0	0.0	0.0
18	0.0	0.0	0.0	0.0	0.0
19	0.0	0.0	0.0	0.0	0.0
20	0.1	0.2	0.3	0.6	0.7
21	0.1	0.8	0.9	0.9	0.5
22	4.3	6.1	7.4	9.6	10.3
23	0.4	0.8	1.1	1.9	2.2
24	0.0	0.0	0.0	0.0	0.0
25	0.0	0.0	0.0	0.0	0.0
26	0.8	1.6	2.4	3.5	3.8
27	4.0	5.1	6.1	7.2	7.4
28	0.0	0.0	0.0	0.0	0.0
29	0.0	0.0	0.0	0.0	0.0
30	4.4	6.0	6.9	8.4	9.0
31	3.9	5.1	6.2	7.6	7.9
32	0.2	0.5	1.0	1.8	2.2
33	2.8	4.5	5.9	7.9	8.6
39	5.1	6.3	7.1	8.2	8.7
41	4.5	5.9	6.2	6.0	5.7
42	5.5	6.8	7.5	8.7	9.2
46	4.6	5.7	6.6	8.2	8.7
47	4.5	6.0	6.6	8.0	8.6
49	3.0	4.6	5.2	8.4	9.3
50	3.0	3.4	4.9	7.7	8.6
54	0.0	0.0	0.0	0.0	0.0
55	2.7	4.2	5.5	7.6	8.3
56	3.1	4.6	6.0	8.7	9.4
59	0.0	0.0	0.0	0.0	0.0
63	2.6	4.1	5.5	7.9	9.0
64	3.0	4.2	5.3	7.8	8.6
65	3.7	5.2	6.5	9.2	10.1

Table 2.9-5.
Wave Height-Frequency Relationships – LOD 3 (continued)

Station Number	Water Level (ft)				
	25-yr	50-yr	100-yr	500-yr	1000-yr
66	4.3	5.2	6.2	8.6	9.4
67	5.1	6.3	6.8	8.2	8.8
68	4.4	5.6	6.5	8.1	8.5
69	6.3	7.7	8.3	9.4	9.6
70	5.5	7.0	8.1	9.8	10.4
71	5.1	6.0	7.2	8.4	8.7
72	5.2	6.6	7.8	10.0	10.8
73	4.8	5.9	7.0	9.1	9.9
74	4.8	6.0	6.7	7.7	7.9
75	6.5	7.8	9.7	11.4	11.8
76	8.3	9.9	10.9	12.7	13.2
77	10.7	12.4	13.6	15.5	16.1
78	10.2	12.2	13.3	15.0	15.7
79	11.9	13.6	15.1	16.8	17.2
80	10.0	11.4	13.3	15.7	16.4

2.9.3.3 Line of Defense 4

The frequency relationships for line of defense 4 were also estimated from the 27 storm subset and methodology discussed in section 2.4.3. The waves were not calculated for stations behind the proposed line of defense. The wave periods were not altered by the presence of the line of defense and thus are the same as for the no project condition. The frequency relationships for water level and wave height are provided by save station in Tables 2.9-6 and 2.9-7, respectively.

Table 2.9-6.
Stage-Frequency Relationships – LOD 4

Station Number	Water Level (ft)				
	25-yr	50-yr	100-yr	500-yr	1000-yr
1	8.2	11.6	14.6	19.4	21.1
2	10.2	14.2	16.8	20.7	22
3	1.2	1.2	1.4	2.3	2.4
4	1.2	1.2	1.3	1.3	1.4
5	11.9	15.5	18.2	23.8	25.4
6	9.1	13.1	16.4	21.5	23.4
7	9	12.8	16	21	22.9
8	9.3	13.2	16.3	21.5	23.4
9	1.2	1.2	1.3	1.3	1.4
10	8.1	11.4	14.3	18.9	20.7
11	7.7	11.2	13.9	18.5	19.7
12	7.5	10.9	13.7	18	19.3
13	7.6	11.4	14	18.4	19.8
14	7.1	9.9	12.1	16.5	18
15	9.2	13.2	16.4	21.4	23.3

Table 2.9-6.
Stage-Frequency Relationships – LOD 4 (continued)

Station Number	Water Level (ft)				
	25-yr	50-yr	100-yr	500-yr	1000-yr
16	2.6	3.2	3.8	4.5	4.8
17	3.2	4.2	4.8	6.1	6.5
18	4.2	5.5	6.6	8.5	9.3
19	5.6	7.4	9	11.8	13.1
20	5.9	7.9	9.7	13	14.3
21	6.4	8.7	10.8	14.6	16
22	7.7	11.2	14	18.3	19.9
23	5.8	7.7	9.4	12.5	13.7
24	5.7	7.5	9	12	13.5
25	5.2	6.6	8	9.7	9.8
26	6.3	8.5	10.4	13.9	15.2
27	8.1	11.4	14.2	18.9	20.5
28	1	1	1.1	1.1	1.1
29	0.8	0.8	0.8	0.9	0.9
30	8.2	11.7	14.6	19.2	20.9
31	8.2	11.6	14.6	19.4	21.1
32	8.7	12.2	15.3	20.2	22.1
33	9.1	13	16.3	21.3	23.3
34	1.2	1.2	1.2	1.3	1.3
35	1.2	1.9	2	2.2	2.4
36	1.2	1.9	2	2.2	2.4
37	1.3	2	2.1	2.5	2.7
38	1	1.2	1.2	1.2	1.2
39	10	14	16.9	22	23.9
40	1.3	1.6	1.6	1.8	1.9
41	9.5	13.6	16.6	21.3	23.3
42	9.8	13.9	16.9	21.9	23.8
43	1.5	2.4	2.5	2.9	3.1
44	3	4.4	4.8	6.4	6.4
45	2.3	3.1	3.5	4.6	4.7
46	10.5	14.4	17	22.7	24.4
47	11	14.7	17.6	23.2	24.9
48	1	1.4	1.4	1.4	1.4
49	10.9	15.3	18.2	23.9	25.7
50	11.3	14.7	18.1	24.4	26.2
51	2.2	2.6	3.1	4.6	4.8
52	1.5	1.5	1.5	1.6	1.7
53	0	0	0.1	0.1	0.1
54	6.9	9.9	11.8	14.9	15.9
55	11.3	16	19.2	24.4	25.9
56	11.1	15.8	18.8	24.3	25.9
57	2.1	3	3.2	3.5	3.7
58	2.2	2.4	3.4	4.7	4.8
59	7	10.1	12.1	15.3	16.4

Table 2.9-6.
Stage-Frequency Relationships – LOD 4 (continued)

Station Number	Water Level (ft)				
	25-yr	50-yr	100-yr	500-yr	1000-yr
60	2.4	3.3	4	5.6	5.8
61	1.3	1.3	1.4	1.4	1.4
62	9.7	13.8	16.4	20.7	22.1
63	10.4	14.5	17	21	22.3
64	10.6	14.7	17.6	22.3	23.6
65	10.9	15.4	18.5	23.6	25.1
66	10.8	14.6	17.6	23.2	25
67	10.8	14.3	17.1	22.7	24.3
68	10.1	14	16.6	22	23.6
69	9.2	13	16.1	20.8	22.7
70	8.6	12.3	15.3	20	21.8
71	8	11.4	14.2	18.8	20.5
72	8	11.5	14	18.6	20.2
73	7.5	10.9	13.4	17.9	19.4
74	7	10.4	13.2	17.5	18.9
75	6.9	10.3	14	18.7	20.2
76	9.5	12.2	14.7	18.6	19.8
77	8	11.2	13.3	16.9	18.2
78	6.7	9.6	12.1	15.9	17.1
79	5.8	8.7	11.7	15.7	17
80	5.6	8.3	11.7	16.1	17.3

Table 2.9-7.
Wave Height-Frequency Relationships – LOD 4

Station Number	Water Level (ft)				
	25-yr	50-yr	100-yr	500-yr	1000-yr
1	3.6	4.9	6.1	8	8.6
2	1.3	2.9	4	6.3	7.1
5	2.8	4.3	5.7	8.1	9
6	3	4.8	6.2	8.7	9.5
7	3.4	5.2	6.9	9.7	10.7
8	2.8	4.5	6.2	9.4	10.5
10	4.6	5.7	6.8	8.5	9
11	2.1	3.2	4.2	6.4	6.9
12	4.8	6.2	7.2	9.1	9.6
13	0.1	0.3	0.5	0.8	1
14	0.2	0.7	1.1	1.8	2
15	2.4	4	5.5	7.8	8.6
16	0	0	0	0	0
17	0	0	0	0	0
18	0	0	0	0	0
19	0	0	0	0	0
20	0.1	0.2	0.3	0.6	0.7

Table 2.9-7.
Wave Height-Frequency Relationships – LOD 4 (continued)

Station Number	Water Level (ft)				
	25-yr	50-yr	100-yr	500-yr	1000-yr
21	0.3	1	1.6	2.8	3
22	4.3	6.1	7.4	9.6	10.3
23	0.3	1	1.3	1.7	2
24	0	0	0	0	0
25	0	0	0	0	0
26	0.8	1.6	2.4	3.5	3.8
27	3.8	5	6	7.1	7.2
28	0	0	0	0	0
29	0	0	0	0	0
30	4.4	6	6.8	8.2	8.7
31	3.9	5.1	6.3	7.7	8.1
32	0.2	0.4	0.7	1	1.9
33	2.9	4.5	6	8.2	9
39	5.1	6.3	7.1	8.3	8.8
41	5.1	7.1	7.5	7.5	7.3
42	5.5	6.8	7.5	8.7	9.2
46	4.5	5.5	6.6	8.2	8.7
47	4.5	6	6.3	8	8.6
49	3.1	4.6	5.7	8.4	9.2
50	0.5	1.9	4.1	7.6	8.9
54	0	0	0	0	0
55	2.7	4.2	5.5	7.5	8.1
56	3	4.5	6	8.6	9.4
59	0	0	0	0	0
62	0.5	1.3	1.9	4	4.7
63	2.6	4.2	5.6	8.1	9.2
64	3	4.2	5.3	7.8	8.6
65	3.7	5.1	6.4	9.2	10.1
66	4.4	5.1	6.1	8.5	9.3
67	5.1	6.3	6.8	8.2	8.8
68	4.4	5.6	6.6	8.3	8.8
69	6.4	7.7	8.4	9.7	10.1
70	5.5	7	8.1	9.6	10.2
71	5.1	6	7.3	8.7	9.2
72	5.2	6.6	7.8	10.1	10.9
73	4.8	5.9	6.7	8.2	8.7
74	4.8	6.1	6.8	7.9	8.2
75	6.5	7.8	9.7	11.4	11.8
76	8.3	9.9	10.9	12.7	13.2
77	10.7	12.3	13.7	16.1	16.9
78	10.3	12.2	13.3	15	15.7
79	11.9	13.6	15.1	17	17.5
80	10	11.3	13.2	15.5	16.1

2.10 Barrier Island Sensitivity

Topography, landscape features, and vegetation 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 purpose of this section is to document a sensitivity study of various barrier island configurations to qualitatively assess the impact of barrier island restoration on storm surge at the mainland coast for storms of varying intensities.

The barrier island sensitivity study was conducted on a grid consistent with that applied for the Interagency Performance Evaluation Team (IPET) study. The analysis 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 changes to the barrier islands caused by erosion that occur during a storms 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 barrier islands.

2.10.1 Storm Suite

Eleven storms were identified for evaluating storm surge response to changes in barrier island configuration: two historical storms and nine hypothetical storms (Table 2.10-1). The two historical storms, Camille and Katrina, were selected because those hurricanes did in fact make landfall on the Mississippi coast in 1969 and 2005, respectively. A suite of storms making landfall on the Mississippi coast were also designed and selected for simulation. The first hypothetical storm (HST001) was designed to produce a 22 ft surge potential seaward of the barrier islands on the Mississippi coast. The storm had a central pressure of 890 mb and a radius to maximum winds of approximately 11 nm, that of Hurricane Camille. Two additional storms were defined by scaling HST001 to produce storms with a surge potential of 13 ft seaward of the barrier islands (HST002) and a surge potential of 8 ft (HST003). The hypothetical storms followed the Katrina track (both geographically and temporally), but were shifted eastward to make landfall at the three locations shown in Figure 2.10-1.

Table 2.10-1.
Barrier Island Sensitivity Storm Suite

Storm Number	Storm Name	Track	Barrier Island Configuration
1	Katrina	Historical	Post-Katrina
			Restored-High
2	Camille	Historical	Post-Katrina
			Restored-High
3	HST001-04	04	Post-Katrina
			Restored-High
			Restored-Low
4	HST003-04	04	Post-Katrina
			Restored-High
5	HST001-06	06	Post-Katrina
			Restored-High
			Restored-Low
6	HST003-06	06	Post-Katrina
			Restored-High
7	HST002-04	04	Post-Katrina
			Restored-High

Table 2.10-1.
Barrier Island Sensitivity Storm Suite (continued)

Storm Number	Storm Name	Track	Barrier Island Configuration
8	HST002-06	06	Post-Katrina
			Restored-High
9	HST001-05	05	Post-Katrina
			Restored-High
			Restored-Low
10	HST002-05	05	Post-Katrina
			Restored-High
11	HST003-05	05	Post-Katrina
			Restored-High

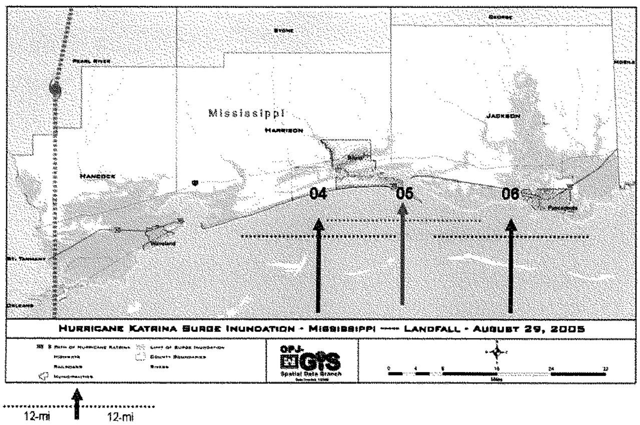


Figure 2.10-1. Hypothetical Storm Tracks

2.10.2 Barrier Island Configuration

The sensitivity storm suite consisting of the eleven storms described in Section 2.10.1 was used to simulate storm surge on three barrier island configurations. The barrier island configurations modeled were: 1) the existing Post-Katrina degraded condition (elevations ranging from approximately 2 to 6 ft (NAVD88 2004.65)); 2) a Restored-Hight barrier island configuration with an extended (pre-Camille) footprint and an elevation of 20 ft NAVD88 2004.65; and 3) a Restored-Low configuration with a footprint representative of the islands pre-Katrina and elevations ranging from approximately 5 to 10 ft (NAVD88 2004.65). The Restored-High configuration represents a massive barrier island configuration that would be difficult to achieve and was modeled for sensitivity purposes. The Restored-Low is a more likely restoration scenario with pre-Katrina footprints and heights of 10 ft or less. Figures 2.10-2 shows the topography of each of the five Mississippi barrier islands for the Post-Katrina and the Restored condition. Note that for the Restored-High condition, the gaps in Ship Island and Dauphin Island have been repaired to the pre-Camille configuration. Bathymetry for the Post-Katrina degraded condition was derived from a SHOALS air-borne LIDAR survey taken in September/October 2005. Figure 2.10-3 shows the difference between the Restored-Low and Post-Katrina conditions.

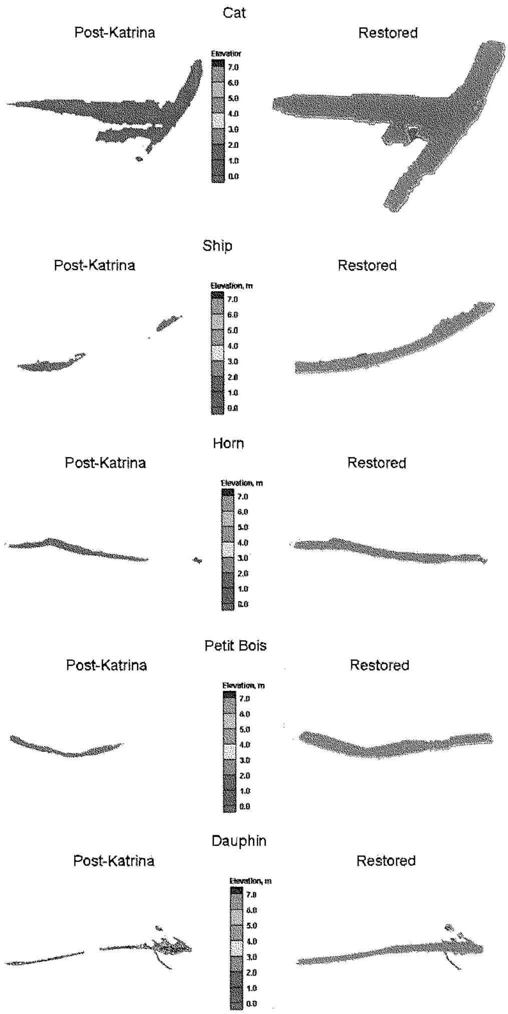


Figure 2.10-2. Mississippi barrier island Post-Katrina and Restored-High configurations

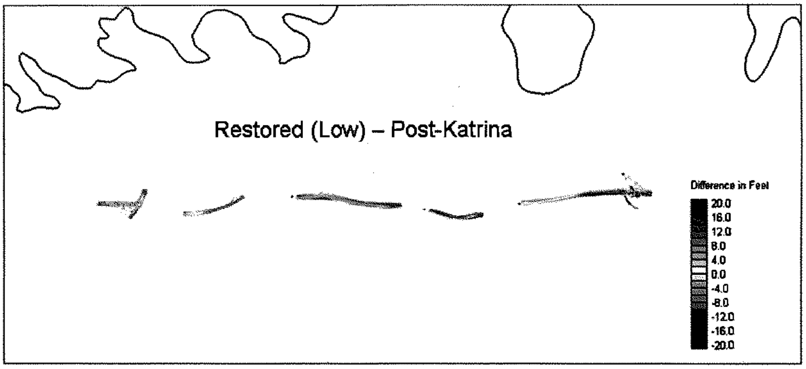


Figure 2.10-3. Difference between Restored-Low and Post-Katrina Mississippi barrier island configurations

The entire eleven storm suite was simulated on the Post-Katrina and Restored-High grids. Storms HST001-04, HST001-05, and HST001-06 were also simulated on the Restored-Low grid (see Table 2.10-1).

2.10.3 Results

Peak water level maps for each of the 11 storms simulated on the existing Post-Katrina configuration were compared to the same storms simulated on the Restored-High barrier island configuration; and the three storms simulated on the Restored-Low configuration were also compared to Post-Katrina. In general, raising the barrier islands caused a decrease in peak water level landward of the barrier islands when compared to the peak water level for the baseline Post-Katrina configuration and an increase in peak water level seaward of the barrier islands. Table 2.10-2 shows the peak water levels for each simulation with Post-Katrina and the Restored-High barrier island configurations. Reduction in the peak water level landward of the barrier islands is as much as 10 ft.

Table 2.10-2.
Peak Water Level for Barrier Island Sensitivity Storms

		Peak Water Level, ft					
		Waveland		Biloxi		Pascagoula	
Storm Name	Track	Post-Katrina	Restored	Post-Katrina	Restored	Post-Katrina	Restored
Katrina	Historical	26-28	26-28	20	18	16	12
Camille	Historical	28	26	22	20	12	10
HST001-04	04	8-12	8-10	40	35	28	18
HST003-04	04	6	6	14	13	6	6
HST001-06	06	3	3	8	8	40	31
HST003-06	06	2	2	6	6	12	6
HST002-04	04	8	6	24	20	14	9
HST002-06	06	2	2	8	6	16	14
HST001-05	05	3	3	24	22	32-33	26-27
HST002-05	05	3	3	18	14	16	11
HST003-05	05	2	2	12	10	7	6

For the purposes of discussion and comparison, Figures 2.10-4 through 2.10-12 show peak water levels for simulations of Hurricane Katrina, HST001-05, HST002-05, HST003-05 storms for both the Post-Katrina and Restored-High barrier island configurations and HST001-05 for the Restored-Low configuration. Peak water levels for Hurricane Katrina show maximum water levels of approximately 26-28 ft for the Waveland area for both the Post-Katrina and Restored-High barrier island configurations (Figures 2.10-4 and 2.10-5). This area of maximum water level is west of all barrier islands that protect the Mississippi coast, therefore little change is observed in this region when the barrier islands are raised. Peak water levels near Biloxi are approximately 20 ft for Post-Katrina and 18 ft for the Restored condition. This area is afforded 1-2 ft of surge protection from the raised Ship and Horn Islands. Further to the east, water levels in Pascagoula are reduced from 12-16 ft to 10-12 ft with the presence of the raised Horn, Petit Bois, and Dauphin Islands. Note that the barrier islands are completely inundated for the Post-Katrina configuration and remain dry for the Restored-High barrier island configuration.

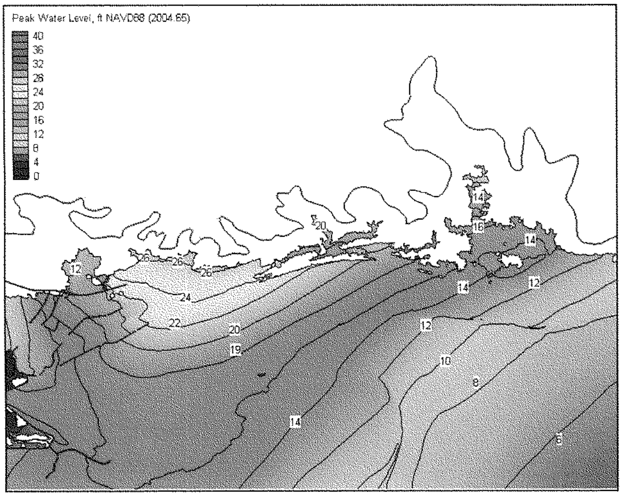


Figure 2.10-4. Katrina peak storm surge with waves; Post-Katrina configuration

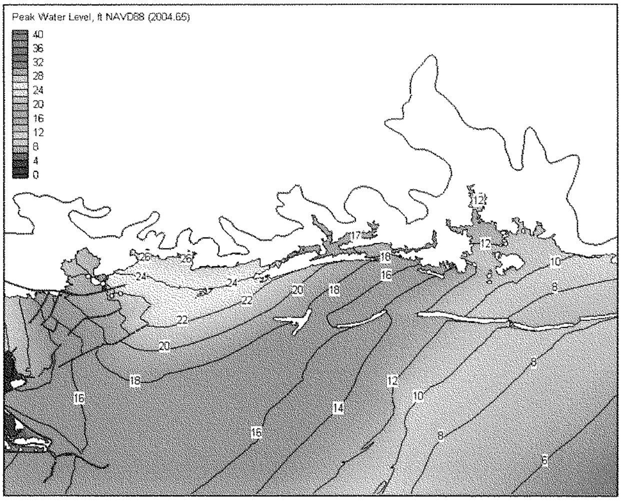


Figure 2.10-5. Katrina peak storm surge with waves; Restored-High configuration

Peak water levels for the HST001-05 storm are higher than the Hurricane Katrina water levels, with the greatest inundation levels in Biloxi and Pascagoula (Figures 2.10-6 to 2.10-8). Post-Katrina peak water levels are 32-33 ft and extend well into the Pascagoula basin with water levels of 24-26 ft. Peak water levels are a maximum of 26-27 ft for the Restored-High barrier island configuration and are 28-30 ft for the Restored-Low. The water levels up the Pascagoula basin reach 18 ft for the Restored-High barrier island configuration and reach 22 ft for the Restored-Low. Water levels at the entrance to Biloxi Bay are 22-24 ft for Post-Katrina, 20-22 ft with the Restored-High barrier islands, and 22-24 ft for the Restored-Low. Water levels seaward of the raised barrier islands are elevated compared to the Post-Katrina barrier islands. That is, the raised barrier islands effectively block some of the surge and it piles up seaward of the islands. Water levels near St. Louis Bay are nearly identical with and without raised barrier islands.

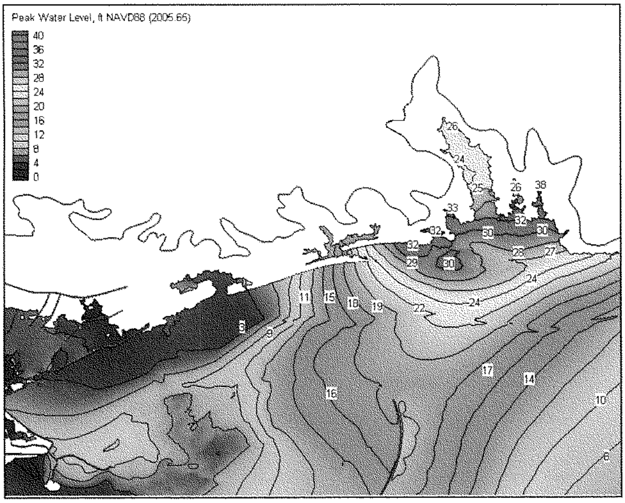


Figure 2.10-6. HST001-05 peak storm surge; Post-Katrina configuration

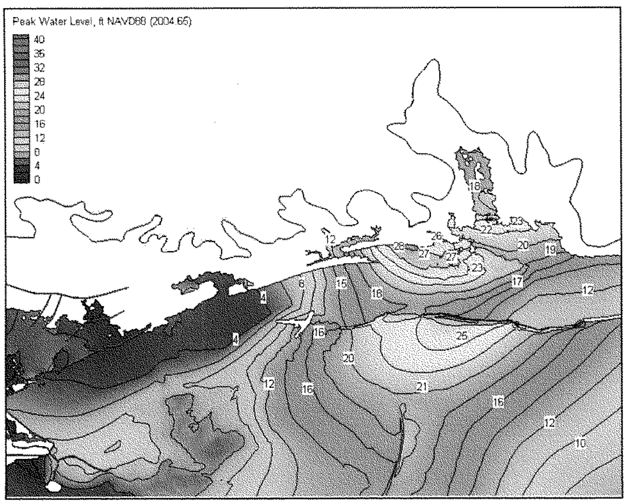


Figure 2.10-7. HST001-05 peak storm surge; Restored-High configuration

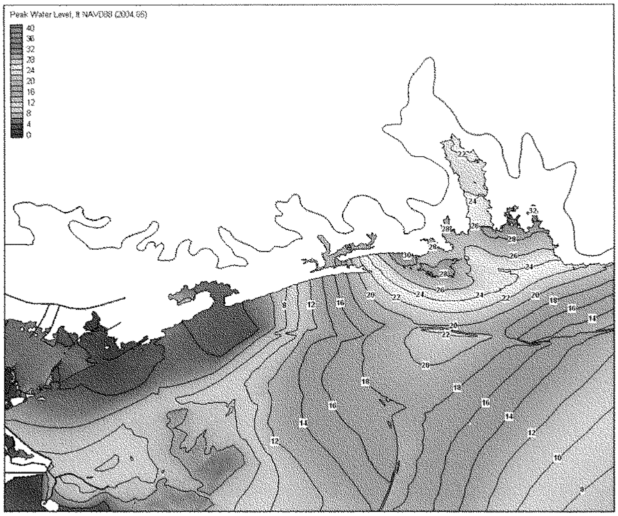


Figure 2.10-8. HST001-05 peak storm surge; Restored-Low configuration

Peak water levels for the HST002-05 storm (Figures 2.10-9 and 2.10-10) are less than the HST001-05 water levels, as expected. The general geographical area of maximum surge however is in the same location (Biloxi and Pascagoula). Peak water levels for the Post-Katrina barrier islands are 14-16 ft in Pascagoula and 16-18 ft near Biloxi. Penetration distance into the Pascagoula basin for the less intense storm is less, as expected. Peak water levels for the Restored-High barrier islands are 10-11 ft in Pascagoula and 14 ft at Biloxi. Water levels seaward of the raised barrier islands are elevated compared to the Post-Katrina barrier islands. Note that even for the 13 ft surge potential storm, the barrier islands are I inundated for the Post-Katrina configuration and remain dry for the Restored barrier island configuration.

Peak water levels for the HST003-05 storm (Figures 2.10-11 and 2.10-12) are less than the HST001-05 and HST002-05 water levels, as expected. The penetration distance into the Pascagoula basin is shorter and peak water levels are only 5-7 ft. Water levels at the entrance to Biloxi Bay are 10-12 ft for the Post-Katrina configuration and 10 ft for the Restored-High barrier islands. The difference between the Post-Katrina and Raised-High barrier island peak surges level is approximately 1-2 ft. Surge build-up seaward of the raised barrier islands is observed near Ship and Horn Islands and the barrier islands are still inundated for the Post-Katrina configuration for the 8 ft surge potential storm.

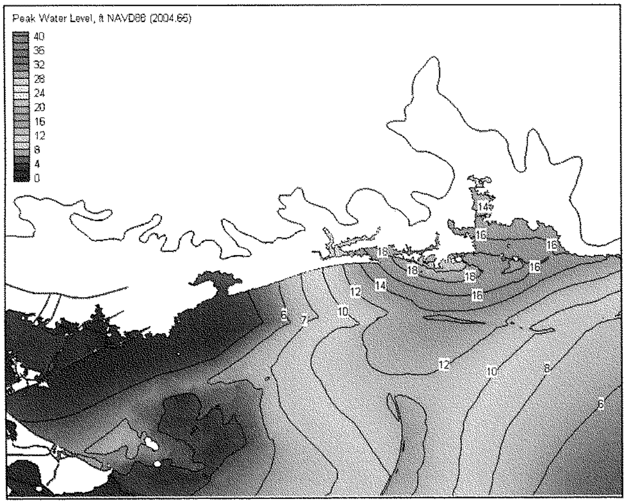


Figure 2.10-9. HST002-05 peak storm surge; Post Katrina configuration

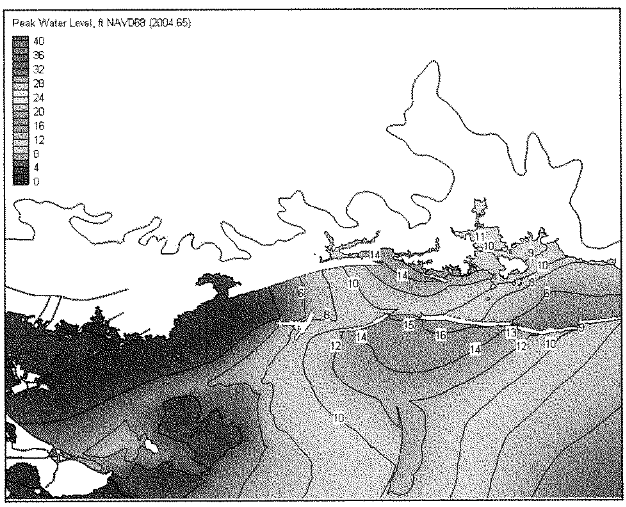


Figure 2.10-10. HST002-05 peak storm surge; Restored-High configuration

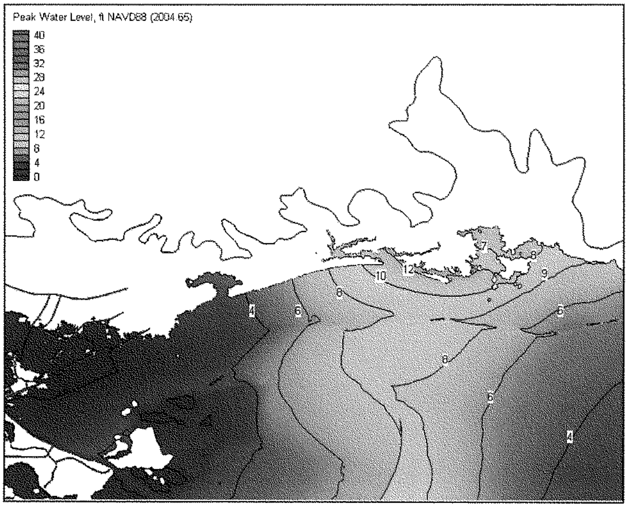


Figure 2.10-11. HST003-05 peak storm surge; Post-Katrina configuration

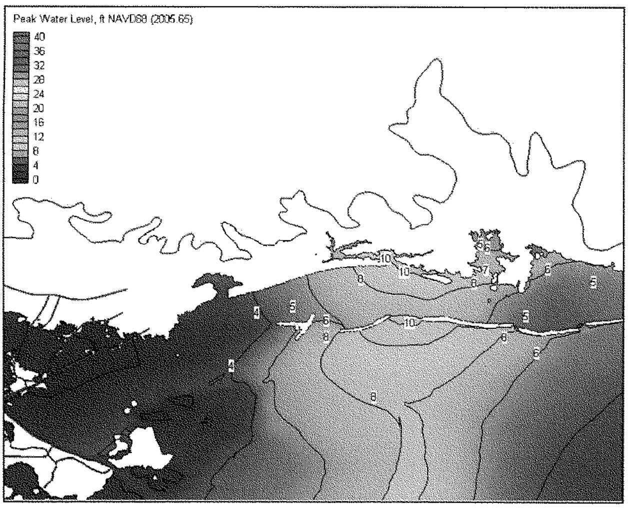


Figure 2.10-12. HST003-05 peak storm surge; Restored-High configuration

The difference in Hurricane Katrina peak water levels for the Restored-High barrier islands versus the Post-Katrina barrier islands (Figure 2.10-13) shows a reduction in water level 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 water level is in the Pascagoula basin where water levels are reduced 1-3 ft. Note that the area of maximum water level for Hurricane Katrina is in Waveland, which is west of all barrier islands that protect the Mississippi coast. Therefore, little change in peak water level (less than 0.5 ft) is observed in this region when the barrier islands are raised. Peak water levels near Biloxi are approximately 20 ft for Post-Katrina and 18 ft for the Restored-High condition. This area is afforded 1-2 ft of surge protection from the raised Ship and Horn Islands. Further to the east, water levels in Pascagoula are reduced from 12-16 ft to 10-12 ft with the presence of the raised Horn, Petit Bois, and Dauphin Islands. The percent reduction in peak water level landward of the barrier islands is greatest in the eastern part of the state (behind Horn and Petit Bois islands) and decreases to the west. Surge reductions were approximately 20% in the Pascagoula area, 5 to 10% in the central part of the state, and less than 5% in Waveland. Similar percent reductions in surge were calculated for Hurricane Camille.

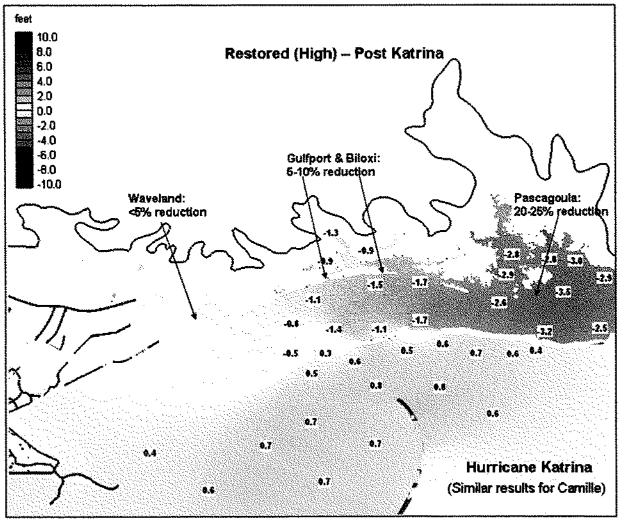


Figure 2.10-13. Difference in peak surge (Restored-High – Post Katrina) for Hurricane Katrina

A greater change in water level from the Post-Katrina to the Restored-High barrier island configuration was observed for the HST001-05 (Figure 2.10-14). HST001-05 made landfall at Biloxi and maximum water levels are observed east of the landfall point, where hurricane winds are strongest. This track passes between Ship and Horn Islands, therefore restoring Horn Island causes a major buildup of surge seaward of this island. Water levels landward of the barrier islands are greatly reduced for the Restored-High barrier island configuration. Post-Katrina flooding extends well into the Pascagoula basin. Water levels are 6-8 ft less in Pascagoula and 2-3 ft less near Biloxi for the Restored-High barrier island configuration. Seaward of the barrier islands surge levels increase 2-4 ft for the Restored-High barrier island configuration. The percent reduction in peak water level landward of the barrier islands is greatest in the eastern part of the state (behind Horn and Petit Bois islands) and decreases to the west. Surge reductions were approximately 20-40% in the Pascagoula area, 5 to 15% in the central part of the state, and less than 5% in Waveland. Similar percent reductions in surge were calculated for other tracks.

A much smaller change in water level is observed between the Post-Katrina and Restored-Low barrier island configurations (Figure 2.10-15). Water level reductions are cut in half relative to the high restoration with 3-4 ft less surge compared to Post-Katrina in Pascagoula and 0-2 ft less in the central part of the state. The percent reduction in peak water level landward of the barrier islands is again greatest in the eastern part of the state (behind Horn and Petit Bois islands) and decreases to the west. However, surge reductions are approximately 10% or less coast –wide. Similar percent reductions in surge were calculated for other tracks.

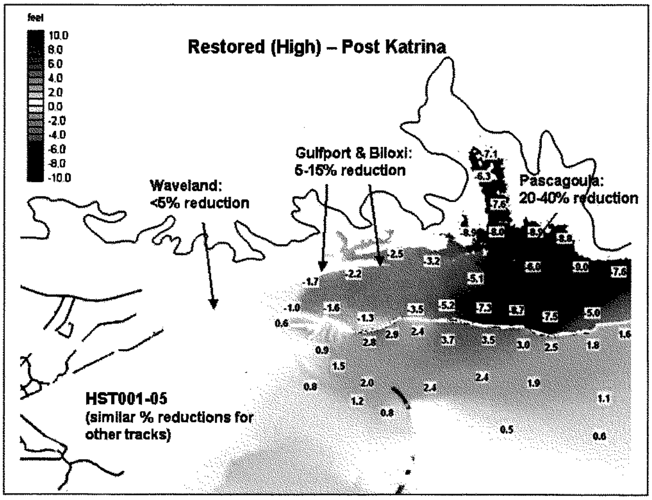


Figure 2.10-14. Difference in peak surge water level (Restored-High – Post Katrina) for HST001-05

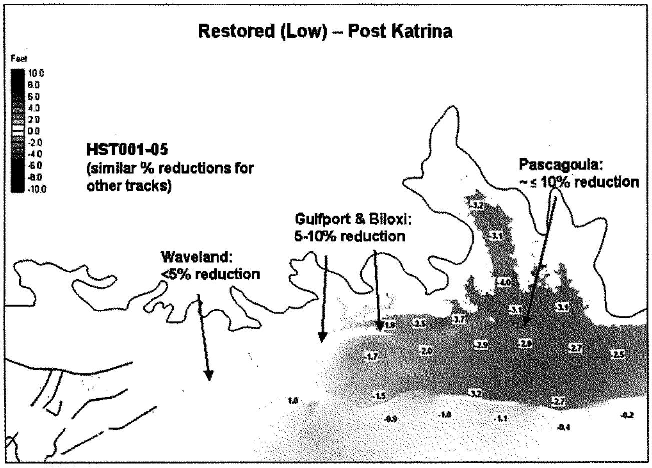


Figure 2.10-15. Difference in peak surge water level (Restored-Low – Post Katrina) for HST001-05

For HST002-05, the difference in the peak water level for the Restored-High barrier island configuration versus the Post-Katrina shows that water levels landward of the barrier islands are reduced 5-6 ft (Figure 2.10-16). Note that the inundation was less for the 13 ft surge potential storm compared to the 22 ft surge potential storm and the reduction in water level is also less for the weaker storm. Reduction in water level with the Restored-High barrier islands is most significant in Pascagoula (5-6 ft) and Biloxi (3 ft). Increased water level seaward of the barrier islands is most significant near Horn Island, but the build up is not as intense as for HST001-05. The percent reduction in surge was greatest for this storm.

With HST003-05, peak water levels were only 10-12 ft at the entrance to Biloxi Bay for the Post-Katrina barrier islands and 10 ft with the Restored-High barrier islands. The difference in peak water level for the Restored-High versus Post-Katrina barrier island configurations shows the protection afforded by the raised barrier islands is 1 to about 2.5 ft at the coast (Figure 2.10-17). The general pattern/area that is protected by the raised barrier islands is still the Pascagoula (~2 ft) and Biloxi (~1.5 ft) areas and surge build-up is observed seaward of Horn Island (~1 ft).

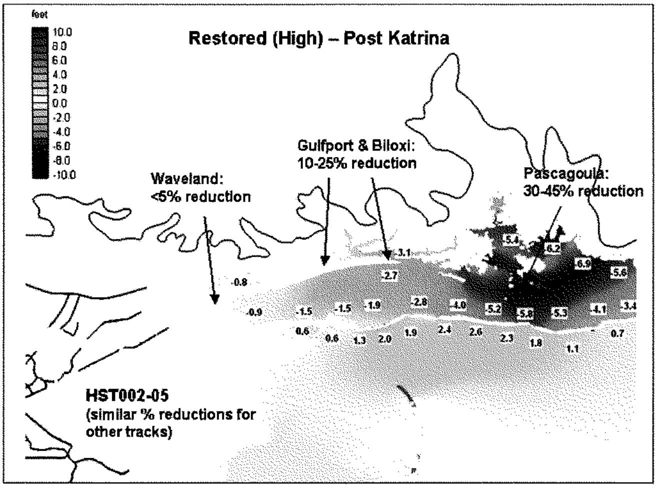


Figure 2.10-16. Difference in peak surge water level (Restored-High – Post Katrina) for HST002-05

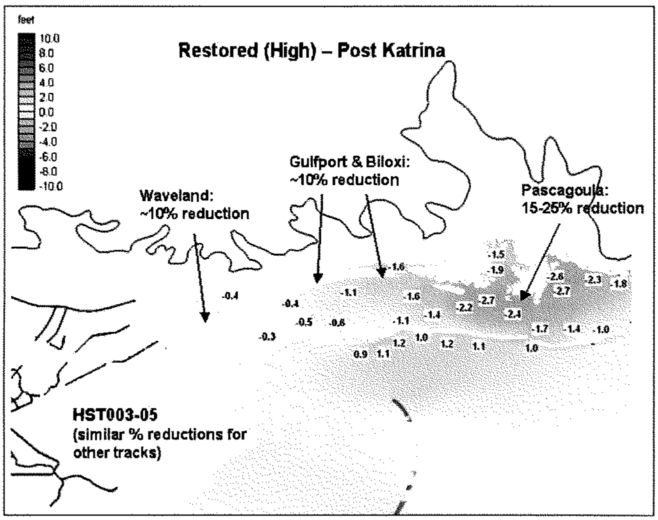


Figure 2.10-17. Difference in peak surge water level (Restored-High – Post Katrina) for HST003-05

2.10.4 Summary

The model results indicate that the barrier islands do provide some level of protection for most of the Mississippi coast, and that restoration of the islands will reduce surges at the mainland coast. The higher and greater in planform extent the islands are, the greater amount of protection the islands provide. The barrier islands do not significantly reduce surges in Hancock County and the surge reductions increase moving from west to east, with the greatest reductions in Jackson County. While model results showed that surge in Jackson County was reduced by as much as 40% for the Restored-High configuration, this represents a massive barrier island configuration that would be difficult to achieve. The Restored-Low is a more likely restoration scenario with pre-Katrina footprints and heights of 10 ft or less, the percent reduction in Jackson County for this configuration was much less at approximately 10%.

2.11 Wetlands, Landscape Features, and Storm Surge

Topography, landscape features, and vegetation 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) and vegetation (e.g., maritime forests and wetlands) are typically below the surge elevation, but they have the potential to create friction and slow the forward speed of the storm surge. The surge then has time to dissipate offshore and alongshore, reducing inland surge elevations. The purpose of this section is to present 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. A sensitivity study of a degraded and restored Biloxi marsh utilizing the modeling tools applied for this study is also presented. Sensitivity to barrier islands is discussed in Section 2.10.

2.11.1 Literature Review

The purpose of this literature review is to document studies that have measured storm surge elevations with the goal of understanding how landscape features and vegetation modify the surge elevation. Numerical modeling studies of this phenomenon are also reviewed.

2.11.1.1 Existing Relationships

Relationships documenting the reduction in storm surge elevation due to landscape features and vegetation have been determined based on limited measurements in Louisiana. Obtaining reliable data from field observations is difficult as many factors control the elevation of the surge. To properly characterize the influence of landscape features and vegetation on storm surge, measurements should be (1) in line with the path of the storm, (2) on the same side of the storm, (3) not so far apart that processes (e.g., barometric pressure, winds, rainfall) are significantly different, (4) inside an enclosed space, to remove the influence of wave height on the measurements, and (5) representative of a homogeneous landscape feature (Figure 2.11-1). The relationships developed from the limited data available and discussed below do not, in general, adhere to these requirements and therefore should not be relied upon for engineering design.

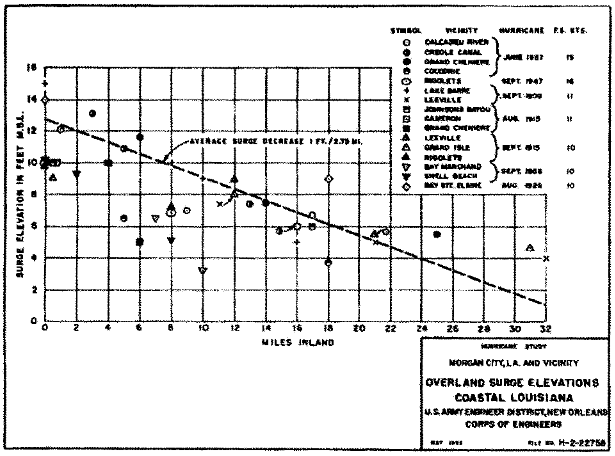


Figure 2.11-2. Observed maximum surge high water marks versus distance inland (USACE 1965)

The Louisiana Coastal Wetlands Conservation and Restoration Task Force and the Wetlands Conservation and Restoration Authority (2004; Chapter 6, p. 55) discuss that it is "commonly acknowledged that barrier islands and wetlands reduce the magnitude of hurricane storm surges and related flooding; however, there are scant data as to the degree of reduction." At the time the report was written, the best information documenting this phenomenon came from gages measuring water elevations during the second landfall of Hurricane Andrew (data documented by Lovelace 1994), which occurred in the vicinity of Point Chevreuil, Louisiana on August 26, 1992. Gage data from Cocodrie, Louisiana indicated a maximum water level elevation equal to 9.3 ft (2.8 m) during this Category 3 Hurricane. Over a 23-mile (37 km) stretch of marsh and open water from Cocodrie to the Houma Navigation Canal, the water elevation decreased from 9.3 ft (2.8 m) to 3.3 ft (1 m), equating to a reduction in surge amplitude equal to 3.1 inch (0.26 ft) per mile of marsh and open water (1 cm per 203 m). A similar set of measurements showed reduction of the storm surge from 4.9 ft (1.5 m) at Oyster Bayou to 0.5 ft (0.15 m) at Kent Bayou, located 19 miles (30.6 km) north. This second set of measurements indicated a 2.8-inch (0.23 ft) decrease in surge per mile (1 cm per 230 m) over "fairly solid marsh." The report cautions that these represent measurements from one storm; other factors, such as storm characteristics, coastal geomorphology, and track of the storm influence the degree to which wetlands decrease storm surge.

The Working Group for Post-Hurricane Planning for Louisiana Coast (2006) wrote "barrier islands, shoals, marshes, forested wetlands and other features of the coastal landscape can provide a significant and potentially sustainable buffer from wind wave action and storm surge generated by tropical storms and hurricanes." ADCIRC results from Rick Luettich (Dec 30, 2005) indicated if wetlands east of the Mississippi River Gulf Outlet (MRGO) were removed and the lake was deepened to 2.5-m (8-ft), the storm surge from Hurricane Katrina would increase by 1-2 m (3-6 ft) for St. Bernard Parish and Eastern New Orleans.

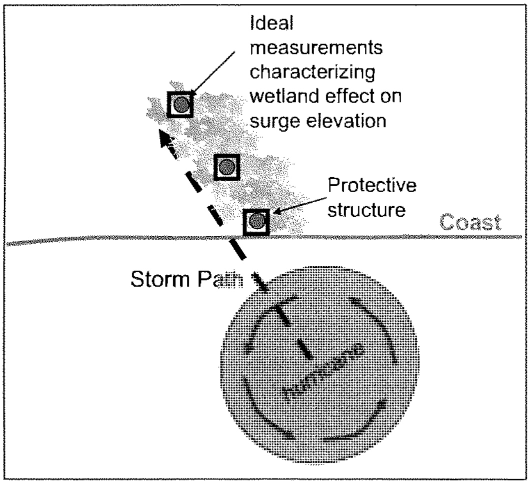


Figure 2.11-1. Ideal measurements for isolating the influence of landscape features on storm surge elevations

In a Letter from the Chief of Engineers (1965) documenting an interim hurricane survey of Morgan City and vicinity, Louisiana, measurements of high water marks due to hurricane surge were correlated with distance inland from the coast. Surge elevations at 16 locations near Morgan City due to seven hurricanes (Sep 1909, Aug 1915, Sep 1915, Aug 1926, Sep 1947, Sep 1956, and Jun 1957) were documented giving 42 data points (Figure 2.11-2). The report states that this area has numerous bays and marshes, but the data evaluated include the western part of Louisiana with cheniers (relatively high wooded ridges). Inconsistent results were obtained when attempting to correlate hurricane translation speed, surge hydrograph at the coast, and surge elevations inland. However, a trend was observed for the decrease in storm surge as a function of distance inland, and is independent of hurricane translation speed, wind speed, and direction. The relationship indicates that storm surge was reduced by 1 foot for every 2.75 miles inland (1 cm decrease in storm surge per 145 m inland).

Lovelace (1994) documented storm surge elevations after Hurricane Andrew in Louisiana. Citing this study, the Louisiana Coastal Wetlands Conservation and Restoration Task Force and the Wetlands Conservation and Restoration Authority (2004) suggest that storm surge reduces about 3-inch (0.25 ft) per mile (1 cm per 211 m) of marsh along the central Louisiana coast. Stone et al. (2003) modeled a Category 3 hurricane that made landfall in 1915 and compared wave and storm surge for the south-central Louisiana coast in 1950 (1.09 million acres of land) to that in 1990 (0.85 million acres of land). Models used were a hurricane planetary boundary model, ADCIRC circulation model, and SWAN wave model. Acreage impacted by a 2.1 m (7 ft) surge and 3.7 m (12 ft) increased by 69,000 and 49,000 acres, respectively, between 1950 and 1990. Surge levels greater than 4.6 m (15 ft) were not significantly different between the two time periods.

2.11.1.2 Engineering Relationships

This section presents a preliminary review of the engineering literature about the quantitative relationships between coastal landscape features and the characteristics of hurricane storms. The effects of each landscape feature on each of the hurricane storm characteristics are reviewed.

Wetlands contain a variety of vegetation types. The physical properties of wetlands that modify storm characteristics include the vegetation type, location, height and density. Vegetation has an effect on storm waves. Waves become depth limited, not fetch limited, over relatively short distance if the friction factor is high enough. Wind stress is also affected by land cover. The sediment geotechnical properties and morphology of each wetland can modify wave height and direction.

Barrier islands and interior landscape ridges modify storm surge as a function of location, elevation, width, vegetation cover, and foreshore slope. The degree to which a barrier island decreases storm surge elevation depends on whether the island is overtopped and if the adjacent tidal inlet cross sectional area is in equilibrium with the bay tidal prism. Inlet parameters include location, cross sectional area, depth, width, and frictional roughness.

2.11.1.2.1 Winds

The strength and impact of hurricane winds in coastal areas is affected by landscape features in two distinct manners. First, the intensity of hurricane storms undergoes a significant decrease in intensity after landfall. Data suggest that this process, referred to as "filling," is initiated before the eye of the storm crosses over land. The filling gradually reduces the wind velocity within the storm. The rate of wind speed reduction has been related to the number of hours after landfall and to the geographic region (NWS 23 1979). This rate of reduction is of highest category for the Mississippi coast, showing a reduction of the wind speed of about 15% at 5 hours after landfall and a reduction of about 30% at 10 hours after landfall.

Landscape features also affect hurricane winds because vegetation which extends above the water surface, both before and during flooding, reduces the speed of the wind at the water surface. This reduction in wind speed translates to a reduction in the wind stress which generates both storm waves and surges. The reduction in wind stress due to the presence of vegetation has been described with a "stress reduction factor" or SRF (Federal Emergency Management Agency (FEMA) 1985). The SRF is affected differently by various land covers and the most important contribution is the areal distribution of the various land covers. Wooded areas have the greatest effect, with the type, height and density of the trees being of primary importance. The SRF may be as low as 0.10, indicating a 90% reduction of the open water wind stress. The SRF for wooded areas is related to the fractional projected area of the trees. This fractional area is the area of the trees divided by the total flow area, with both areas being projected on a vertical plane perpendicular to the wind velocity. The effect of trees on the SRF is not linear. For a fractional projected area of 10% the SRF is 0.85, while for 40%, the SRF is 0.30. The effect decreases with higher fractional areas. At fractional areas equal to 60% and 80%, the SRF is 0.20 and 0.10, respectively.

Marsh grasses also affect the SRF, although this effect is very complex. Overall marsh grass has a smaller roughness than wooded areas, and has a smaller effect on wind velocity. Marsh grass is quite flexible and can be blown over during the hurricane. Also the marsh grasses can become inundated exposing the water surface to the full effect of the wind. The expected range in SRF for marsh is 0.70 to 0.90 with the higher value being used when the surge height is higher than the average height of the marsh grass.

A value for 0.30 for the SRF has been used successfully by the USGS in the SWIFT2D hydrologic modeling of coastal wetlands (Swain 2005). The value of SRF equal to 0.30 was used for all computational grids having a Manning's coefficient greater than 0.10, implying that the vegetation is emergent.

Open water near land can experience a reduction in the wind stress when the wind is blowing offshore. This "downwind sheltering effect" results from the modification of the winds surface boundary layer as it passes a land surface having high roughness. This effect may extend to a distance of 2 to 10 nautical miles from the upwind land, and would be particularly important behind barrier islands. The approach used by FEMA is to linearly increase the wind stress from the reduced overland value to the open water value over a distance of from 2 to 10 nautical miles.

2.11.1.2.2 Waves

Storm waves are affected by several coastal landscape properties. These properties include the water depth (before and during flooding), bottom roughness or friction, water column friction, and bottom sediment characteristics.

The effect of water depth on waves becomes fundamental as waves propagate into shallow water and controls wave kinematics and dynamics (U.S. Army Corps of Engineers 2003). Shallow water wave processes includes generation, shoaling, refraction, diffraction, reflection, breaking, setup, run-up, bottom friction, water column friction, and dissipation of wave energy through wave/bottom interaction. The water depth and variations in water depth associated with coastal landscape features become particularly important when they cause wave breaking. Wave breaking occurs when the still water depth equals about 78% of the wave height and involves intense energy loss and can, for example, reduce wave heights by 90% over a distance of 10 meters. Wave run-up and overtopping occur if the height of a barrier island or an interior ridge equals or is less than the still water elevation.

Bottom friction and wave/bottom interaction in shallow bays dissipates wave energy and can limit the height of waves to values considerably below the breaking criteria. This effect depends upon the type of bottom sediment in the bay. Muddy bottom sediments have a response that can involve actual motion of the bottom due to the elastic properties of clay and mud.

The wave energy loss through vegetation results from the drag force of the wave current on the plants (FIA 1984, FEMA 1988). The rate of energy loss depends upon the geometry of the individual plants and the density of the plants in a given area. For areas containing a variety of plant types, the number of plants of each type can be specified as the fraction of the total area covered by a plant type and the average number of plants per square foot in the fractional area. The total energy loss for all plants along a transect is the sum of the energy loss associated with all of the individual plant types. The time average energy loss, $E_{i,j}$ for all plants of all plant types is given by:

$$E_{i,j} = \frac{\int_0^T \int_0^{h_i} \left|F_{i,j} u\right| dz\, dt}{T} \qquad \text{E 2.11-1}$$

where z is the elevation, $F_{i,j}$ is the drag force for the j^{th} member of the i^{th} plant type, h_i is the height of the submerged plant or the wave crest height if the plant is exposed, u is the horizontal wave current, and T is the total time being evaluated. The drag force on each individual plant is given as:

$$F_{i,j} = \frac{\rho C_D D_{i,j} \left|u\right| u}{2} \qquad \text{E 2.11-2}$$

where ρ is the water mass density, C_D is the plant drag coefficient, and $D_{i,j}$ is the effective diameter of the j^{th} member of the i^{th} plant type. The drag coefficient generally varies with plant roughness and the Reynolds number, but is taken as 1.0 for most plants. The contribution from the flat parts of the plant leaves is generally ignored.

The growth or decay of wind waves propagating over vegetated areas can estimate the effects of high friction by adjusting the fetch length (Camfield 1977). In this analysis the friction factors associated with vegetation can be up to 100 times the friction factor associated with unvegetated shallow water. The friction factor for various vegetation types are given as a function of water depth for thick stands of marsh grass; dense grass, brush or bushy willows and scattered tress; and dense stands of trees. Based upon a water depth of 3 m (10 ft), the friction factor for marsh grass is 0.20, for dense grass and brush it is 0.48 and for dense stands of trees, 0.90. These values represent an increase over the unvegetated bottom friction by factors of 20, 48, and 90, respectively. An example can be cited of the effectiveness of vegetated wetlands to dissipate wave energy (U.S. Army Corps of Engineers 2003). Storm waves having an initial height of 3 m (10 ft) are predicted to be reduced to a height of 1.5 m (4.8 ft) after passing over 1000 m (3300 ft) of tall grass and brush.

2.11.1.2.3 Currents and Storm Surge Elevation

Currents and surge are affected by coastal landscape features through two mechanisms. Bottom friction is generated by fluid shear stresses on the water bottom, while flow-drag resistance is generated by fluid stresses on objects extending through the water column (FEMA 1985). Bottom friction only occurs in bays whereas bottom friction and flow-drag resistance can occur in vegetated areas.

The most widely used formulation of bottom friction for flow in shallow water is the Manning-Chezy formula,

$$\tau = \frac{g|U|u}{C^2}, \quad and \quad C = \frac{1.486h^{1/6}}{N} \qquad \text{E 2.11-3}$$

where τ is the bottom stress, $|U|$ is the flow speed, u is the vector velocity, C is the Chezy coefficient, h is the flow depth, and N is the Manning's coefficient. The Manning's coefficient is not a constant and varies with water depth and bottom roughness. For bays the Manning's coefficient has been represented as an exponential function of the water depth, by the following formula (FEMA 1985),

$$N = Ah^{-B} \qquad \text{E 2.11-4}$$

where A and B are curve fitting parameters. Calibration data for various studies indicate B is about 0.5 and A varies between 0.08 and 0.12, with a mean value of 0.10. This formula indicates the Manning's coefficient decreases as the water depth increases, with values of N of about 0.044 for a depth of 1.5 m (5 ft), 0.032 for a depth of 3 m (10 ft) and 0.022 for a water depth of 6 m (20 ft). Since the Manning's N is typically used as a tuning factor in calibrating hydrodynamic models, in this formulation A can be used for the same purpose. For flooded wetlands, the Manning's N is assumed to be a constant that varies with vegetation type.

Flow-drag resistance also occurs in vegetated areas and represents flow resistance within the water column. Taking the approach that the flow-drag force on natural vegetation can be expressed as some the force on an equivalent cylinder, the total drag force for a given area of wetland can be given by

$$F_d = \frac{\rho C_d n D h_p V^2}{2} \qquad \text{E 2.11-5}$$

where F_d is the drag force, C_d is the drag coefficient for the cylinder, n is the total number of plants, D is the diameter of each cylinder, h_p is the height of the submerged part of the cylinder, and V is the flow velocity. The drag coefficient C_d is not a constant and depends upon the size and proximity of each plant. An equivalent stress can be defined as the total drag force over an area, divided by the size of the area.

An alternative representation of the drag force on a number of plants is based upon the Darcy-Weisbach formulation,

$$F_d = \frac{\rho f V^2}{8} \qquad \text{E 2.11-6}$$

where f is the Darcy-Weisbach resistance coefficient. This coefficient has been related to the "roughness concentration" given as

$$f = a\sigma^b, \; and \; \sigma = nDh_p \qquad \text{E 2.11-7}$$

where σ is the roughness concentration, and a and b are calibration parameters.

The effect of wetland vegetation density on the Manning's coefficient for overland flow was studied in a series of laboratory experiments (Hall 1994). The experiments involved placing bulrushes in various spatial densities in a 1.2 m (4 ft) wide channel and then subjecting them to discharges of 0.009, 0.026, 0.044 and 0.057 m^3/sec. The results of the tests indicated that for flow velocities in the range of 0.01 to 0.05 m/sec (0.03 to 0.16 ft/s), the Manning's N decreased as the average flow velocity increased, ranging about 0.3-0.9 at the lowest velocity to 0.2-0.3 at the highest velocity. A linear relationship was found between the density of plants and the Manning's N, with the value of N being about 0.6 for a density of 800 stems per square meter.

2.11.2 Sensitivity Analysis

A sensitivity analysis was performed to assess the impact of bathymetric and frictional resistance changes on ADCIRC-simulated peak surge elevations and STWAVE-simulated waves. The impact of coastal landscape features on surge propagation and waves is a relatively new application for surge and wave models and an area of active research that suffers from a lack of quality data. The purpose of the analysis is to qualitatively assess the potential of coastal features for reducing storm surge and waves for hurricanes with varying intensity. The analysis provides valuable information on trends and relative performance but should not be taken as a quantitative assessment of surge and wave reduction. It should be noted that the analysis does not consider the changes to the landscape that occur during a storms passage, where vegetation cover can be stripped away and land masses eroded. 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. The physics of this process are not well known and research in this area is required. The analysis was performed for differing configurations of the Biloxi marsh on the Louisiana coast, south of the Mississippi coast.

A base configuration consistent with that applied for the Interagency Performance Evaluation Team (IPET) study and two Biloxi marsh conditions, one degraded and one improved from the base case, are evaluated. The marsh elevations for both the improved and degraded cases were provided by the environmental group at the USACE New Orleans District. Two storms were simulated for each configuration: 1) Hurricane Katrina as it occurred in August 2005, making landfall as a Saffir-Simpson scale Category 3 (CAT3) storm and 2) Hurricane Katrina reduced to a Category 1 (CAT1) storm at landfall. The smaller CAT1 storm was only simulated with ADCIRC without radiation stress forcing. STWAVE simulations were performed for both the CAT3 and CAT1 storms. The analysis first discusses the friction formulations in the models that impact surge and waves. The peak water levels and waves for each marsh configuration are then compared to the base condition. Finally, results for storms with varying intensity are compared.

2.11.2.1 Landscape Feature Roughness and Frictional Resistance

Coastal landscape features can reduce surge potential by reducing surface winds due to higher sub-aerial surface roughness and slow surge propagation due to bottom friction in shallow flow at the inundation front. The base condition coastal feature landscape land cover type was taken from the USGS National Land Cover Dataset (NLCD) classification raster map based upon Landsat imagery. Each NLCD classification has an associated land roughness length ($z_{0_{land}}$) and Manning's *n* value as defined by Federal Emergency Management Association (2005). These values are applied in the models as described below to reduce wind and water speeds. The values used for this analysis are summarized in Table 2.11-1. It should be noted that the passage of large storms can alter the landscape, stripping away vegetation cover is some areas and this impact is not considered in this analysis.

Table 2.11-1.
$Z_{0\text{-land}}$ Factors and Manning's n Values for NLCD Classifications

NLCD Class	Description	$Z_{0\text{-land}}$	Manning's n
11	Open Water	0.001	0.020
12	Ice/Snow	0.012	0.020
21	Low Residential	0.330	0.070
22	High Residential	0.500	0.140
23	Commercial	0.390	0.050
31	Bare Rock/Sand	0.090	0.040
32	Gravel Pit	0.180	0.060
33	Transitional	0.180	0.100
41	Deciduous Forest	0.650	0.120
42	Evergreen Forest	0.720	0.150
43	Mixed Forest	0.710	0.120
51	Shrub Land	0.120	0.050
61	Orchard/Vineyard	0.270	0.100
71	Grassland	0.040	0.034
81	Pasture	0.060	0.030
82	Row Crops	0.060	0.035
83	Small Grains	0.050	0.035
84	Fallow	0.050	0.030
85	Recreational Grass	0.050	0.025
91	Woody Wetland	0.550	0.100
92	Herbaceous Wetland	0.110	0.035
95	Cypress Forest	0.550	0.100

The winds input to the ADCIRC and STWAVE models are reduced to account for the higher surface roughness through a directional land masking procedure. Since the wind boundary layer does not adjust to surface roughness instantaneously, wind reduction factors are computed based on the weighted average of roughness coefficients (z_{0land}) within 10 km in the upwind direction. The wind reduction factor (f_r) is calculated as (Powell et al. 1996, Simiu and Scanlan 1986):

$$f_r = \left(\frac{z_{0_{marine}}}{z_{0_{land}}} \right)^{0.0706} \qquad \text{E 2.11-8}$$

where $z_{0marine}$ is the marine roughness length that is computed based on the Charnock relationship (Charnock 1955) and the relationship between the friction velocity and the applied drag law (Hsu 1988):

$$z_{0_{marine}} = \frac{\alpha_c C_d W_{10}^2}{g} \qquad \text{E 2.11-9}$$

where the Charnock parameter (α_c) is set to 0.018, C_d is the air-sea drag coefficient, W_{10} is the wind speed sampled at a 10 m height over a 10 min period, and g is the acceleration due to gravity. As inundation takes place, landscape features are submerged and their roughness is reduced. In the model, the roughness length is reduced according to (Simiu and Scanlan 1986):

$$z_0' = z_{0land} - \frac{d}{30} \qquad \text{for } z_0' \geq z_{0_{marine}} \qquad \text{E 2.11-10}$$

where d is the local water depth. The reduced roughness length is limited to the marine roughness value.

In addition to reducing wind speeds, coastal landscape features can also inhibit wind from penetrating through the features and shelter the water surface from wind stress. Features such as heavily forested canopies allow little momentum transfer from wind fields to the water column (Reid and Whitaker 1976) and thus areas classified as NLCD forest do not apply a wind stress in the model.

The speed at which a storm surge propagates and thus surge water level is affected by coastal landscape features through bottom friction and form drag. Bottom friction is the generated by fluid shear stresses at the water bottom and flow-drag resistance is generated by fluid stresses on objects extending through the water column (FEMA 1985). Bottom friction occurs in relatively shallow areas and bottom friction and flow-drag resistance can occur in vegetated areas. The ADCIRC and STWAVE models presently only account for bottom friction, the effect of form drag can only be approximated by increasing the bottom friction coefficient. The ADCIRC and STWAVE models apply a Manning's-type bottom friction formulation with the bottom friction coefficient specified as:

$$C_f = g \frac{n^2}{d^{1/3}} \qquad \text{E 2.11-11}$$

where n is the Manning roughness coefficient with values based on the USGS land use factors. The Manning n values applied for this analysis are summarized in Table 2.11-1. The values applied in the model for both the Manning n values and the roughness coefficients were validated through comparison of model hindcast results and measured high water marks for Hurricanes Katrina and Rita.

2.11.2.2 Sensitivity of Peak Water Level and Maximum Waves to Marsh Condition

The CAT3 and CAT1 storms were simulated on a base configuration, a case with Biloxi marsh raised to 1.05 ft NAVD 88 (2004.65) and restored to herbaceous wetland, and a case with Biloxi marsh lowered to -2 ft NAVD 88 (2004.65) and represented as open water. For the degraded case, the entire Biloxi marsh area was lowered and for the restored case only two strips of Biloxi marsh were altered (see Figure 2.11-3). Discussion of the peak water levels refers to the surge-plus-wave simulation results for the CAT3 storm only. Similarly, peak wave height maps for each of the CAT3 simulations were compared to the baseline configuration. In addition, maximum wave height maps were compared for the CAT1 simulations.

Figure 2.11-3. Outline of marsh areas restored (red) and deteriorated (blue)

Biloxi marsh was raised and restored to herbaceous wetland along two 100,000 ft by 15,000 ft strips of marshland for a total raised area of 116 sq mi. The change in bathymetry and frictional resistance slowed surge propagation resulting in an increase in water level seaward of the change and a decrease in water level landward of the change. The greatest change in peak water level was observed landward of the marsh feature where the decrease in peak water level was 0.9 to 1.3 ft (Figure 2.11-4). Changes on the Mississippi coast were less than 1 ft. The percent reduction in peak water level was as much as 8% in the New Orleans area and less than 3% on the Mississippi coast. The original STWAVE grid was also modified to represent the raised Biloxi marsh configuration and changes in maximum wave height are shown in Figure 2.11-5. The greatest change in maximum wave height was observed landward of the marsh feature where the decrease in maximum wave height was 1.0 to 2.0 ft for the CAT3 simulation. No changes in wave height were estimated on the Mississippi coast. Similar result patterns were observed for the reduced Katrina CAT1 simulation. The wave change patterns are consistent with the water level changes suggesting that the waves are depth limited.

The spatial extent where Biloxi marsh was lowered greatly exceeds the area that was raised. The lowered Biloxi marsh area encompassed 507 sq mi and was degraded (lowered) to -2.0 ft (NAVD88 2004.65) and returned to open water. The marsh reduction allows surge to propagate more rapidly, resulting in a rise in peak water level (relative to the original simulation peak water level) that extended beyond the Biloxi marsh region. The Biloxi marsh area increased in peak water level by 2.4 ft at the MRGO-GIWW junction (Figure 2.11-6). Peak water level south of English Turn increased 1.1 ft, Lake Pontchartrain peak water levels increased approximately 0.8 ft, and water levels on the Mississippi coast increased by less than 0.5 ft. The percent increase in peak water level was 8-13% near the New Orleans area levees but was less than 3 percent on the Mississippi coast. A map of changes in maximum wave height is shown in Figure 2.11-7. The greatest change in maximum wave height was observed landward of the marsh feature where the increase in maximum wave height was 2.0 to 4.5 ft for the Katrina CAT3 simulation. Similar result patterns were observed for the reduced Katrina CAT1 simulation. The wave change patterns are consistent with the water level changes suggesting that the waves are depth limited.

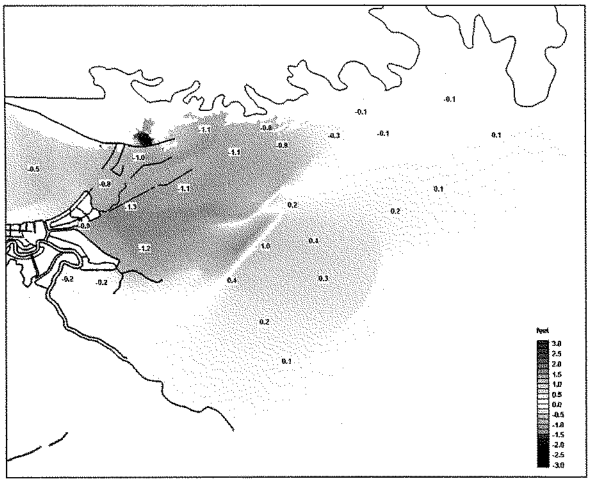


Figure 2.11-4. Difference in peak surge: Biloxi Marsh raised to 1.05 ft minus base configuration.

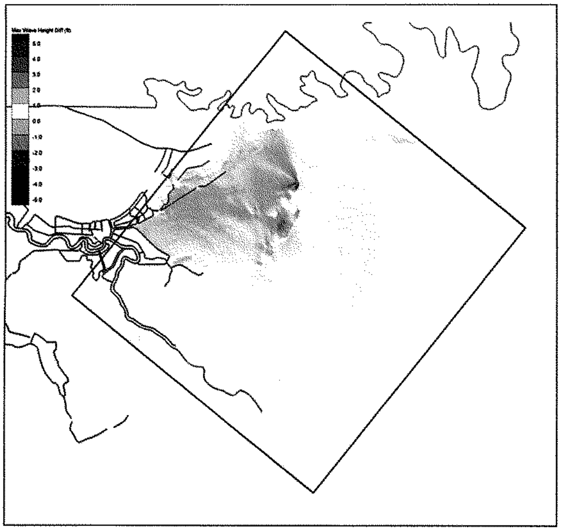


Figure 2.11-5. Difference in maximum wave height for CAT3 simulation: Biloxi Marsh raised to 1.05 ft minus base configuration.

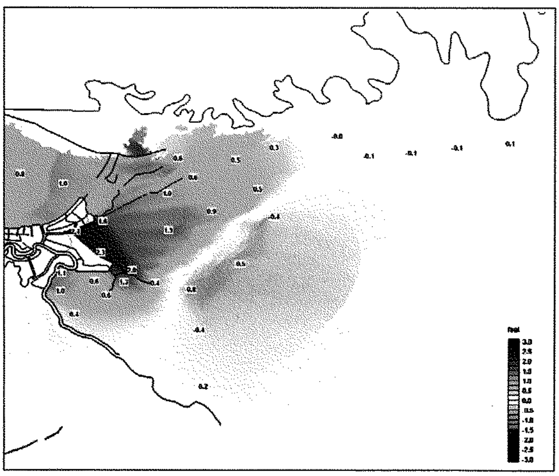


Figure 2.11-6. Difference in peak surge: Biloxi Marsh lowered to -2.0 ft minus base configuration.

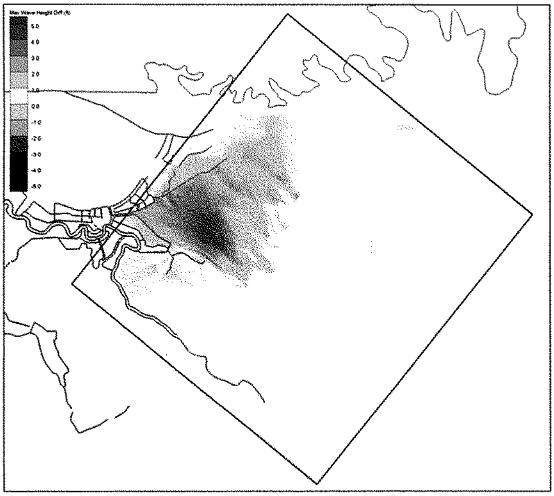


Figure 2.11-7. Difference in maximum wave height for CAT3 simulation: Biloxi Marsh lowered to -2.0 ft minus base configuration.

The CAT3 storm discussed in the previous section was scaled to produce a storm of Category 1 intensity on the Saffir-Simpson scale and thus has less surge potential. Simulations without wave radiation stress forcing were made for the less intense (CAT1) storm. Analysis and comparison of the CAT1 peak water level differences to the CAT3 surge only peak water level differences show similar patterns. Table 2.11-2 lists the peak water level change for the CAT1 and CAT3 storms for comparison. Water level changes on the Mississippi coast were less than 0.5 ft. The most significant difference in peak water level change between the CAT1 and CAT3 storms occurred when the marsh was lowered. The difference in surge for the two storm intensities for the lowered marsh configuration is given in Figure 2.11-8 and Figure 2.11-9. The peak water level is higher for the CAT3 storm, but the high peaks in Biloxi marsh extend over a broader area with the CAT1 storm. In the region further south from the lowered Biloxi marsh area, the CAT3 storm causes greater increases than the CAT1 storm in peak water level. For these cases, the change in peak water level change for a CAT3 storm can be more than double the change in peak water level for a CAT1 storm. A similar trend is observed with the STWAVE results when comparing storm intensity and maximum wave height. An example of the maximum wave height difference for the two storm intensities is given in Figures 2.11-7 and 2.11-10. Note that the maximum wave height change is larger and broader in extent for the CAT3 storm when compared to the CAT1 storm. This trend was especially evident for the lowered marsh configuration simulations performed for this study. For the raised marsh configuration, the area of changes in maximum wave heights is broader in extent, even if the maximum values are comparable for both CAT3 and CAT1 simulations.

Table 2.11-2.
Difference in Surge-only Peak Water Level for the Marsh Change Configuration – Original Marsh Configuration for CAT 1 and CAT3 Storms

Marsh Condition	Maximum Change in Peak Water Level, ft	
	CAT1	CAT3
Restored	-1.2	-1.4
Degraded	1.7	2.7

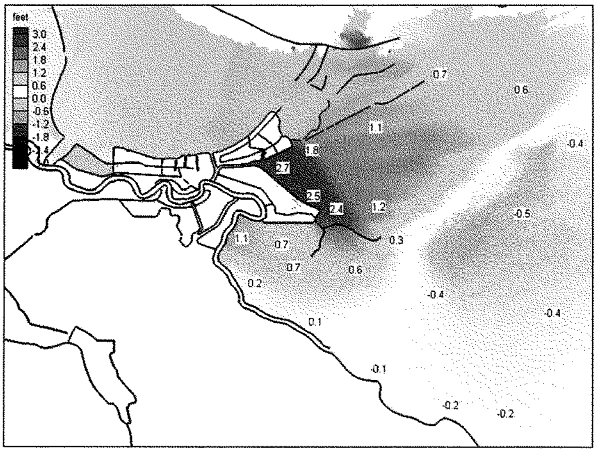


Figure 2.11-8. Difference in peak surge only (no radiations stresses): Biloxi Marsh lowered minus base configuration for a CAT3 storm.

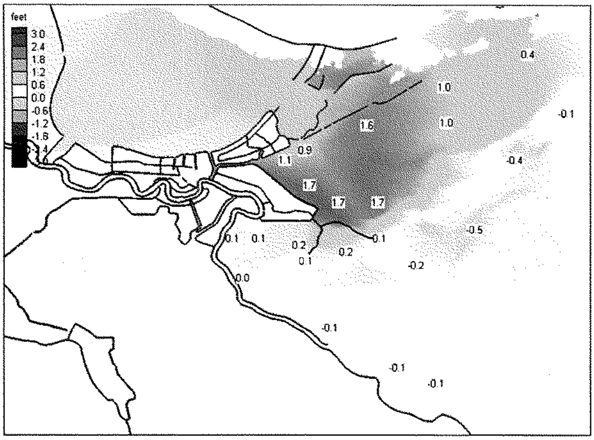


Figure 2.11-9. Difference in peak surge only (no radiation stresses): Biloxi Marsh lowered minus base configuration for a CAT1 storm.

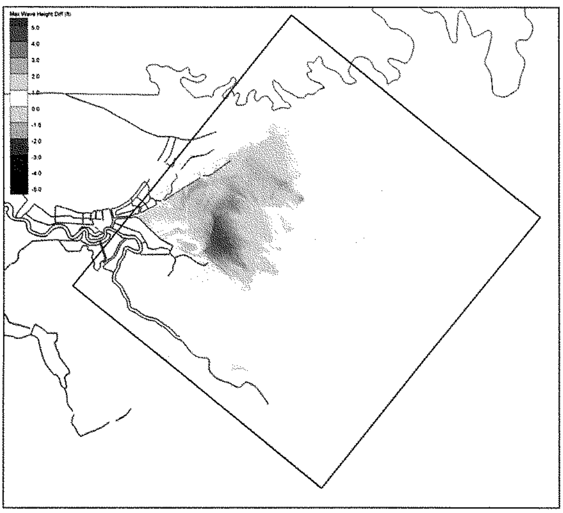


Figure 2.11-10. Difference in maximum wave height: Biloxi Marsh lowered minus base configuration for a CAT1 storm.

2.11.2.3 Summary

The purpose of this sensitivity analysis is to qualitatively assess the potential of coastal landscape features for reducing storm surge and waves for hurricanes with varying intensity. The impact of landscape features on surge propagation is a relatively new application for surge and wave models and an area of active research that suffers from a lack of quality data. The analysis provides valuable information on trends and relative performance but should not be taken as a quantitative assessment of surge and wave reduction. Results indicate that coastal marsh does have surge and wave reduction potential. Restoration and degradation of marsh resulted in decreases (for restoration cases) and increases (for degradation cases) in both surge and waves for both a Category 3 storm on the Saffir-Simpson scale and a less intense Category 1 storm. The magnitude of change was greatest for the more intense storm. The magnitude of change was also correlated with the magnitude of the horizontal extent and elevation changes in the marsh. In general, the wave change patterns are consistent with the water level changes suggesting that the waves are depth limited. Results indicate that the impact of the landscape features is amplified in areas where there are levee pockets, such as at the MRGO and GIWW junction and south of English Turn. Results also indicate that changes in the Biloxi marsh will have little or no impact on water levels and waves for the Mississippi coast.

2.12 Regional Sediment Budget

2.12.1 Purpose

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. Based on analysis of previous studies, historical bathymetric and shoreline change, and numerical modeling, a suite of sediment budgets was developed. First, a conceptual sediment budget was developed through a review of existing studies; 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. Engineering activities and significant storm events were also documented. A calculated sediment budget was developed based on numerical modeling of regional waves and sediment transport, 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, and is presented herein along with a summary of information pertinent to the final budget. Details about the conceptual, historical, and calculated sediment budgets and further discussion of the entire study can be found in Rosati et al. (2007).

2.12.2 Mississippi Coast Physical Setting and Processes

The barrier islands in the project area, Cat, West and East Ship, Horn, Petit Bois, and Dauphin Islands, provide the offshore boundary for Mississippi Sound (Figure 2.12-1). These islands are the first line of defense for the mainland as tropical storms, hurricanes, and cold fronts pass the region. Table 2.12-1 summarizes the tropical storm and hurricane history for locations in and around the study area from 1871 (or 1872) through 2006. Because data were not provided for a city in Hancock County, New Orleans, Louisiana is shown in Table 2.12-1 to provide a western boundary to the study area. Locations in Hancock County are assumed to have storm occurrences similar to those presented for New Orleans and Gulfport.

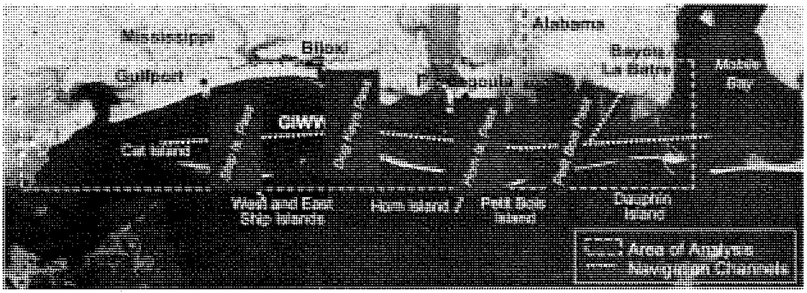


Figure 2.12-1. Mississippi Gulf Coast, showing barrier island system, navigation channels, and the area of study for the regional sediment budget (image courtesy NASA's Earth Observatory, dated 15 Sep 05)

Table 2.12-1.
Storms within 60 miles of Selected Mississippi, Alabama, and Louisiana Cities West of Mobile Bay, 1871/2 through 2006[1]

Location (from west to east)	Year of Storm Occurrence t=tropical storm; b=brush; h=hurricane	Frequency of Occurrence (yr)	
		Brush or Hit	Direct Hit
New Orleans, LA	1879h, 1879t, 1887h, 1888b, 1897b, 1892t, 1893h, 1900tb, 1901h, 1905t, 1907t, 1909h, 1914t, 1915h, 1916b, 1932t, 1934tb, 1936t, 1944tb, 1947h, 1948h, 1949t, 1955t, 1964t, 1965h, 1969b, 1979h, 1985b, 1988t, 1992b, 1998t, 2002t(2), 2004tb, 2005t, 2005h	3.8	12.4
Gulfport, MS	1872t, 1879b, 1881b, 1885t, 1885tb, 1887t, 1892t, 1893h, 1895t, 1900t, 1901b, 1904tb, 1905tb, 1906h, 1907tb, 1912b, 1914tb, 1916h, 1923t, 1926t, 1932b, 1934tb, 1944t, 1947h, 1947t, 1955tb, 1960t, 1965b, 1969h, 1979b, 1985h, 1988b, 1998h, 2002tb, 2002t(2), 2004b, 2005t, 2005h	3.5	15.1
Biloxi, MS	1879b, 1880b, 1881t, 1885t, 1885tb, 1887t, 1892tb, 1893h, 1895h, 1900t, 1901h, 1906h, 1907tb, 1912h, 1916h, 1923t, 1926h, 1932h, 1934tb, 1947h, 1955tb, 1960t, 1969h, 1985h, 1997b, 1998h, 2002t, 2002tb, 2004b, 2005t, 2005h	4.4	11.3
Pascagoula, MS	1872b, 1881t, 1885t, 1885tb, 1887t, 1893b, 1893b, 1895t, 1900t, 1901b, 1902tb, 1904tb, 1906h, 1912h, 1914tb, 1916h, 1923tb, 1926h, 1932h, 1934tb, 1944tb, 1947b, 1950b, 1960b, 1969h, 1979h, 1985h, 1998h, 2002t, 2004h, 2005t, 2005h	3.8	9.7
Dauphin Island, AL	1880b, 1881t, 1882b, 1885, 1887t, 1893h, 1895tb, 1900t, 1901t, 1902t, 1904t, 1906h, 1910h, 1911b, 1912b, 1914tb, 1916b, 1919tb, 1922tb, 1923tb, 1926h, 1932h, 1934t, 1939t, 1944tb, 1947t, 1950h, 1956b, 1959t, 1960tb, 1979h, 1985h, 1985tb, 1995b, 1997h, 1998b, 2002t, 2004h, 2005(2)tb, 2005h	3.3	11.3

[1] http://www.hurricanecity.com/. This database does not have any locations in Hancock County, Mississippi; thus, data for New Orleans, Louisiana are included to provide a western boundary for the study area. Locations in Hancock County are assumed to have storm occurrences similar to those provided for New Orleans and Gulfport.

The frequency of direct landfall is approximately equal for Biloxi, Pascagoula, and Dauphin Island, with a direct hit every 10-11 years. The likelihood for a direct hit decreases to approximately once every 15 and 12 years for Gulfport and New Orleans, respectively. However, all locations listed in Table 1 have historically been brushed or hit with a tropical storm or hurricane approximately once every 3-4 years. Cold fronts, although less intense than tropical storms and hurricanes, occur more frequently at approximately 30 to 40 times per year (Stone et al. 1999).

The barrier islands protecting Mississippi Sound experience a low energy wave climate, with average significant wave height at National Data Buoy Center (NDBC) Buoy 42007 (22 nautical miles south-southeast of Biloxi, in 46 ft depth) averaging 2 ft and 1.3 ft in the winter and summer months, with associated average peak wave periods of 4 to 3.5 sec, respectively. Wave transformation modeling by Cipriani and Stone (2001) indicated that breaking wave heights on the barrier islands range from 1 to 2 ft. Waves in Mississippi Sound are fetch- and depth-limited. The Coastal Studies Institute's Wave-Current Surge Information System (WAVCIS[3]) gage CSI-13 located at Ship Island Pass (23 ft depth) from June 1998 through July 2005 measured an average significant wave height of 0.3 ft and associated average wave period of 2.5 sec.

Tides in Mississippi Sound are diurnal, with a tidal range of 1.5 ft and 1.8 ft for the mean and spring tides at Biloxi, Mississippi[4], respectively. However, the relatively shallow and large area of the Sound create strong currents in the tidal passes between the barrier islands, ranging from 1.63 to 3.3 ft/sec and 5.9 to 11.5 ft/sec on flood and ebb tides, respectively (Foxworth et al. 1962). In the winter months, winds from the same direction and of a sufficient magnitude are capable of lowering water surface elevations in the bays and nearshore from 1-2 ft (U.S. Army Corps of Engineers Mobile District 1984).

For the Gulf barrier island beaches, net longshore sediment transport is from east to west, although local reversals in the net transport occur adjacent to the tidal passes. The primary sources of sediment are longshore sediment transport from east to west, and, potentially, the offshore shelf (Otvos 1979, Cipriani and Stone 2001). Cipriani and Stone (2001) discussed that a well-defined cellular structure exists for each barrier island in which, over historic times, little sand transfer exists between islands. However, dredging records at Horn Island and Ship Island Passes (also called Pascagoula Bar Channel and Gulfport Bar Channel, respectively) suggest that infilling of sand from adjacent barrier islands occurs, indicating the potential for transport of sand between islands. Eastern Dauphin Island, with a Pleistocene core, is more stable than the other barriers although eastern Dauphin Island has been eroding in response to the dominant westerly-directed transport. Based on grain size analysis, Cipriani and Stone (2001) inferred that offshore sources may provide some sediment to central Petit Bois Island. The Mississippi Sound barrier islands range from very well vegetated, with maritime forests on east Dauphin Island, to low elevation barriers that are overwashed and breached during hurricanes. Long-term relative sea level rise for Dauphin Island, Alabama from 1966 to 1997 was 0.12 +/- 0.023 in/year[5].

On the mainland coast, beach change in Harrison County has been dominated by harbor construction, beach restoration and replenishment since 1951 (Byrnes et al. 1993a, 1993b). Cross-shore sediment transport processes dominate beach change, with wave-induced sediment transport processes of secondary importance, typically from east-to-west (Byrnes et al. 1993a, 1993b). Hancock County had beach nourishment in 1993-1994 between Waveland and Bay St Louis and again in 1996 for the Bay St Louis Downtown beach (Schmid 2002). Net longshore transport in Hancock County is generally from northeast to southwest. The bays, distributaries, and bayous of

[3] http://www.wavcis.lsu.edu/, dated 11 December 2006, accessed 11 December 2006.
[4] http://tidesandcurrents.noaa.gov/tides05/tab2ec4.html#107, dated 25 March 2005, accessed 11 December 2006.
[5] http://tidesandcurrents.noaa.gov/sltrends/sltrends_station.shtml?stnid=8735180, dated 10 February 2006, accessed 29 July 2006.

the remaining coast are typically bordered with marsh populated by *Spartina-Juncus* succession (Christmas 1973).

2.12.3 Review of Existing Studies and Dredging Database

Existing studies were reviewed for the project area to provide information about sediment transport processes of the barrier island and mainland coast. This knowledge gained was incorporated into the sediment budget as appropriate. For a full summary of each study that was reviewed, please see Rosati et al. (2007).

Dredging rates for navigation channels within Mississippi Sound were also evaluated in the study. As shown in Figure 2.13-1, the study area is traversed by many navigation channels: two "bar" channels that extend through Horn Island Pass (also called Pascagoula Bar Channel) and Ship Island Pass (also called Gulfport Bar Channel); the Gulf Intercoastal Waterway (GIWW) that runs east-west through Mississippi Sound; and five Sound navigation channels that extend from Gulfport, Biloxi, Pascagoula, Bayou Cassotte, and Bayou La Batre. The SAM dredges these channels on a regular basis. The U.S. Army Corps of Engineers' Navigation Data Center[6] (NDC) has documented all Corps contract and non-contract dredging for all Districts for Fiscal Year (FY) 1990 through 2005. NDC's database for SAM's entire District dredging program is provided in Rosati et al. (2007).

Byrnes and Griffee (2007) culled historical dredging and placement information from published Corps reports and databases to develop annual dredging and placement rates for each of the bar channels. Sediment dredged from the GIWW and other channels extending through Mississippi Sound was side-cast or placed in disposal areas to either side of the channels, and is assumed to shoal primarily from fine sediment that is mobilized in the bay. Thus, these dredging and placement activities in the Sound do not change the sediment budget for the mainland and barrier islands. However, dredging and placement adjacent to the barrier islands (Ship Island Pass/Gulfport Bar Channel and Horn Island Pass/Pascagoula Bar Channel) must be considered in the sediment budget.

Dredging data provided by Byrnes and Griffee (2007) have been analyzed to provide estimated maintenance shoaling rates for each of the Bar Channels as a function of channel depth, width, and length (Table 2.12-2). Of particular interest is the maintenance dredging rate as a function of channel depth, as shown in Figure 2.12-2.

Table 2.12-2.
Summary of Dredging Rates for Navigation Channels Adjacent to Barrier Islands (modified from Byrnes and Griffee 2007)

Date	Description	New Work (cy)	Maintenance (cy)
Ship Island Pass/Gulfport Bar Channel (Data from 1881-2003)			
Mar 1899–Mar 1948	26-ft deep, 300-ft width, 0.76-mile long channel (1.9-mile length dredged in 1922)	163,401	2,115,576 (43,175 cy/yr) (33,028 cu m/yr)
Mar 1948–Jul 1992	32-ft deep, 300-ft wide, 8 miles long	3,679,044	21,111,495 (476,200 cy/yr) (364,292 cu m/yr)
Nov 1993–Apr 2003	38-ft, 300-ft wide, 8 miles long	9,695,988	5,456,817 (579,485 cy/yr) (443,306 cu m/yr)

[6] http://www.iwr.usace.army.mil/NDC/data/datadrg.htm , updated 25 July 2006, accessed 13 December 2006.

Table 2.12-2.
Summary of Dredging Rates for Navigation Channels Adjacent to Barrier Islands
(modified from Byrnes and Griffee 2007) (continued)

Date	Description	New Work (cy)	Maintenance (cy)
1899 to 2003	**Total Dredging**	**13,538,433**	**28,683,888 (275,807 cy/yr) (210,992 cu m/yr)**
Horn Island Pass/Pascagoula Bar Channel (Data from 1881-2005)			
Feb 1897–Mar1948	25-ft deep, 300-ft wide channel	896,748	1,735,817 (34,000 cy/yr) (26,010 cu m/yr)
Mar 1948–Jan 1965	38-ft deep, 325-ft wide, 2.8 mile length	2,910,835	2,711,925 (161,104 cy/yr (123,245 cu m/yr)
Jan 1965–Sep 1993	40-ft deep, 350-ft wide; Impoundment area along the western end of Petit Bois Island	1,305,589	14,772,517 (515,320 cy/yr) (394,220 cu m/yr)
Sep 1993–Nov 2005	44-ft deep, 550-ft wide; Impoundment area along the western end of Petit Bois Island	3,117,658	2,986,712 (245,483 cy/yr) (187,690 cu m/yr)
1897 to 2005	**Total Dredging**	**8,230,830**	**22,206,971 (205,600 cy/yr) (157,284 cu m/yr)**

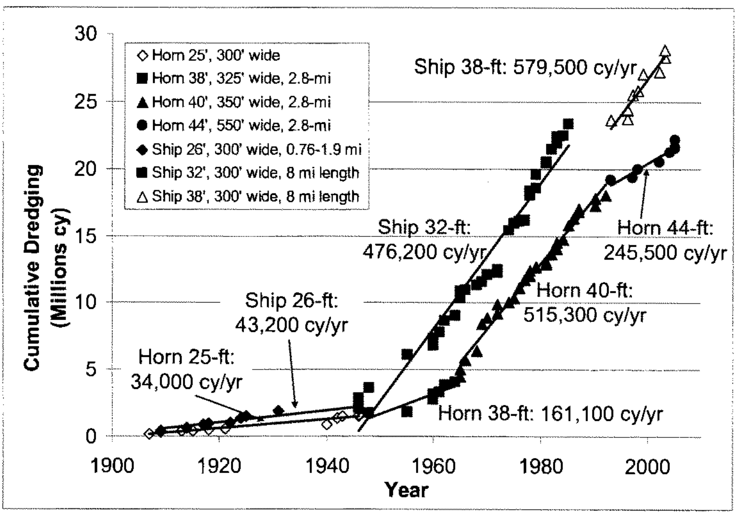


Figure 2.12-2. Cumulative maintenance dredging volumes and associated dredging rates for Horn Island Pass (Pascagoula Bar Channel) and Ship Island Pass (Gulfport Bar Channel)

These data indicate that deepening Ship Island Pass in 1948 by 23% (from 26 to 32 ft depth) and lengthening the channel (from 0.76 and 1.9 miles to 8 miles) increased the maintenance dredging rate by more than an order of magnitude (from 43,200 to 476,200 cy/yr). Dredging rates also increased more than an order of magnitude at Horn Island Pass through several depth increases from 25 to 40 ft, an increase in width from 325 to 350 ft, and length to 2.8 miles (dredging increased from 34,000 to 515,300 cy/yr). However, the dredging rate at Horn Island Pass decreased most recently when the channel was deepened to 44 ft and widened to 550 ft. This decrease in shoaling is opposite to what would be expected and possibly indicates a change in dredging or placement practices at Horn Island Pass. As these channels were deepened, they were also lengthened to provide safe navigation from a similar depth contour offshore. Thus, the deeper channels not only provided a better trap for sand moving alongshore but also resulted in longer channels which captured more of sand that is being transported in the offshore zone.

As mentioned previously, dredging for channels in the Sound do not modify the sediment budget for the barrier islands and mainland coast. The NDC's dredging database has been evaluated to provide a complete regional sediment budget as shown in Table 2.12-3.

Table 2.12-3.
Dredging Rates for Navigation Channels in Mississippi Sound (from SAM and NDC Database)

Location	Dates	Duration (years)	Shoaling Rate (cu yd/yr)	Notes
Gulfport Harbor Channel[1]	Jul 1991 – Sep 2004	8.3	1,151,000	Assume includes GIWW dredging
Biloxi Harbor Channel	Dec 1991 – Aug 2003	12.5	43,600	
Pascagoula Harbor Channel	Aug 1992 – Jan 2005	13.5	3,074,600	Assume includes GIWW dredging in vicinity of Pascagoula
Bayou Cassotte	Sep 1992 – Sep 2000	8	248,500	
Bayou La Batre	May 1996 – Sep 2004	8.3	732,400	Assume includes GIWW dredging

[1] Omitted Gulfport deepening in 1992.

2.12.4 Historical Data Analysis

A second phase of this study developed a historical sediment budget for the barrier islands and adjacent passes based on bathymetric change, shoreline position change, and dredging and placement data. The historical sediment budget is utilized to develop the present-day sediment budget. In this chapter, historical volumetric change, shoreline position change, and dredging data are reviewed. This portion of the study was conducted by Byrnes and Griffee (2007).

Shoreline and bathymetric data were compiled within a Geographic Information System (GIS) for the Mississippi Sound region. This database has associated metadata specifying the coordinate system, vertical datum, measurement units, and timing of data collection for each data set. Data are available for 1846/57, 1916/21, and 1960/71 periods, with coverage of the eastern portion of the study area available for 1984/89.

The primary goal of bathymetric change analysis is to identify regional sediment transport pathways and quantify net sediment volume changes associated with the historical evolution of nearshore morphology and adjacent beaches. Table 2.12-4 provides a summary of bathymetric data available for the Mississippi Sound area. Initial bathymetric surveys of the area were completed for the period 1847/56. All data have been compiled within a GIS framework, so metadata regarding coordinate system, vertical datum, measurement units, and timing of data collection are provided in the attribute table for each data set. These data, in addition to recorded shoreline changes, have been used to quantify regional sediment dynamics throughout the study area and evaluate the historical sediment budget for the period 1917/21 to 1960/71. Limited coverage offshore of Horn, Petit Bois, and Dauphin Islands for the 1960/71 period limits volumetric change calculations and, ultimately, the historical sediment budget.

Table 2.12-4.
Bathymetry Source Data Characteristics (from Byrnes and Griffee 2007)

Date	Data Source	Comments and Map Numbers
1847/56	USC&GS Hydrographic Sheets 1:20,000	First regional bathymetric survey within the study area. 1847 - H-00191; 1847/48 – H-00192; 1848 – H-00193, H-00194; 1851 – H-00256, H-00261; 1852 – H-00329; 1853 – H-00328, H-00365; 1854 – H-00430; 1855 – H-00485, H-00488, H-00489; 1856 – H-00546.
1916/20	USC&GS Hydrographic Sheets 1:40,000 (all others) 1:80,000 (H-4171)	Second regional bathymetric survey in the study area. 1916/17 – H-03960; 1917 – H-04000; 1917/18 – H-04020, H-04021, H-04023; 1920 - H-04171.
1960/71	USC&GS Hydrographic Sheets 1:10,000 (H-08524, H-08525, H-08560, H-08561, H-08562, H-08642, H-08643, H-08644, H-08645, H-08646, H-08649 to 08652, H-08922, H-08923, H-08925, H-08970, H-09156, H-09177) 1:20,000 (all others)	Third regional bathymetric survey in the study area. 1960 – H-08524, H-08525, H-08562, H-08563); 1960/61 - H-08560, H-08561; 1961 – H-08642; 1961/62 - H-8643 to 08648; 1962 – H-08649 to 08652; 1966/68 – H-08922, H08923; 1967/68 – H-08924, H-08925; 1968 – 08970, H-08971; 1968/69 – H-09004; 1970 – 09103, H-09109; H-09028, H-09156, H-09177; 1971 – H-09200.
1984/89	USC&GS Hydrographic Sheets 1:20,000 (D-00079, F-00324, H-10179, H-10208, H-10226, H-10247, H-10261) 1:40,000 (D-00078, H-10206) 1:80,000 (D-00065)	Survey covering eastern portion of the study area; 1984/87 - D-00065, D-00078; 1985/87 - H-10179; 1985 - H-10206, H-10208; 1986/88 – H-10226; 1987 - H-10247, H-10261; 1988 - D-00079; 1989 - F-00324.

Several insights into forcing processes and engineering activities were observed from the bathymetric change data.

(1) Overall, the barrier islands have eroded on the eastern regions and accreted to the west, indicating the dominant direction of longshore sand transport from east-to-west. Similarly, the Passes between barrier islands have also migrated to the west, as noted by the ebb shoal that erodes to the east and reforms to the west. Thus, the migrating barrier islands naturally "push" the Passes to the west.

(2) Dredging of the ship channels in Mississippi Sound is readily observed in the bathymetric change maps that include the 1960/71 surface, with side-casting and placement of the dredged material shown on either side of the channels. This side-cast sediment does not appear to move within Mississippi Sound.

(3) As the barrier islands have eroded, portions of the barriers have rolled over towards the Sound. For example, East Ship Island and western Dauphin Island have eroded on the Gulf side and reformed in a more northerly location further into the Sound. The processes transporting sand into the Sound is a combination of overwash during storms and inlet formation and possible subsequent closure.

(4) Portions of the barrier islands are relatively stable and maintain position through time (this is observed in Byrnes and Griffee's (2007) shoreline position data). Examples of these locations are the widest portions of Horn, Petit Bois, and Dauphin Islands. These areas are likely more stable ancient Pleistocene formations along which the sand spits which comprise the rest of the barrier island morphology form.

(5) Cat Island is not part of the sand-sharing system that comprises Dauphin, Petit Bois, Horn, and Ship Islands and the Passes that separate these barrier islands. Cat Island is a separate entity and the bathymetric change maps do not indicate that sand from Ship Island naturally bypasses or transports to Cat Island. If there were connectivity between Ship and Cat Island, it would be evidenced by erosion or accretion of morphologic features between the islands.

(6) From the historical shoreline position data (Byrnes and Griffee 2007), it is evident that the barrier islands have experienced cycles of breaching and mending throughout history. For example, Dauphin Island breached in 1917 in response to the 1915 hurricane, and reformed by 1957 slightly further northward (into the Sound) at the location of the washover deposit. Dauphin Island again shows a breach in the 2006 shoreline position data. Similarly, Ship Island breached in response to the 1947 hurricane and the barrier had reformed by 1950. Ship Island has been divided into East and West Ship Islands since another breach formed in the 1960s. These cycles of breaching and reformation indicate that breaches will naturally mend through the dominant longshore sand transport direction to the west, if a sufficient source of sediment is available. The historical data analysis is further discussed in Byrnes and Griffee (2007) and Rosati et al. (2007).

2.12.5 Numerical Modeling

Two numerical models were applied to develop estimates of sediment transport magnitudes and pathways. First, GENESIS shoreline change modeling that was conducted as a part of a larger regional study was incorporated to provide potential longshore sand transport rates for the Gulfside of the barrier islands for representative yearly waves. This model used pre-Katrina shoreline positions. Next, regional wave transformation modeling was conducted with STWAVE to estimate breaking wave height and direction magnitudes for the Gulfside and mainland coast beaches. These wave parameters and the shoreline orientation for sections of the Gulf barrier beaches and mainland coast were used to calculate potential longshore sand transport rates. Potential longshore sand transport rates are those estimated to occur if a sufficient quantity of sand were available for transport. Thus, these calculations do not apply to muddy coastlines or wetland regions of the study area. Finally, STWAVE was also applied to estimate wind-induced wave parameters for the Sound side of the barrier islands and subsequent sand transport on the Sound barrier coast. The methodology and results for this numerical modeling are discussed in Rosati et al. (2007).

2.12.6 Sediment Budget

Using the calculated and historical sediment budgets, and dredging and placement practices from 1993-2005 as presented by Rosati et al. (2007), a present-day (post-Katrina shoreline position) sediment budget has been hypothesized. In formulating this budget, several assumptions were made as follows:

(1) The historical sediment budget (1917/20-1960/71) was weighted more heavily than the calculated sediment budget, because the historical budget is based on actual measured changes in the region. However, for portions of the barrier islands that have changed morphology since the 1917/20 to 1960/71 period, or would be modified by a change in dredging or placement practices, the calculated sediment budget was given preference. The calculated sediment budget was adopted

for eastern Dauphin Island because volume change data have not yet been released, pending acceptance of the Dauphin Island mitigation study.

(2) In the absence of historical data, the calculated sediment budget and observed morphologic response were adopted for the mainland coast.

(3) Dredging and placement practices from 1993 to 2003/2005 were adopted for Ship Island Pass and Horn Island Pass, and the barrier island response to these activities was hypothesized. Dredging rates for Gulfport, Biloxi, and Pascagoula Harbor Channels, and Bayou Cassotte and Bayou La Batre were adopted as shown in Table 2.12-3. The source of sediment for these channels in Mississippi Sound was assumed to be fine-grained sediment that is mobilized during storms and wind events.

The hypothetical present-day sediment budget is shown in Figures 2.12-3 through 2.12-10, in which P=placement of dredged material, R=dredging or removal of sand, and sand fluxes are shown in thousands of cubic yards per year. It is emphasized that this sediment budget is only one of many possible solutions that could represent typical present-day conditions.

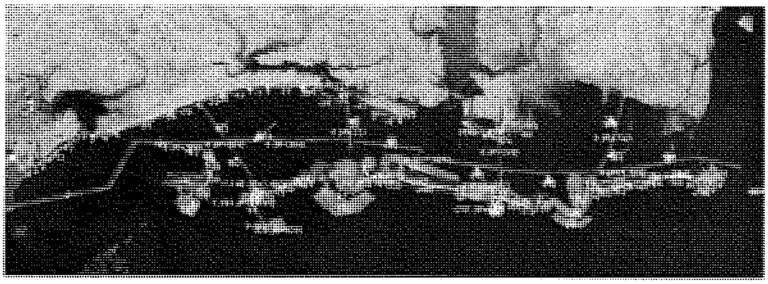


Figure 2.12-3. Overview of hypothetical present-day sediment budget (thousands of cy/yr)

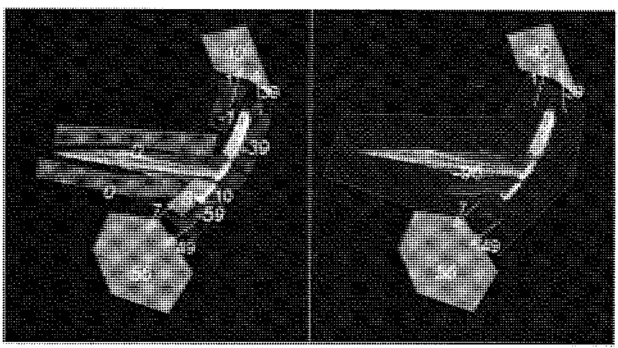


Figure 2.12-4. Hypothetical present-day sediment budget and macrobudget: Cat Island thousands of cy/yr).

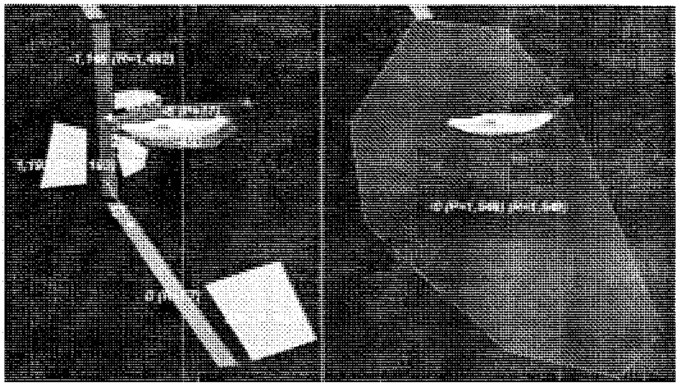


Figure 2.12-5. Hypothetical present-day sediment budget and macrobudget: West Ship Island and Ship Island Pass (thousands of cy/yr).

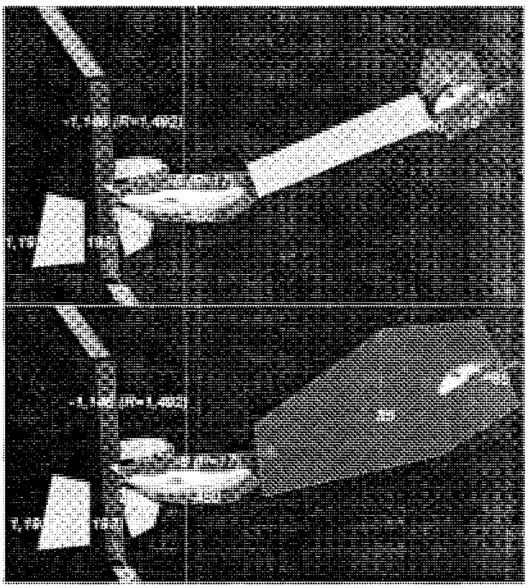


Figure 2.12-6. Hypothetical present-day sediment budget and macrobudget: East Ship Island and Camille Cut (thousands of cy/yr).

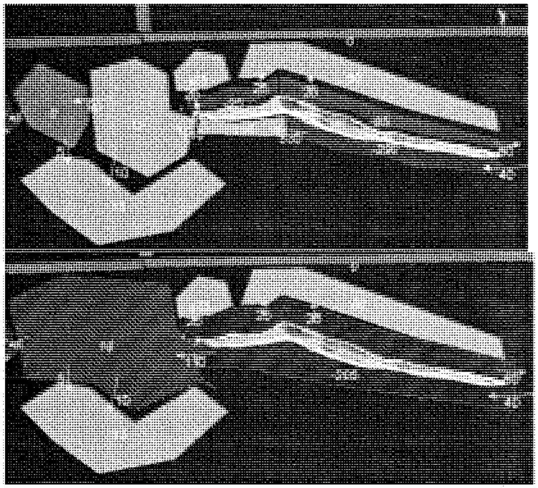


Figure 2.12-7. Hypothetical present-day sediment budget and macrobudget: Horn Island and Dog Keys Pass (thousands of cy/yr).

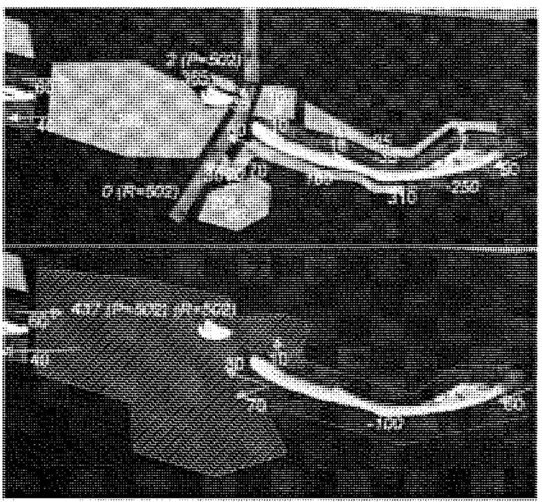


Figure 2.12-8. Hypothetical present-day sediment budget and acrobudget: Petit Bois Island and Horn Island Pass (thousands of cy/yr).

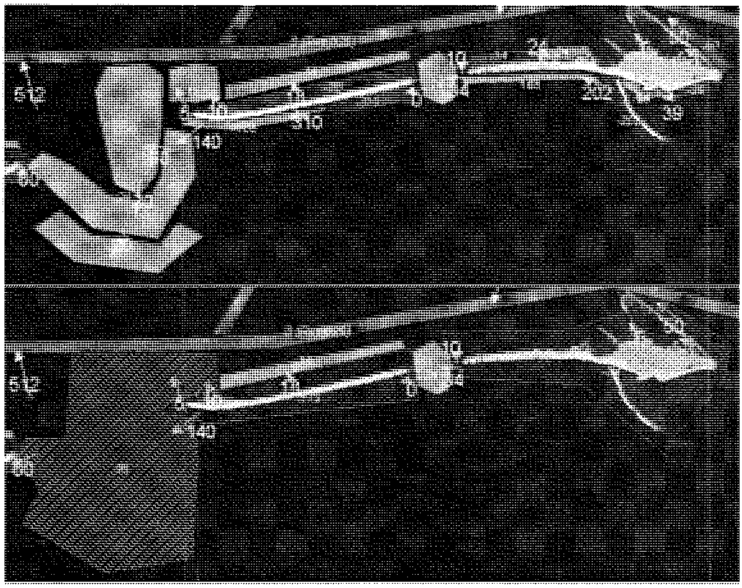


Figure 2.12-9. Hypothetical present-day sediment budget and macrobudget: Dauphin Island and Petit Bois Pass (thousands of cy/yr).

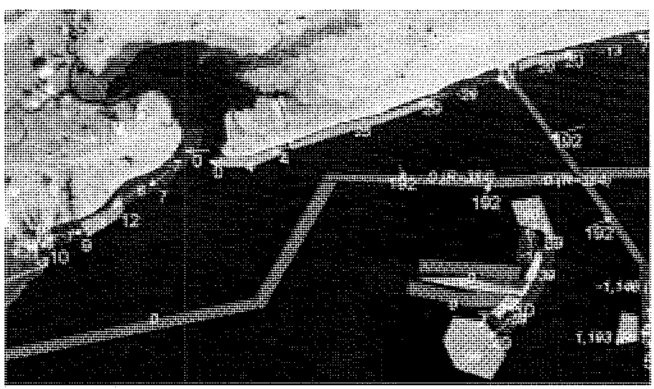


Figure 2.12-10. Hypothetical present-day sediment budget: Hancock County, Gulfport Harbor Channel, and a portion of the Gulf Intercoastal Waterway (thousands of cy/yr).

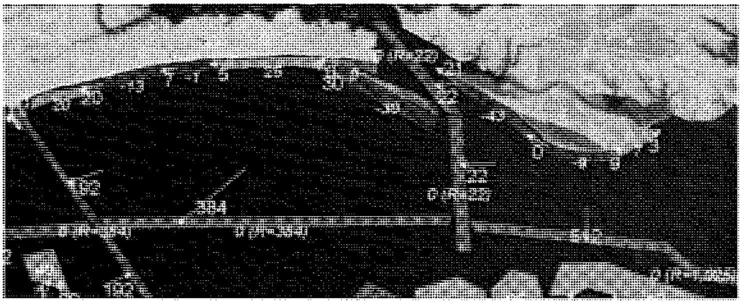


Figure 2.12-11. Hypothetical present-day sediment budget: Harrison County, Pascagoula Harbor Channel, and a portion of the Gulf Intercoastal Waterway (thousands of cy/yr).

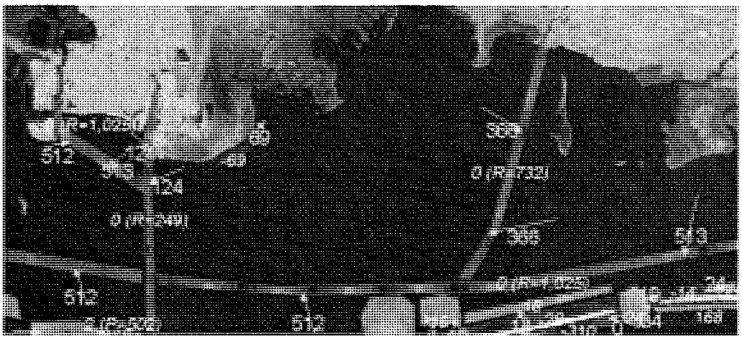


Figure 2.12-12. Hypothetical present-day sediment budget: Jackson County, Bayou La Batre, and a portion of the Gulf Intercoastal Waterway (thousands of cy/yr).

Knowledge gained through this study and recommendations that follow include the following:

(1) Cat Island is not a part of the barrier island littoral system represented by Dauphin, Petit Bois, Horn, and East and West Ship Islands. Cat Island is a separate morphologic feature that is naturally eroding due to waves, storm surge, and relative sea level rise in the region. Dredged sand that is placed in the littoral zone to the west of Ship Island Pass most likely will not be transported to Cat Island. Even in the absence of any engineering activities in Mississippi Sound, there is no evidence that sand from Ship Island would ever reach Cat Island.

(2) The net longshore sand transport rate for the barrier islands is from east-to-west. The barrier islands are migrating towards the west and, as they move west, also move the Passes between islands in a westerly direction. The source of sand for this region is the Mobile Pass ebb tidal shoal and the sandy shelf and shoreline to the east of Mobile Pass. Ship Island is the terminus of the longshore sand transport system in this region. Thus, the regional shortage of littoral sand will be most profoundly observed at Ship Island. We do observe disintegration of this barrier island, especially since Hurricane Katrina in 2005. We recommend that restoration of any barrier islands in

Mississippi Sound begin with Ship Island. In addition, we recommend back-passing sand dredged from Ship Island Pass, placing this sand either in Camille Cut, near East Ship Island, or in Dog Keys Pass. Sand can be placed in the surf zone (3 to 6-ft depths) and the natural longshore sand transport process will rebuild the island and begin to mend breaches.

(3) The historical sediment budget from 1917/20 to 1960/71 includes bathymetry change, shoreline position change, and dredging and placement practices representative of this period. However, data for the 1960/71 period are very sparse offshore of the barrier islands. This lends some uncertainty to the historical budget. In addition, Ship Island Pass and Horn Island Pass were deepened (and Horn Island was widened) in 1992/1993. Since that time, dredging rates have increased from those that occurred during the 1917/20 to 1960/71 period. Thus, the historical sediment budget is not representative of present-day dredging and placement activities, and has uncertainty with respect to bathymetric change offshore of the barrier islands. We recommend measurement of modern bathymetry (to 30 or 40-ft depths) and formulation of a sediment budget characterizing the period from 1917/20 (which has sufficient bathymetric coverage) to present-day.

(4) The historical analysis indicated that Horn Island has not experienced washover deposition across the entire island and has only been breached on a part of terminal spit during Hurricane Katrina (personal communication, Ms. Linda Lillycrop, May 2005). This cross-shore stability implies that the elevation and width of this barrier island might be a good template to evaluate for possible future restoration of the Mississippi Sound barrier islands.

(5) Wave modeling indicated that the mainland coast experiences a greatly reduced wave climate due to sheltering by the barrier islands fronting Mississippi Sound, as well as the Chandeleur Islands, and the Mississippi River's Bird's Foot delta. Restoration of the barrier islands could also consider lengthening the islands to recreate a previous historical footprint to provide additional wave protection for the mainland coast.

2.13 Flood Damage Analysis Model HEC-FDA

The Hydrologic Engineering Center's Flood Damage Analysis (HEC-FDA) program uses risk-based 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 annual damages. The program's risk-based analysis methods conform to Corps of Engineers policy regulations (Ref. 1, 2) and technical procedures (Ref. 3).

Version 1.2.3b dated August 2007 was used. This is a customized version of the current official release version 1.2 dated March 2000. The official version computes uncertainty using the method of order statistics as described in ETL 1110-2-537. Because uncertainty distributions for the synthetic portion of the stage-frequency curves used for these evaluations were developed using methods different than order statistics, customization by the HEC was required in order to permit user-specified stage-frequency uncertainty as discussed in Section 2.13.2. Detailed model information is contained in the HEC-FDA User's Manual (Ref. 4).

This section of the Engineering Appendix deals primarily with the model's hydrologic and hydraulic input. The Economic appendix describes the economic input and results. The MsCIP Main Report describes how the model output was examined and used in the plan formulation process.

2.13.1 Model Overview

Generally, HEC-FDA computes flood damages for a given area by integrating the flooding source's annual stage-frequency curve with that area's structure inventory's stage-damage curve, resulting in a damage-frequency curve. The stage-frequency curve reflects the annual probability of a stage, or water surface elevation, being equaled or exceeded and the resulting damage-frequency curve represents the annual probability that a given dollar amount of damage will be equaled or exceeded. Uncertainty is accounted for by sampling the stage-frequency and stage-damage curves throughout their respective uncertainty ranges using an iterative numerical process called Monte Carlo simulation and the expected annual damage (otherwise known as the probability weighted average annual damage) with uncertainty is determined. Expected annual damage is the mean estimate of annual damage obtained from the resultant annual damage probability distribution. There are numerous permutations of economic output according to the plan (including the no-action plan and alternative plan(s)), year, and subject area. MsCIP economic input and output is discussed in detail within the economic appendix.

2.13.2 Methodology

HEC-FDA models were developed and model simulations were carefully constructed and executed to systematically evaluate flood damage risk and the effectiveness of various storm damage reduction measures, individually and combined, for reducing flood damage risk. All plans and measures were evaluated against a range of sea level rise scenarios (no rise, 'expected' rise, and 'high' rise).

2.13.2.1 Planning Sub-units

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). Each planning sub-unit is an HEC-FDA 'damage reach.' The planning subunits are shown in Figures 2.13-1 through 2.13-3. The planning units were numbered only for bookkeeping purposes. The PSU's were extended inland to early (Fall 2006) estimates of the inland limit of surge-induced flooding and do not cover the entirety of each county. Political boundaries, source of flooding, topography, development density, potential surge inundation limits, and preliminary Lines of Defense (LOD) alignments were also considered when delineating the sub units. Where these factors did not clearly dictate where PSU boundaries might exist, or where the planning units were so large as to bring into question the whether the flooding threat for that planning unit might be reasonably approximated by a single stage-frequency curve, circa 2001 hurricane surge atlases (Ref. 5) were used to interpret where they might be located such that that PSU's representative stage-frequency curve would be representative of the surge still water elevation to +/- 1 foot. There are ten PSU's in Hancock County, 19 in Harrison County, and 26 in Jackson County.

2.13.2.2 Stage-Frequency Curve Overview

The source of flooding is Mississippi Sound with the primary cause being severe tropical system disturbance of that water body. Stage datum is the North American Vertical Datum of 1988 (NAVD '88). Stage-frequency curves were developed for each PSU from (a) long-term Mobile District tide gage data for Biloxi no. 02480350, Gulfport no. 02481341, and Pascagoula no. 02480301 through the 2005 calendar year; and (b) hydrodynamic simulation modeling conducted at the Engineer Research and Development Center (ERDC) in Vicksburg, MS. USACE tide gage records are discussed in Chapter 1.3, and the hydrodynamic modeling effort is described in Chapter 2. The USACE Gulfport, Biloxi, and Pascagoula tide locations correspond to hydrodynamic model 'save points' (a location for which detailed hydrodynamic output was obtained) 47, 15, and 14 respectively. The observed data were plotted at the median plotting position based on the period of record of each gage and graphically fit, while hydrodynamic plotting positions were determined by statistical analysis of the computed inundation surface as described by the save points; the resultant frequency curves were joined graphically resulting in a composite stage-frequency curve for each save point location. The observed data generally constitute that portion of each stage-frequency curve between the 99.9 percent and 25 percent annual chance exceedance stages, while the ERDC results composing the balance of the curves out to the 1 in 1000 annual chance event. Each stage-frequency curve then is composed partly of one of the three gage data sets, and partly from one 'save point' output file.

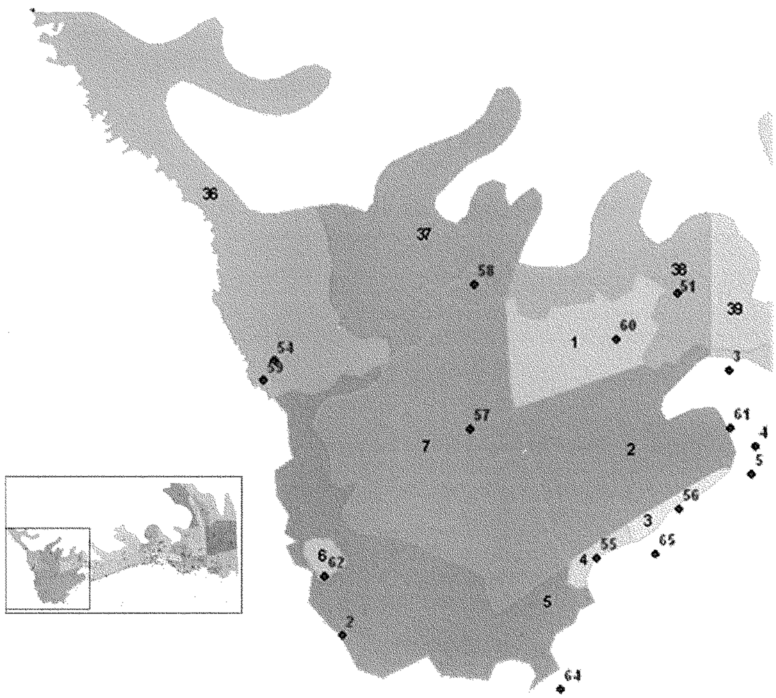
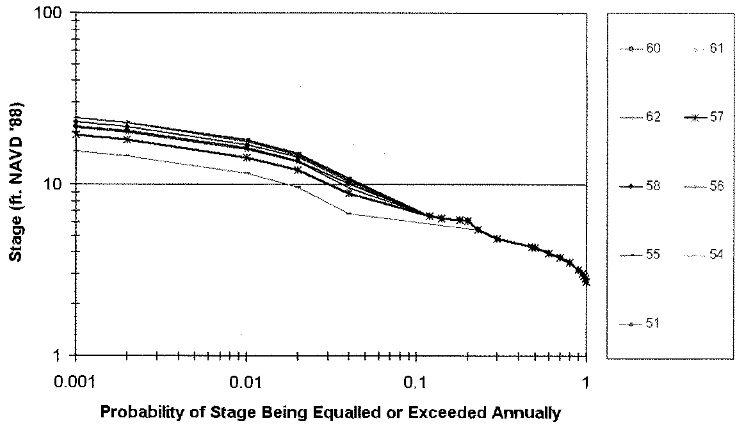


Figure 2.13-1. PSU's and Save Points, Vicinity of Hancock County



Note: Save points referenced to USACE Gulfport gage.

Figure 2.13-2. Composite Stage-Frequency Curves, Hancock Co. Save Points

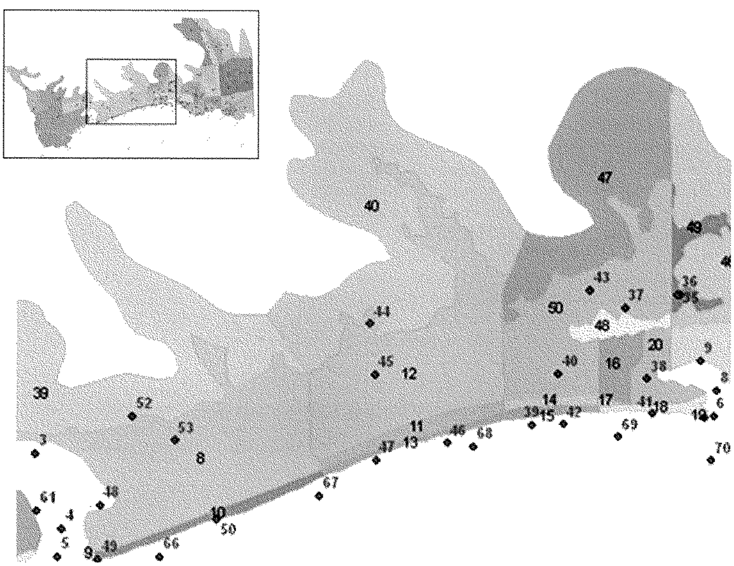


Figure 2.13-3. PSU's and Save Points, Vicinity of Harrison County

USACE technical guidance (Ref. 6) recommends the method of order statistics for computing uncertainty for graphical, synthetic, or composite frequency curves. Stage uncertainty at +/- 1 and +/- 2 standard deviations was computed by the method of order statistics using HEC-FDA Version 1.2 dated March 2000. Uncertainty for that portion of the curve described by hydrodynamic modeling results were estimated at one standard deviation by recently developed statistical methods described by Resio et. al. (Ref. 7). Uncertainties obtained by both methods were merged graphically. HEC-FDA Version 1.2 was modified by the HEC in order to allow direct input of these composite stage-frequency uncertainties.

The stage-frequency curves represent an estimate of the probability of a 'still water elevation' being equaled or exceeded in a calendar year. Waves are not explicitly accounted for in the stage-frequency curves; in other words, the observed or computed portions of each stage frequency curve have not been adjusted upward for surge-coincident wave amplitude[7]. This simplifying assumption is necessary for a variety of reasons, the most compelling being that (1) while participatory scientists agreed that existing shoreline and inundated area wave prediction methods are archaic and in need of revision, there is presently no regionally unified agreement as to how to treat them; (2) surge modeling evaluations do not provide for coincident unsteady freshwater inflow and (3) the level of effort required to develop representative wave information, particularly over inundated inhabited/developed areas where wave behavior is complex and highly variable, exceeded the scope and time available for this effort. While these issues may be overcome to various degrees by careful examination, such effort exceeds the scope and overall level of detail of this investigative phase. The impact of this assumption is that damages and benefits may be somewhat understated. The adopted method used does allow for a consistent evaluation between plans and is consistent with the overall level of study detail.

Each PSU's stage frequency curve was adjusted for future relative sea level rise as required by adding the computed sea level rise to the present stage for a given frequency. Adopted relative sea level rise predictions were derived from IPCC circa 2001 sea level rise predictions and are shown in Table 1.6-9.

The contribution of riverine or rainfall-runoff flood phenomena is not explicitly reflected in the FDA stage-frequency curves with the exception of tributary runoff and its contribution to Bay St. Louis and Biloxi Bay stage as a result of the surge barriers. This exception only applies for certain 'with-project' scenarios. That runoff should be neglected for FDA purposes at this stage of analysis is necessary one, given the relatively flat terrain and large number of sub-basins for which no previous hydrologic studies exist, and should not obscure coastal storm damage problems or opportunities. Should certain storm damage reduction measures be selected for further consideration, additional consideration will be given to quantifying the coincident nature of riverine flooding and coastal surge. Note that runoff has not been neglected in the conceptual design of the lines of defense, which provide dedicated water conveyances for the 24-hour, 25-year event rain event (no hurricane), and pumping for runoff coincident with hurricane storm events, as discussed in the Interior Drainage sections of Chapter 3.

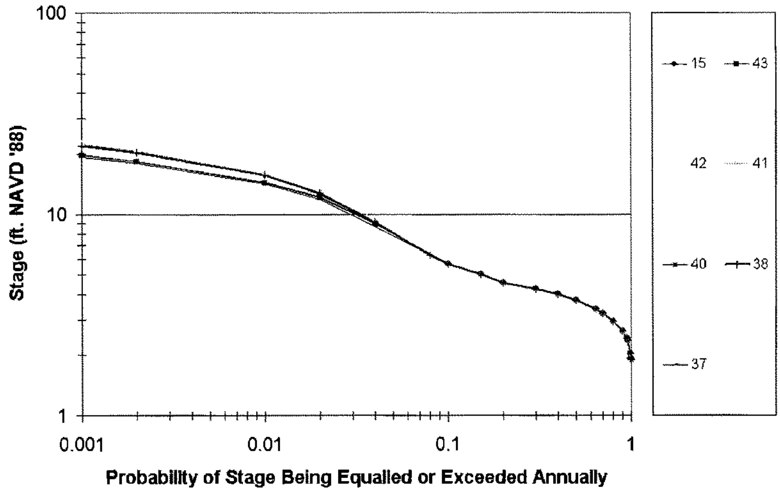
2.13.2.3 Assignment of Stage-Frequency Curves to Planning Sub Units

One stage-frequency curve is assigned to each Planning Sub Unit (PSU). Stage frequency curve components and assignments are displayed by Planning Unit (i.e. county) and PSU in Table 2.13-1. PSU (black numbering) and save point locations (blue numbering) are shown for Hancock, Harrison, and Jackson counties in figures 2.13-1, 2.13-3, and 2.13-6 respectively. Composite without-project stage-frequency curves are shown for Hancock County in Figure 2.13-2; for Harrison County in figures 2.13-4 and 2.13-5, and for Jackson County in figures 2.13-7, 2.13-8.

[7] The contribution to surge due to wave radiation stresses is accounted for as discussed in Chapter 2.

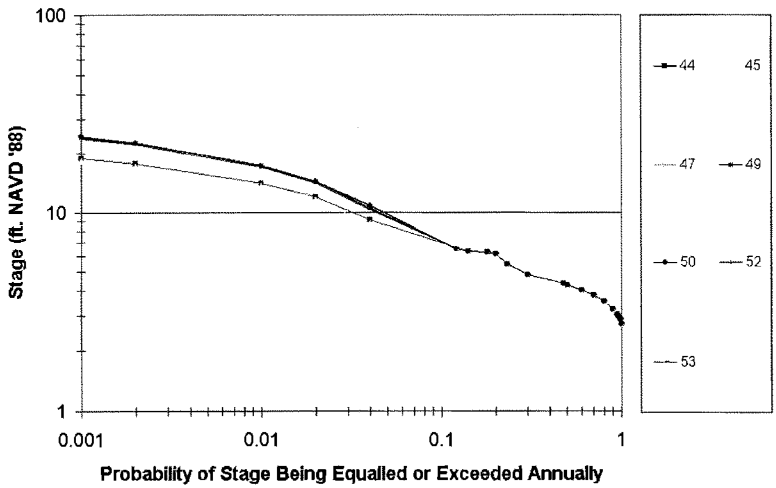
Table 2.13-1.
Stage-Frequency Curve Components and Assignments

County	PSU Number	Assigned Tide Gage	Assigned Save Point Number	County	PSU Number	Assigned Tide Gage	Assigned Save Point Number
Hancock County	5	Gulfport	62	**Jackson County**	21	Biloxi	9
	2	Gulfport	61		22	Biloxi	33
	1	Gulfport	60		23	Biloxi	29
	36	Gulfport	54		24	Biloxi	32
	6	Gulfport	62		25	Biloxi	25
	3	Gulfport	56		26	Biloxi	1
	4	Gulfport	55		27	Biloxi	30
	37	Gulfport	58		28	Biloxi	30
	7	Gulfport	57		29	Pascagoula	30
	38	Gulfport	51		30	Pascagoula	27
Harrison County	8	Gulfport	53		31	Pascagoula	26
	9	Gulfport	49		32	Pascagoula	23
	10	Gulfport	50		33	Pascagoula	17
	11	Gulfport	47		34	Pascagoula	18
	12	Gulfport	45		35	Pascagoula	20
	13	Gulfport	47		41	Biloxi	28
	14	Biloxi	42		42	Pascagoula	17
	15	Biloxi	42		43	Pascagoula	24
	16	Biloxi	38		44	Pascagoula	19
	17	Biloxi	42		45	Pascagoula	18
	18	Biloxi	41		46	Biloxi	35
	19	Biloxi	15		49	Biloxi	35
	20	Biloxi	38		51	Pascagoula	21
	39	Gulfport	52		52	Pascagoula	22
	40	Gulfport	44		53	Pascagoula	11
	47	Biloxi	43		54	Pascagoula	21
	48	Biloxi	37				
	50	Biloxi	40				



Note: Save points referenced to USACE Biloxi gage.

Figure 2.13-4. Composite Stage-Frequency Curves, Harrison Co. Save Points



Note: Save points referenced to USACE Gulfport gage.

Figure 2.13-5. Composite Stage-Frequency Curves, Harrison Co. Save Points (cont.)

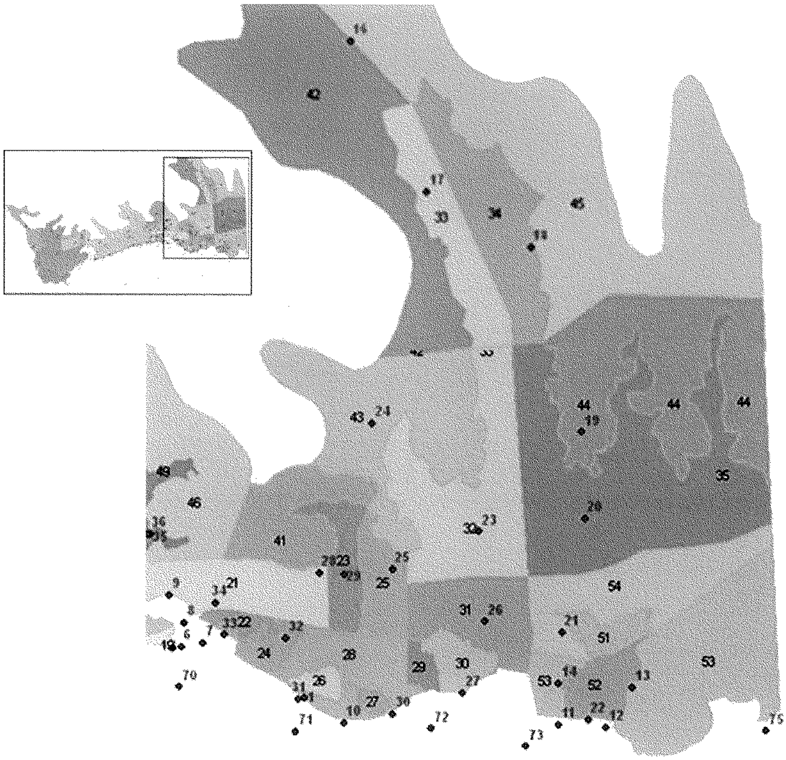
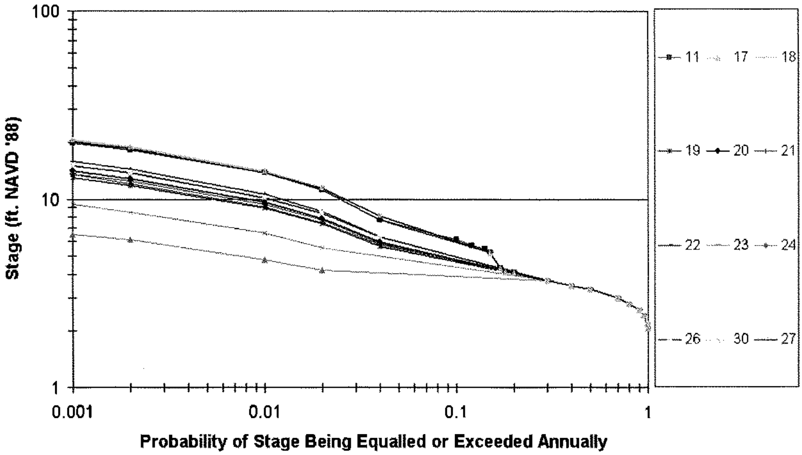
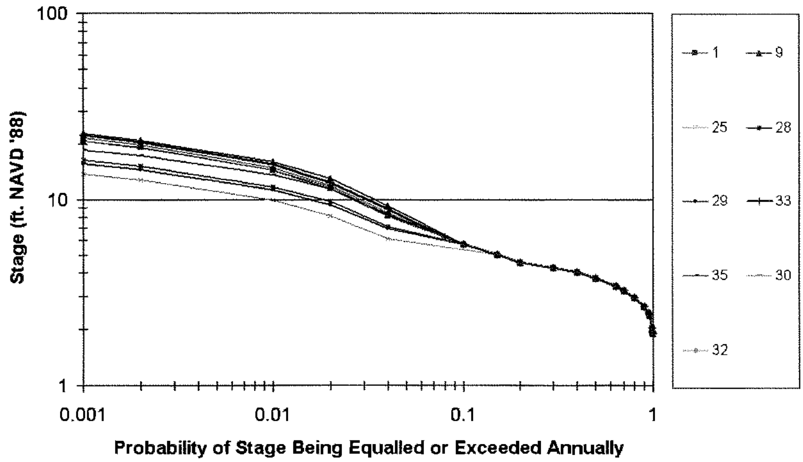


Figure 2.13-6. PSU's and Save Points, Vicinity of Jackson County



Note: Save points referenced to USACE Pascagoula gage.

Figure 2.13-7. Composite Stage-Frequency Curves, Jackson Co. Save Points



Note: Save points referenced to USACE Biloxi gage.

Figure 2.13-8. Composite Stage-Frequency Curves, Jackson Co. Save Points (cont.)

2.13.2.4 Scenarios

A number of scenarios, or plans, were evaluated. Scenarios include the existing condition; the future without-project; and the future with-project. The existing condition is the assumed condition for the base year 2012. The future without-project is an 'average' of future conditions over the project lifetime, which in this case is presumed to be 100 years. Existing condition and without-project evaluations differ only in their assumed structure inventories, which were varied to evaluate the sensitivity of computed damages to reconstruction patterns. Without-project conditions were also evaluated against 'expected' and 'high' sea level rise scenarios to test damage sensitivity to sea level rise uncertainty. Existing condition and without-project scenarios are shown in Table 2.13-2.

Table 2.13-2.
Existing Condition and Without-Project Scenario HEC-FDA Simulations

Run	County	Structure Inventory	MLFY (2111) Sea Level Scenario
1	Hancock	EC	Existing Sea Level
2	Harrison	EC	Existing Sea Level
3	Jackson	EC	Existing Sea Level
4	Hancock	Residential	Existing Sea Level
5	Hancock	Commercial/Condo	Existing Sea Level
6	Hancock	Residential	'Expected'
7	Hancock	Commercial/Condo	'Expected'
8	Hancock	Residential	High Sea Level Rise
9	Hancock	Commercial/Condo	High Sea Level Rise
10	Hancock	Residential	Existing Sea Level
11	Harrison	Commercial/Condo	Existing Sea Level
12	Harrison	Residential	'Expected'
13	Harrison	Commercial/Condo	'Expected'
14	Harrison	Residential	High Sea Level Rise
15	Harrison	Commercial/Condo	High Sea Level Rise
16	Harrison	Residential	Existing Sea Level
17	Jackson	Residential	'Expected'
18	Jackson	Residential	High Sea Level Rise

The future with-project condition represent an average of future conditions over the project lifetime with the incorporation of storm damage reduction measures, individually or in combination, in place. A number of model evaluations were structured in order to test the effectiveness of any one measure (e.g. Line of Defense 4) in the absence of all other measures for reducing without-project expected annual damages. The evaluations also provide for a cursory evaluation of measure performance with respect to uncertainty as to the rate of future sea level rise. The intent of structuring the model runs in this manner was to help identify measures that may warrant further consideration. Generally, the primary modeling differences between with-project conditions for a given planning unit rest (a) in the structural inventories attributed to the base year and most likely future year (MLFY); (b) the treatment of stage-frequency curves to reflect the presence of storm damage reduction measures; and (c) stage-frequency curve adjustments for sea level rise. Structure inventory assumptions are described in the Economics appendix.

With-project HEC-FDA evaluations are shown in Table 2.13-3. The simulations are grouped by county. Each measure is tested against a sea level rise scenario. The measures are assumed to remain 'as-built' (i.e. they are not significantly changed over their lifetime, and are not raised according to the sea level rise that is assumed). Additional measures (e.g. Menge Avenue, Hancock Co. ring levee, etc.) have since been added under this program but have not been fully developed for economic evaluations at press time for this document; future versions of this document will be revised to reflect evaluation of the additional measures.

Table 2.13-3.
HEC-FDA Individual Measures Scenario Simulations

Run	County	Measure	MLFY (2111) Sea Level Scenario
1	Hancock	LOD4-20'	Existing Sea Level
2	Hancock	LOD4-30'	Existing Sea Level
3	Hancock	LOD4-40'	Existing Sea Level
4	Hancock	Seawall	Existing Sea Level
5	Hancock	Pearlington 20'	Existing Sea Level
6	Hancock	Pearlington 30'	Existing Sea Level
7	Hancock	Nonstruct 1	Existing Sea Level
8	Hancock	Nonstruct 2	Existing Sea Level
9	Hancock	SHORELINE	Existing Sea Level
10	Hancock	LOD4-20'	'Expected' sea level
11	Hancock	LOD4-30'	'Expected' sea level
12	Hancock	LOD4-40'	'Expected' sea level
13	Hancock	Seawall	'Expected' sea level
14	Hancock	Pearington 20'	'Expected' sea level
15	Hancock	Pearlington 30'	'Expected' sea level
16	Hancock	Nonstruct 1	'Expected' sea level
17	Hancock	Nonstruct 2	'Expected' sea level
18	Hancock	Shoreline	'Expected' sea level
19	Hancock	LOD4-20'	'High' sea level
20	Hancock	LOD4-30'	'High' sea level
21	Hancock	LOD4-40'	'High' sea level
22	Hancock	Seawall	'High' sea level
23	Hancock	Pearington 20'	'High' sea level
24	Hancock	Pearlington 30'	'High' sea level
25	Hancock	Nonstruct 1	'High' sea level
26	Hancock	Nonstruct 2	'High' sea level
27	Hancock	Shoreline	'High' sea level
28	Harrison	LOD4-20'	Existing Sea Level
29	Harrison	LOD4-30'	Existing Sea Level
30	Harrison	LOD4-40'	Existing Sea Level
31	Harrison	Seawall	Existing Sea Level
32	Harrison	Nonstruct 1	Existing Sea Level
33	Harrison	Nonstruct 2	Existing Sea Level
34	Harrison	Turkey Creek	Existing Sea Level
35	Harrison	LOD4-20'	'Expected' sea level
36	Harrison	LOD4-30'	'Expected' sea level
37	Harrison	LOD4-40'	'Expected' sea level
38	Harrison	Seawall	'Expected' sea level
39	Harrison	Nonstruct 1	'Expected' sea level
40	Harrison	Nonstruct 2	'Expected' sea level
41	Harrison	Turkey Ck.	'Expected' sea level
42	Harrison	LOD4-20'	'High' sea level
43	Harrison	LOD4-30'	'High' sea level
44	Harrison	LOD4-40'	'High' sea level
45	Harrison	Seawall	'High' sea level
46	Harrison	Nonstruct 1	'High' sea level
47	Harrison	Nonstruct 2	'High' sea level
48	Harrison	Turkey Ck.	'High' sea level
49	Jackson	LOD4-20'	Existing Sea Level
50	Jackson	LOD4-30'	Existing Sea Level
51	Jackson	LOD4-40'	Existing Sea Level
52	Jackson	Seawall	Existing Sea Level
53	Jackson	Ring Dike 20'	Existing Sea Level
54	Jackson	Ring Dike 30'	Existing Sea Level
55	Jackson	Nonstruct 1	Existing Sea Level
56	Jackson	Nonstruct 2	Existing Sea Level
57	Jackson	Bayou Cumbest	Existing Sea Level
58	Jackson	LOD4-20'	'Expected' sea level
59	Jackson	LOD4-30'	'Expected' sea level
60	Jackson	LOD4-40'	'Expected' sea level
61	Jackson	Seawall	'Expected' sea level
62	Jackson	Ring Dike 20'	'Expected' sea level
63	Jackson	Ring Dike 30'	'Expected' sea level
64	Jackson	Nonstruct 1	'Expected' sea level
65	Jackson	Nonstruct 2	'Expected' sea level
66	Jackson	Bayou Cumbest	Existing Sea Level
67	Jackson	LOD4-20'	'High' sea level
68	Jackson	LOD4-30'	'High' sea level
69	Jackson	LOD4-40'	'High' sea level
70	Jackson	Seawall	'High' sea level
71	Jackson	Ring Dike 20'	'High' sea level
72	Jackson	Ring Dike 30'	'High' sea level
73	Jackson	Nonstruct 1	'High' sea level
74	Jackson	Nonstruct 2	'High' sea level
75	Jackson	Bayou Cumbest	Existing Sea Level

2.13.2.5 Scenario Stage-Frequency Curves

As discussed previously, the stage-frequency curves used in HEC-FDA analyses were composed from observed tide gage data and from hydrodynamic modeling results. In support of the HEC-FDA effort, the hydrodynamic modeling evaluated the existing condition; Line of Defense (LOD) 4 alone; and LOD 3 plus ring levees. Additional simulations could not be accomplished for this program. The LOD's and ring dikes were coded into the hydrodynamic terrain database of their respective hydrodynamic models as 'infinitely high walls', thus obtaining an estimate of the height of the LOD required to contain a given annual chance event from model output nodes located seaward of each LOD. LOD's 3 and 4 are discussed in detail in Chapter 3.

Existing condition stage-frequency curves (adjusted for sea level rise as required) were used for all damage reaches in many of the measure evaluations listed in Table 2.13-3.

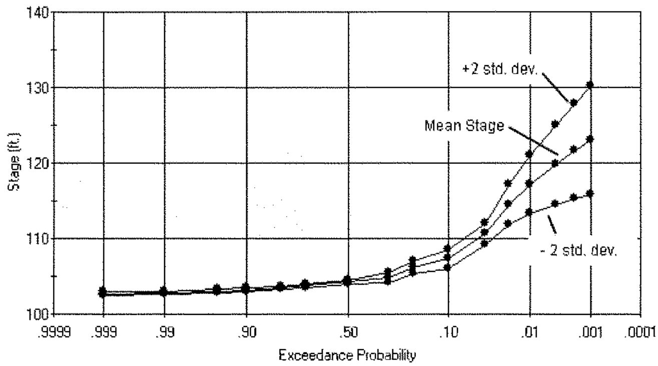
For future with-project HEC-FDA evaluations involving individual measures, stage-frequency curve development required use of either existing condition hydrodynamic model output, or LOD hydrodynamic model output, or both, depending upon the location of both the PSU and that PSU's hydrodynamic model save point with respect to the line of defense. Additional consideration was required if the PSU was subject to induced runoff storage due to Bay St. Louis or Biloxi Back Bay closure structures. The following paragraphs describe the methodology used to develop stage frequency curves for the with-project scenarios involving individual measures.

- *Save Point and PSU behind levee or ring-dike.* For example, consider PSU 7 and its representative save point (57) in Hancock County as shown in Figure 2.13-1. This PSU is located behind both of the conceptual LOD3 and 4 alignments. This case is typical of many inland PSU's that do not border Biloxi Bay or Bay St. Louis. For this circumstance, the existing condition stage-frequency curve is used and PSU is coded into HEC-FDA as being protected to the prescribed LOD crest elevation. The existing condition stage-frequency curve is used because the with-LOD save point is essentially 'dry' due to the infinite wall approach in the hydrodynamic modeling. The interior water surface elevation is assumed to equal the stage-frequency curve stage for all events exceeding the levee crest elevation.
- *Save Point in front of levee and PSU behind levee or ring dike.* Consider PSU 11 and its representative save point (47) in Harrison County as shown in Figure 2.13-3. This PSU is also located behind the prospective LOD 3 and 4 alignments, but it's representative save point is outside (seaward) of the LOD's. This case is typical of nearshore and ring-levee PSU's. The stage-frequency curve was developed from observed gage data and the appropriate ERDC LOD model output and coded into HEC-FDA as being protected by a levee to the prescribed LOD crest elevation. As with the previous case, the interior water surface elevation is assumed to equal the stage-frequency curve stage for all events exceeding the levee crest elevation.
- *Save Point and PSU behind levee and PSU is subject to induced stage due to closure structures across bays.* As with the '*Save Point and PSU behind LOD'* situation, this situation also utilizes the existing conditions stage-frequency curve but the HEC-FDA levee routine cannot be invoked because streamflow into Bay St. Louis and Biloxi Bay will cause their water surface elevations to rise when the surge barriers are closed to prevent hurricane surge inundation. Existing condition frequency curves (e.g. Figure 2.13-9) were transformed (e.g. Figure 2.13-10 for the LOD4 at 20' crest elevation) graphically using the following assumptions:
    - The surge barriers would be operated for extreme hurricanes only, on average once every twenty years (e.g. hurricanes resembling H. Katrina, H. Betsy, H. Camille, or the 1947 or 1915 hurricanes etc.)

- Closure of the barriers would result in Bay St. Louis and Biloxi Bay water surface elevations rising to elevation 6.8 ft. and 8.4 ft NAVD '88, respectively based on preliminary hydrologic analyses (see Chapter 3.4).
- Should the crest elevation of the barrier be such that it overtopped, the representative existing condition stage would rapidly be attained.

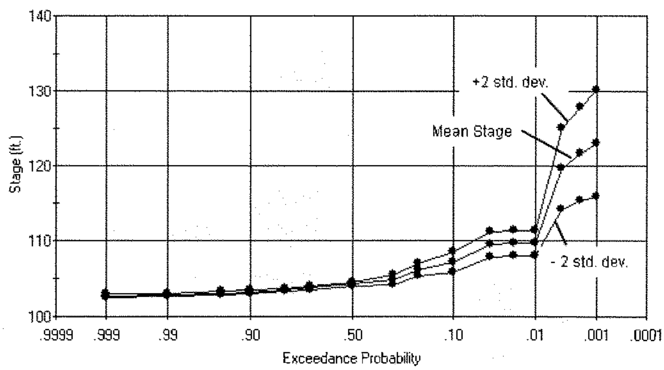
As mentioned previously, Most Likely Future Year (MLFY) stage frequency curves were adjusted for future sea level rise by adding the predicted rise to stage for a given frequency.

Flood damage evaluation results are reported in the Economics Appendix.



Note: 100 ft. added to stage for HEC-FDA computational purposes.

Figure 2.13-9. Existing Condition Frequency Curve, PSU 1 Save Point 60, Hancock Co.



Note: 100 ft. added to stage for HEC-FDA computational purposes.

Figure 2.13-10. Transformed Frequency Curve, PSU 1 Save Point 60, Hancock Co.

2.13.3 References

USACE (2000). Planning Guidance Notebook. Engineer Regulation ER 1105-2-100. Department of the Army, US Army Corps of Engineers, Washington, D.C. 22 April 2000.

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2.14 Lines of Defense Crest Elevation Analyses

Evaluations were conducted to estimate the required levee crest elevation in order to provide protection to the one in one hundred (1%), one in five hundred (0.2%), and one in one thousand (0.1%) annual chance exceedance surge events.

Typical levee and elevated roadway sections are shown in Figures 2.14-1 and 2.14-2. The crest elevations shown on the typical levee section were used to generate levee cost-height curves, and should not be interpreted to be design elevations. Design elevations follow from performance and cost effectiveness objectives as discussed in the main report.

Resultant crest elevations are a function of the surge still water elevation, wave height, wave period, levee slope, levee surface roughness, nearshore depth, nearshore slope, and the seaward levee side slope. Still water elevations for the given events were obtained for the nearest representative save points using the same ERDC results comprising the synthetic portions of the composite stage frequency curves. ERDC also provided mean estimates of the 1%, 0.2%, and 0.1% significant wave height (Hs) and peak period (Tp) estimates based on statistical analyses of with-project (either LOD3 or LOD4) STWAVE model results. Wave characteristics were computed independently of surge characteristics. Surge elevation, Hs, and Tp determinations are given in Chapter 2.9 of this appendix. Nearshore depth and geometry was estimated from a limited number of beach profiles (i.e. sections normal to the shoreline) obtained by Mobile District; and/or from interpretation of existing USGS topographic maps; and/or from interpretation of post-Katrina, LIDAR-derived topography. Levee side-slopes were assumed to be 3 to 1 (horizontal to vertical) with a mowed grass face except as noted in following paragraphs.

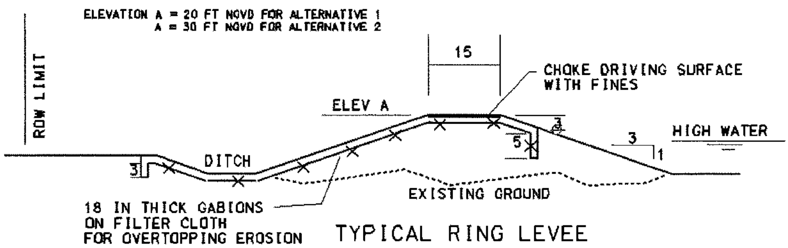
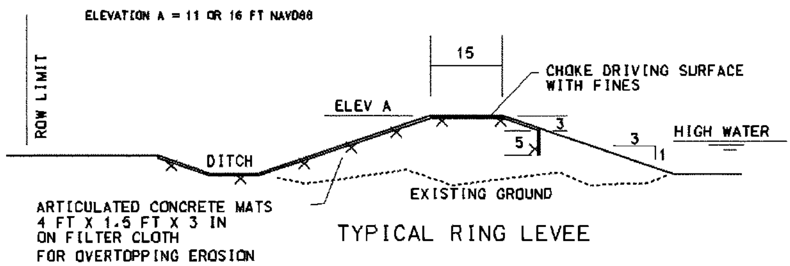


Figure 2.14-1. Typical Section, Levees



Source: ERDC, Steven Hughes

Figure 2.14-2. Typical Section, Elevated Roadway

Computations generally followed those prescribed in a recent, though draft, USACE Technical Letter (Ref. 1). Crest elevations for a given event assumed coincident occurrence of percent chance event surge and wave characteristics; in other words, the crest elevation computations for the 1% event assumed coincident occurrence of the mean 1% Hs, 1%Tp, and 1% surge elevations. Because Tp and Hs percentiles were computed independently of surge elevations, this assumption is thought to yield somewhat conservative results (Ref. 1). Computations were performed using Table VI-5-11 (van der Meer and Janssen's equation) of the Coastal Engineering Manual (CEM) Professional Edition software, version 2.0.1.1. All gamma factors in the underlying equation were assigned a value of unity. The presence of other potentially complementary project features, such as sand dunes and berms, was neglected.

Adequate protection was defined for these preliminary purposes as the crest elevation for which the computed average overtopping rate for each event was on the order of 0.01 cubic feet per second per foot (cfs/ft), which is equivalent to an average overtopping discharge rate of 10 cfs per 1,000 feet of levee. This rate is less than the 0.1 cfs/ft which is currently being considered as an appropriate threshold for well-designed and constructed coastal levee defenses, but this higher rate is best applied in conjunction with conditional probability methods; the lower rate assumed herein was judged appropriate for these preliminary purposes given the limited spatial extents of model output and the deterministic methods otherwise employed.

The information available for these computations allows for just a few spot estimates of requisite levee elevations. Those elevations presented in following paragraphs should be understood to be applicable to a discreet location and not interpreted to describe the crest elevation of any particular line of defense throughout its entire length. Should a levee or other structural line of defense measure be selected for additional investigation, a much higher density of well positioned surge, wave, and geometric information would be needed in order to adequately define the required levee profile along its length for the desired level of performance. These computations are deterministic thought in most instances the results are expected to agree reasonably with results determined through a probabilistic conditional probability simulation.

2.14.1 Line of Defense 3

Computed crest elevations for locations along LOD 3 are given in Table 2.14-1. Crest elevations given are reported in feet NAVD '88 datum. Locations at which the elevations were computed are shown in Figures 2.14-3 through 2.14-11. Computed crest elevations range from elevation 13 feet to 53 feet over the range events. For the one in 100 chance events, computed crest elevations range from 13 to 37 feet, with most locations yielding elevations in the high teens to mid twenties. In some instance, such as the Harrison County elevated roadway, the computed elevation is on the order of 36 feet. Locations that yield these types of results would be inherently difficult to defend due to large surge depths, severe storm wave climates, and the absence of a shallow foreshore. The typical levee section is inappropriate where results such as these arise, which would probably be better defended perhaps by a levee with some or all of the following features: (a) a frontal berm seaward of the primary levee prism; (b) a flatter seaward slope (6 to 1 or greater); and (c) a roughened, hardened slope in lieu of grass. Such features would reduce the required height at a given location for a given event overtopping rate. Where possible, the levee height may also be reduced by removing the structure landward from the shoreline to an upslope location beyond the wave breaking zone. For example, the results in Table 2.14-1 suggest that the levee crest elevation at Pascagoula might be reduced from 37 feet to 19 feet by removing the levee from the shoreline to an alignment in the vicinity of Washington Avenue. Similar findings and recommendations apply when interpreting LOD 4 levee performance and attributes.

Table 2.14-1.
Computed Structure Crest Elevations, LOD 3

Feature and Location	Annual Event Chance		
LOD-3	**1 in 100**	**1 in 500**	**1 in 1000**
Hancock County			
Pearlington Levee	20	30	34
Bay St Louis Levee	22	38	42
Hancock Elevated Road, 11.0	N/A[1/]	N/A[1/]	N/A[1/]
Harrison County			
Harrison Elevated Road, 16.0	36[2/]	50[2/]	N/A[3/]
Jackson County			
Ocean Springs Elevated Road, 11.0			
Ocean Springs Levee	20	27	29
Gulf Park Estates	24	35	40
Gulf Park Estates Alter.	20	25	29
Belle Fontaine	29	41	45
Bell Fontaine Alter.	20	29	33
Gautier	32	41	43
Pascagoula			
South Shore	37	39	53
Bayou Cassotte	18	23	26
River near tide gage	16	24	27
Moss Point	13	19	21
Pascagoula – Washington			
At Washington Ave.	19	28	31
Bayou Cassotte	18	23	26
River near tide gage	16	24	27
Moss Point	14	19	21
Pascagoula Moss Pt. Alter			
Moss Point Alt.	14	19	21
Bayou Cassotte	18	23	26
River near tide gage	16	24	27
South Shore	37	39	53
Pascagoula – Washington/MP			
Moss Point Alt.	14	19	21
Bayou Cassotte	18	23	26
River near tide gage	16	24	27
At Washington Ave.	19	28	31

Notes: 1/ This feature is given a discrete elevation. El. 11 ft. is approximately the 1 in 25 annual chance still water elevation. Feature was dropped from consideration. 2/ This feature is also given a discrete elevation. Crest el. of 16 ft. is between the 2% (1 in 50 chance) and 1% (1 in 100) still water elevation. This feature was also dropped from consideration. 3/ Not computed due to excessive crest elevations required at this location for lesser events.

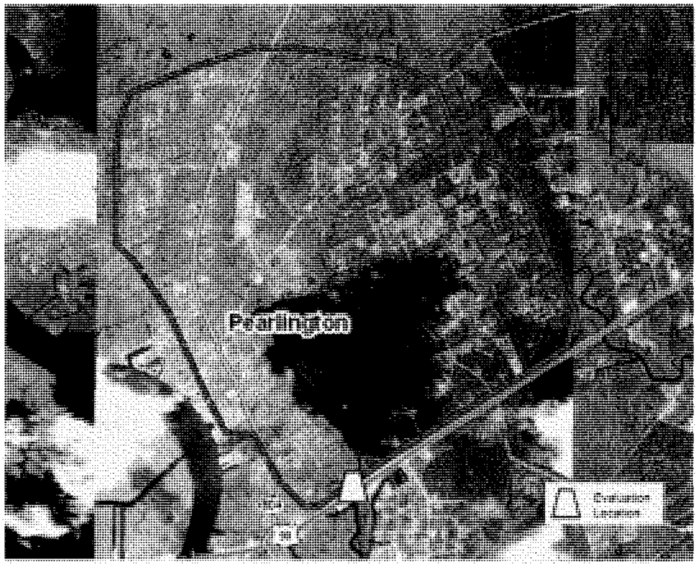


Figure 2.14-3. Hancock County, Pearlington Ring Levee

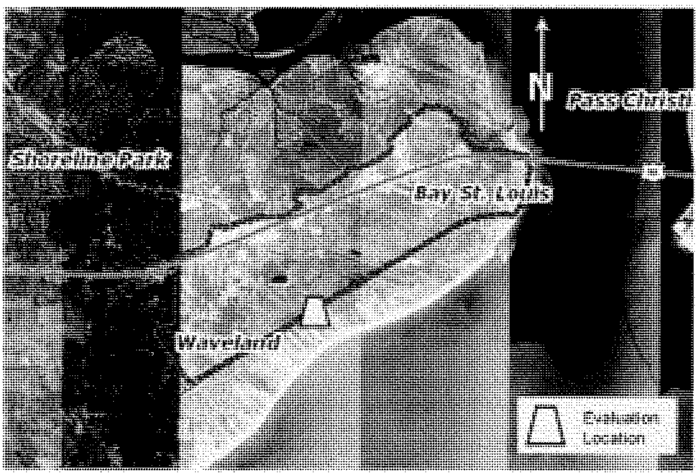
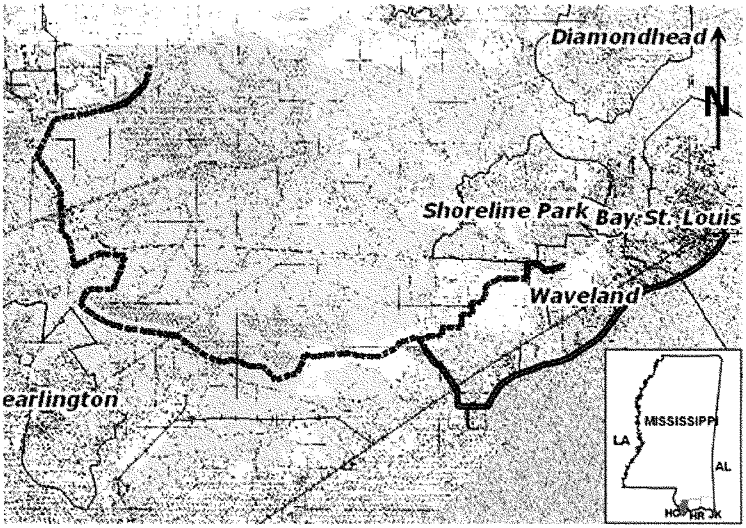


Figure 2.14-4. Hancock County, Bay St. Louis Ring Levee



NOTE: LOD3 shown linked to inland LOD4 feature.

Figure 2.14-5. Hancock County, Elevated Roadway and LOD4

Figure 2.14-6. Harrison County, LOD3 at Pass Christian

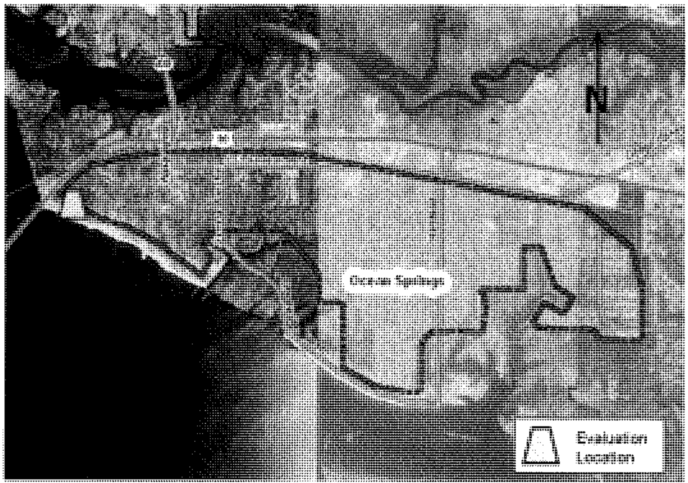


Figure 2.14-7. Jackson County, Ocean Springs Ring Levee

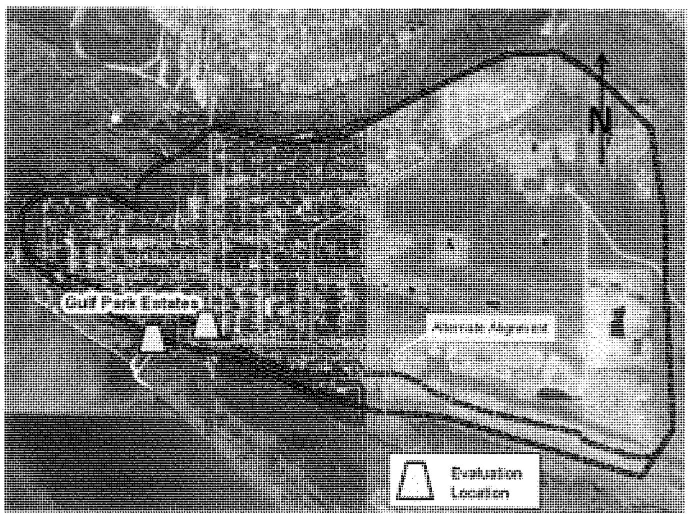


Figure 2.14-8. Jackson County, Gulf Park Estates Ring Levee

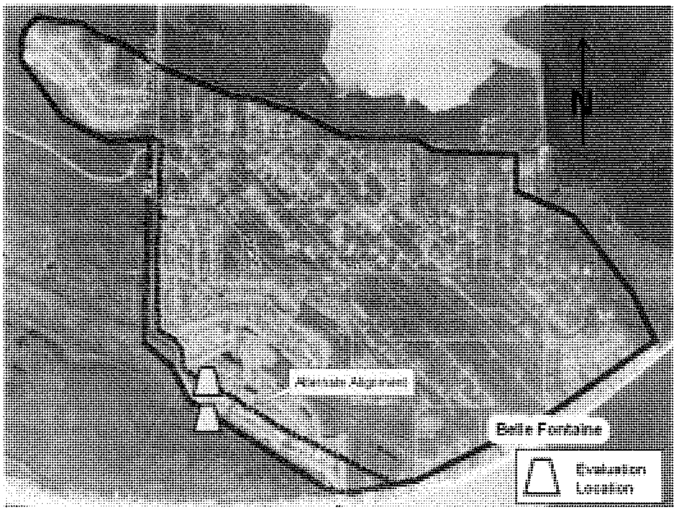


Figure 2.14-9. Jackson County, Bellefontaine Ring Levee

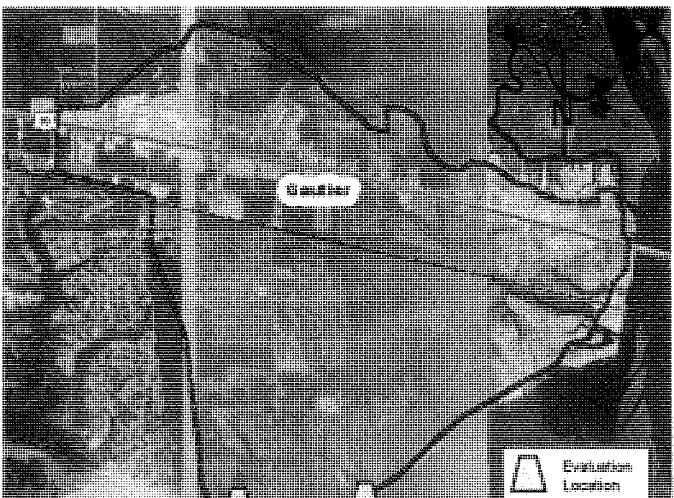


Figure 2.14-10. Jackson County, Gautier Ring Levee

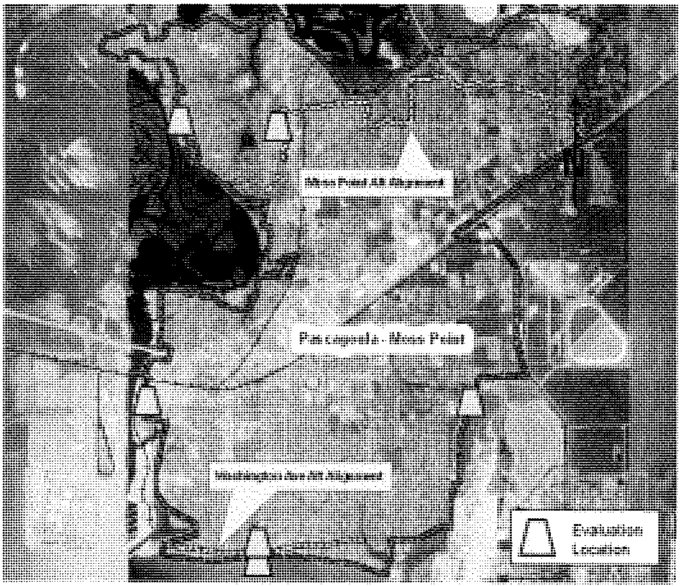


Figure 2.14-11. Jackson County, Pensacola/Moss Point Ring Levee

2.14.2 Line of Defense 4

Computed crest elevations for locations along LOD 4 are given in Table 2.14-2. Crest elevations given are reported in feet NAVD '88 datum. Locations at which the elevations were computed are shown in Figures 2.14-12 through 2.14-16. Computed levee crest elevations range from elevation 18 feet to 50 feet over the range events. For the one in 100 chance events, computed crest elevations range from 13 to 35 feet, with most locations yielding elevations in the high teens to mid twenties. Here, as also with LOD3, the given crest elevation for the 1 in 100 annual chance event is on the order of 30 to 35 feet; such results suggest that the typical levee cross-section geometry is not practicable at the given location and would benefit from modification and/or from a change in alignment to a more quiescent location.

The surge barriers are of novel geometry in their at-rest and deployed condition and empirical overtopping rate relations do not apply to them. Crest elevations for the surge barriers were computed using Table VI-5-13 (Franco and Franco's equation) of the Coastal Engineering Manual (CEM) Professional Edition software, version 2.0.1.1. This equation is most applicable to vertical wall structures. As with the levees, the elevations given assume an acceptable overtopping rate of 0.01 cfs/ft without consideration to interior (i.e. landward of the barrier) flooding attributes. It is possible that a larger overtopping rate might be structurally and operationally acceptable for these features, which would result in a lower crest elevation and lower construction costs. Design refinement awaits further study as desired.

Table 2.14-2.
Computed Structure Crest Elevations, LOD 4

Feature and Location	Annual Event Chance		
LOD-4	**1 in 100**	**1 in 500**	**1 in 1000**
Hancock County			
Clermont	35	47	50
Bay St. Louis Levee	22	29	32
Harrison County			
Pass Christian Harbor	21	29	31
Biloxi West	20	26	29
Biloxi Casino Row	20	29	34
Menge Ave	20	28	30
Jackson County			
Jackson County - Ocean Springs	18	25	28
Surge Barriers			
Bay St. Louis Closure Structure	30	44	49
Biloxi Bay Closure Structure	31	43	47

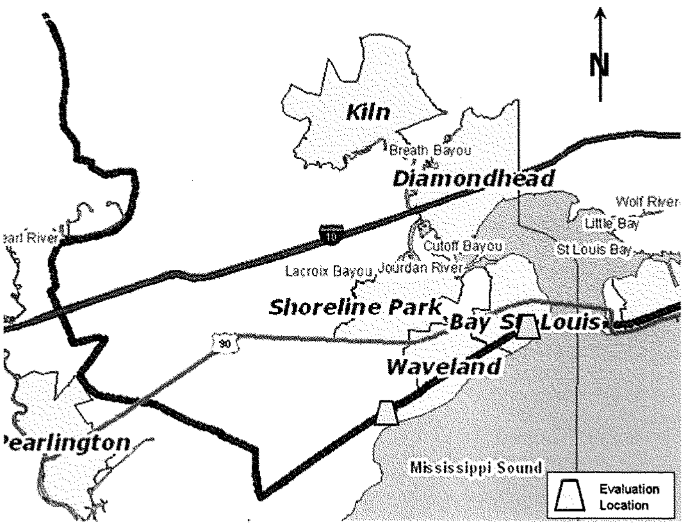


Figure 2.14-12. Hancock County Inland Barrier

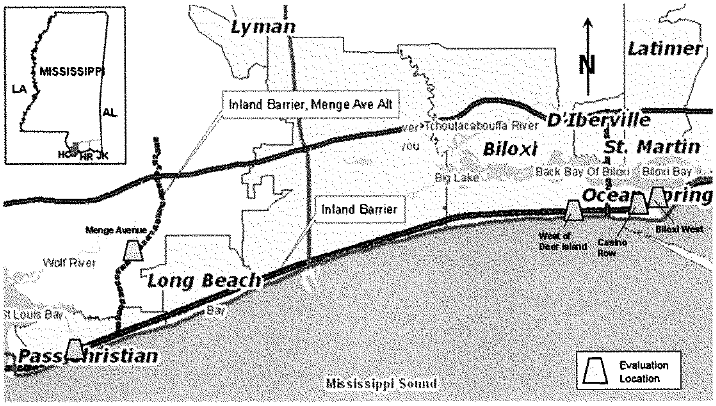


Figure 2.14-13. Harrison County Inland Barrier

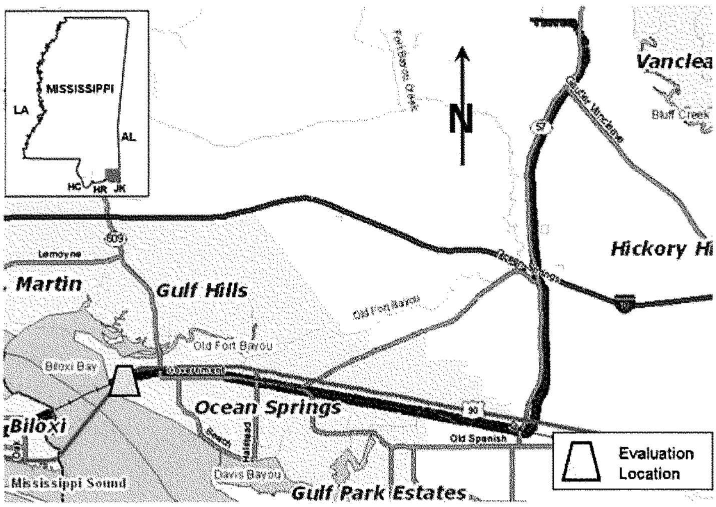


Figure 2.14-14. Jackson County Inland Barrier

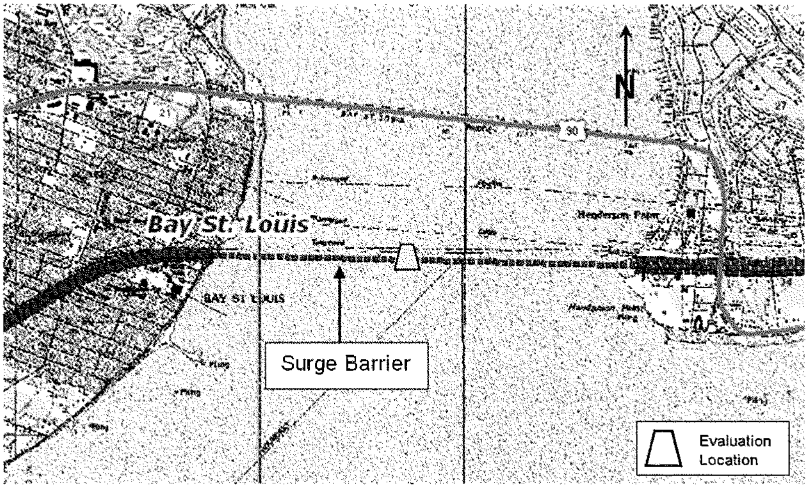


Figure 2.14-15. Bay St. Louis Surge Barrier

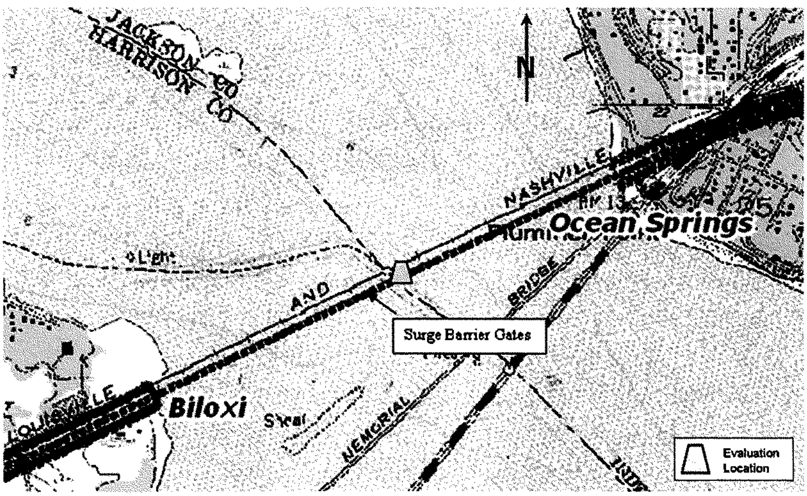


Figure 2.14-16. Biloxi Bay Surge Barrier

2.14.3 References

USACE (2007). Certification of Levee Systems for the National Flood Insurance Program (NFIP). Technical Letter No. 1110-2-570. US Army Corps of Engineers, Washington, DC. 7 August 2007.

PART 3. LINES OF DEFENSE

3.1 Line of Defense 1 – Offshore Barrier Islands

3.1.1 General

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 as shown in Figure 3.1.1-1. These barrier islands are located along a littoral drift zone that moves sand westward creating three elongated islands and then westward toward Cat Island, where littoral currents are not as well defined. The birds-foot delta system from the Mississippi River has extended through the historic littoral system, cutting off the sediment transport. Cat Island had the same origin than the other islands, but now being re-shaped by wave action and lack of new sediments moving into the system. Wave action has created a beach on the eastern side of the island forming a distinctive T-shape. From west to east, the islands are Cat, Ship (now actually two islands, West and East Ship Island), Horn and Petit Bois. As noted above, 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 and is now known as Camille Cut. The western ends of both Petit Bois and West Ship Islands have migrated westward and are now against maintained deep-water navigation channels and the continuing littoral drift of the sand into the channels is causing an artificial termination of the migration. A small, new island has emerged on the west side of the channel from Petit Bois Island, created from the dredged sand coming from the island that is disposed of on the west side of the channel.

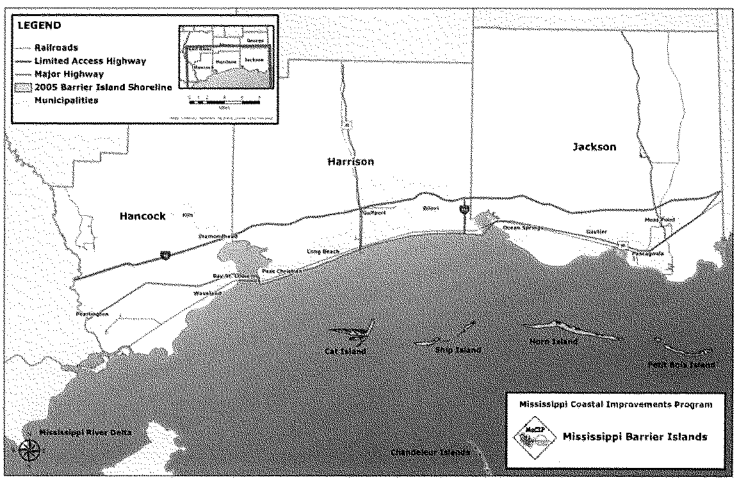


Figure 3.1.1-1. Location of the Mississippi Barrier Islands

Immediately following Hurricane Katrina, most of the effort was spent protecting human life and securing structures throughout the impacted areas on the mainland; therefore, few assessments of the vegetation impacts exist, especially on the barrier islands. For the barrier island system, most all of the marsh vegetation recovered several months following Hurricane Katrina. The predominant vegetation that has long-term impacts consists of those pines found in the maritime forests. It is estimated that about 75% of these pine species were killed following the hurricane season of 2005, with most of that attributable to Hurricane Katrina. Figure 3.1.1-2 is a photograph taken on Horn Island after Hurricane Katrina that shows the loss to the pine trees. The emergent marsh habitat is thriving so well it actually looks as though hurricanes never passed through the barrier island system. The sea oats are still found in small patches due to the reduced dune system. Any option that includes the planting of marsh vegetation will have to consider the current population of nutria that inhabits the islands. These exotic animals from South America can destroy attempts to establish marsh planting and any program should include the control of these rodents.

Figure 3.1.1-2. Photo of interior of Horn Island. Note the mature pine trees that were killed from the effects of salt water that covered the island during Hurricane Katrina.

In 1998, Hurricane George played a role in destroying many of the sand dunes on the islands. Although a relatively small storm, the constant pounding of the waves along the beaches eroded most of the dunes on the southern shores which were the higher elevations on the islands. Along with the destruction of the dunes was the loss of the associated vegetation and habitat. Figure 3.1.1-3 is a photo of the south beach of Horn Island where hurricanes have destroyed the dune system.

Prior to Hurricane Katrina, the State of Mississippi was working on a coastal storm protection plan that included restoring the barrier islands to the condition that existed prior to Hurricane Camille. The general assumption was that there would have been less damage along the coast from Hurricane Katrina if the islands had been in this improved condition. This was also included in the Mississippi Governor's Hurricane Katrina Recovery Plan which called for restoring the islands to a pre-Camille footprint. This concept was included in the hurricane protection study as LOD-1.

Figure 3.1.1-3. Photo of the south beach at Horn Island. Pre-existing dunes have been destroyed by numerous hurricanes over the last several years.

To determine the effects of the islands in reducing the surge damage to the mainland, a number of storms were selected to model against the chain of islands in a pre-Camille and a post-Katrina configuration. The post-Katrina condition can be considered a baseline condition for the modeling and the pre-Camille condition would be an improved condition. The pre-Camille footprint of the islands was obtained from historical records and an assumption was made as to a top of dune elevation and a typical island width. During the modeling process, the island sizes were held constant and not allowed to be destroyed. It should be noted that some of the islands have migrated and any reconstruction would be to increase their footprint at their present location and not move them back to historical locations. In general, the islands were modeled with a 2000-foot width and with an elevation 20.0 dunes, but may be in a slightly different position. Modeling efforts have concluded that over a wide range of storms, there would be some protection provided to the eastern coast of Mississippi along the Jackson County shoreline if the islands are in the pre-Camille condition. This area is the most protected from the restored islands and this protection may result in only up to a 10% reduction in storm surge. The effect of this protection diminishes rapidly to the west from Jackson County. An important aspect of the islands shown by the modeling is the reduction of the large sea waves as they advance towards the mainland. Reduction in wave height up to several feet is realized by the presence of the islands. Loss of Ship Island would leave a portion of the heavily developed Harrison County shoreline subject to these larger waves.

All of Petit Bois, Horn, and Ship Islands and part of Cat Island are within the boundaries of the Gulf Islands National Seashore under the jurisdiction of the National Park Service. The park boundaries are shown in Figure 3.1.1-4. In most cases, the boundary extends one mile from the shore of the island. Petit Bois and Horn Islands have also been designated as Wilderness Areas by the U.S. Department of the Interior and have a higher degree of protection than the other islands.

The formation of Camille Cut has created problems for the National Park Service due to the location of two historically important sites. Fort Massachusetts is located on the northern shore of West Ship and the French Warehouse is located on the northern shore of East Ship Island. Both of these sites are endangered by on-going erosion of the shoreline with Mississippi Sound. Another site known as the Quarantine Station has already been lost to erosion. These sites are shown in Figure 3.1.1.-5. This photo was taken after Hurricane Katrina, but, would be similar to conditions after Hurricane Camille.

Figure 3.1.1-4. Boundaries of the Gulf Islands National Seashore

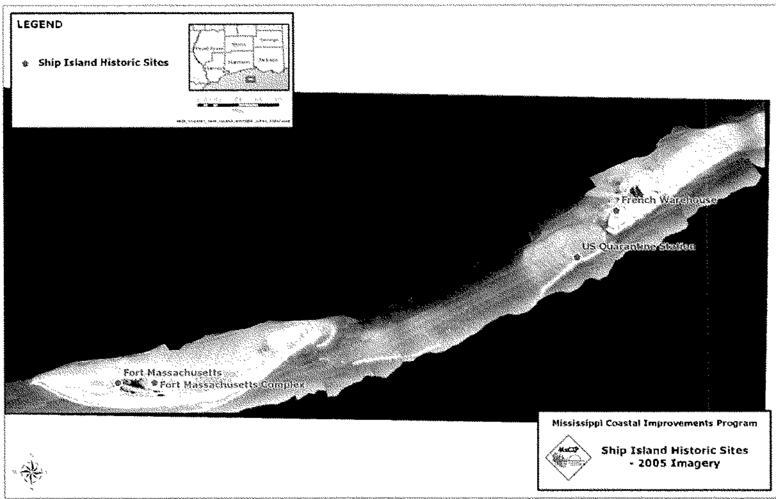


Figure 3.1.1-5. Aerial photo of West and East Ship Island taken in 2005 after Hurricane Katrina showing the locations of listed historical sites separated by Camille Cut.

Fort Massachusetts was originally built on the western tip of Ship Island. The westward migration of sand along the southern shore and erosion of the northern shore now has put the fort almost a mile from the western tip of the island, but dangerously close to being in the Sound. Several emergency beach re-nourishments have taken place over the last 35 years to protect the fort from wave action during winter storms. At present, the NPS is again requesting that the Corps place sand along the shore near the fort in conjunction with dredging operations at the Gulfport navigation channel. This emergency placement of sand is being repeated about every five to six years.

The French Warehouse site has not had any sand placement on its shoreline in the past. The erosive process is slower at that location, but now there are concerns from the NPS about the integrity of the site. Unlike the location of the fort, the warehouse site is covered by maritime forest which may be slowing the erosion of the shore.

The Corps was asked to visit Fort Massachusetts with the NPS during July, 2007 to look at the present erosion problem and to discuss any possible long-term solutions to the loss of sand along the shoreline. The immediate erosion problem will require re-nourishment of the beach adjacent to the fort similar to the past protection projects. Any type of hardened structural feature as protection for the fort was not desired by the NPS nor was this recommended by the Corps. There was a breakwater placed north of the fort in the past (prior to the barrier islands becoming a National Seashore under the NPS) and seems to be compounding the erosion problems. The problem of a long-term fix may be tied to closing the three mile wide breach known as Camille Cut between West and East Ship Island. Review of historical footprints of the islands indicates that after the breach caused by Hurricane Camille, the westward migration of sand was continuing, but that the sand supply was being depleted before it reached West Ship Island. Aerial photos show the formation of a sand spit that extends westward from East Ship Island. The volume of sand that is creating this spit is being depleted from reaching West Ship Island. The photos also show that a deeper channel has formed a pass between the eastern end of West Ship Island and the western end of the spit. It appears that an ebb tidal delta at this pass moves the sand southward where it is removed from any migration along the northern shore of West Ship Island. The sand continues to supply the south beach and extends the western tip of the island in its migration. The loss of the sand from the littoral drift along the northern shore of West ship Island has resulted in erosion of that shoreline. Figure 3.1.1-6 shows an excellent aerial view of this process. Note the boat on the northern side of the pass.

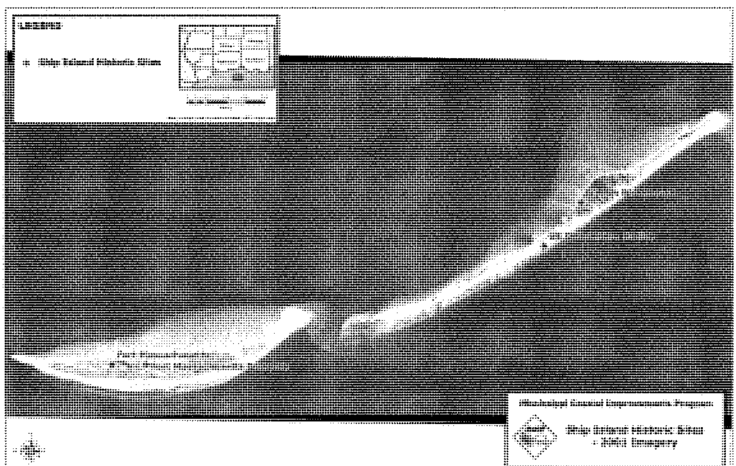


Figure 3.1.1-6. Aerial photo of West and East Ship Island taken in 2001. Note the sand spit extending westward from East Ship Island and the pass between the two islands.

A positive by-product of filling of the Camille Pass would be to provide a longer term solution to the erosion on the northern shores of West Ship Island. This will require modeling to better understand the benefits that are believed to be associated with this plan. The costs will be substantial due to the large quantities of high quality sand that will be required to fill the breach. Initial estimates for sand requirements are approximately 8 million cubic yards. The fill would be expected to prevent the continuing loss of sand to West Ship Island, but it is also understood that the islands are a dynamic system, ever changing to nature's forces. Different types of dune vegetation planting would also be included to restore habitat on the newly created land.

3.1.2 Restoration of the Offshore Barrier Islands

3.1.2.1 General

Soon after Hurricane Katrina, it was reported that many residents in Mississippi were of the opinion 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 initial concept was also included in the Mississippi Governor's Restoration Plan which called for restoring the islands to a pre-Camille footprint. Changes in the footprints are shown in Figures 3.1.2.1-1 through 3.1.2.1-4.

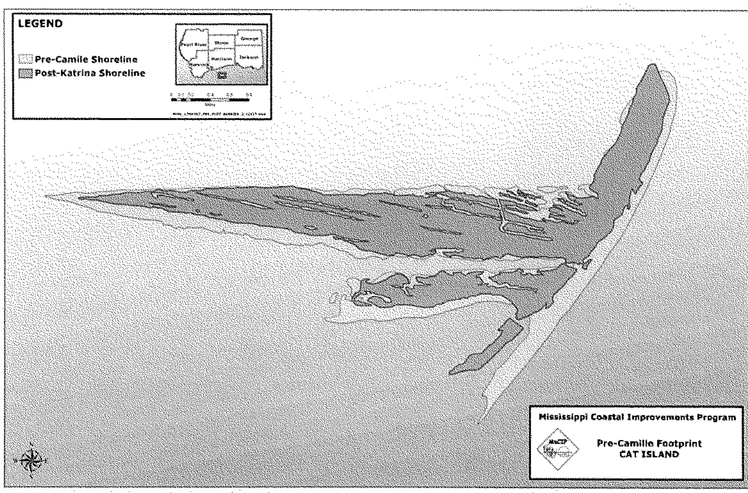


Figure 3.1.2.1-1. Changes in footprint of Cat Island from pre-Camille to post-Katrina

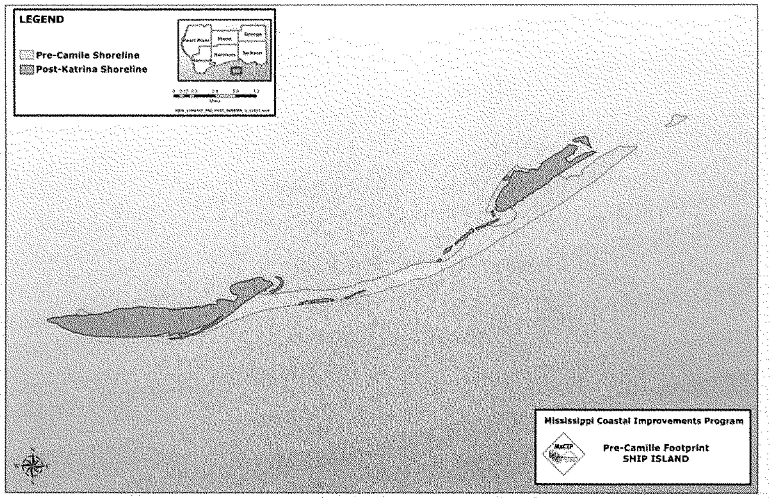


Figure 3.1.2.1-2. Changes in footprint of Ship Island from pre-Camille to post-Katrina

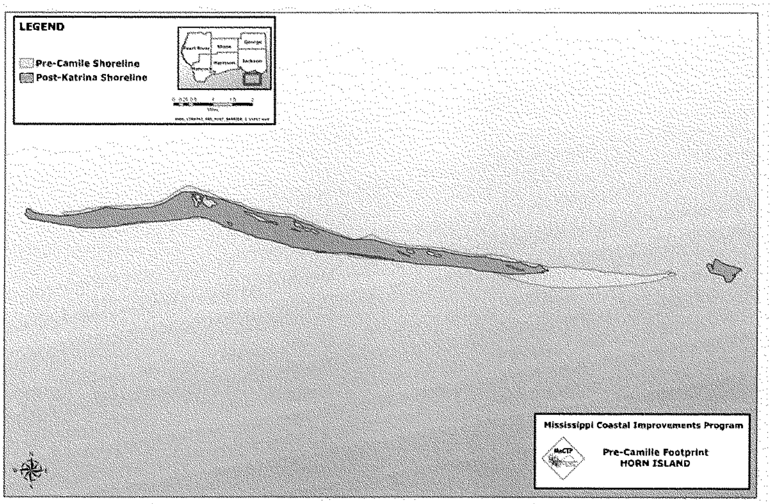


Figure 3.1.2.1-3. Changes in footprint of Horn Island from pre-Camille to post-Katrina

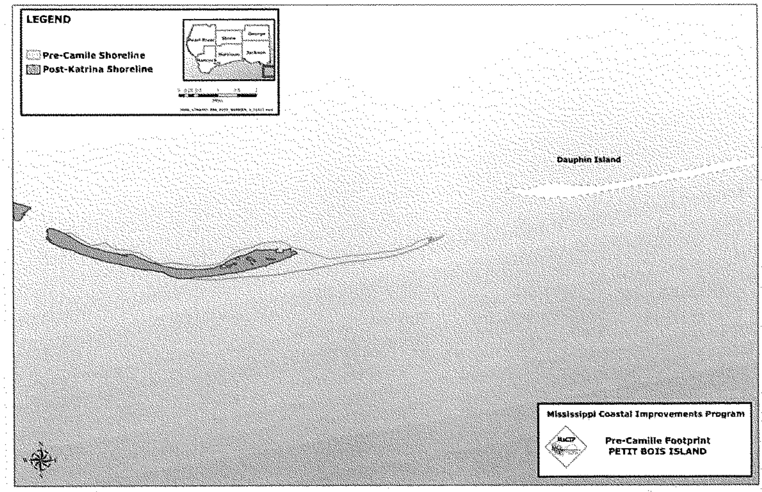


Figure 3.1.2.1-4. Changes in footprint of Petit Bois Island from pre-Camille to post-Katrina

As discussed in Section 3.1.1, a number of storms were selected to model against the chain of islands in a pre-Camille and a post-Katrina configuration. The post-Katrina condition can be considered a baseline condition for the modeling and the pre-Camille condition would be an improved condition. The pre-Camille footprint of the islands (USGS, 2007) was obtained from historical records and an assumption was made as to a top of dune elevation of 20 feet. It should be noted that some of the islands have migrated and any reconstruction would be to increase their footprint at their present location and not move them back to historical locations. This increase in size generally increased their length and maintained their typical width.

Modeling efforts have concluded that over a wide range of storms, there would be some protection provided to the eastern coast of Mississippi along the Jackson County shoreline if the islands are in the pre-Camille condition. This area is the most protected from the restored islands and this protection may result in only up to a 10% reduction in storm surge. As was shown in Figure 2.1-6, the effect of this protection diminishes rapidly to the west from Jackson County. With the consideration that these islands are within the National Park Service and that Petit Bois and Horn Islands are designated Wilderness Areas, any improvements to these islands may be politically difficult based on the limited benefits.

Another consideration to help restore the islands is to supplement the sand into the littoral system. This could be accomplished by adding sand in specific locations based on sediment transport modeling. This sand would not be put on the islands, but in areas between the islands where the currents that make up the littoral drift zone could transport the sand to the islands where the natural process of island building could take place. There, waves and wind could cause accretion on the islands. This may mitigate the loss of land mass at the islands that has been occurring since Hurricane Camille. The source of these sands may be from inland sources or from offshore borrow areas. This would not directly affect the present-day islands and would help mitigate any effects of dredging the ship channels that pass through the chain of islands where sand may have been lost from the system.

A positive affect that the islands have is to provide a natural off-shore breakwater for the large sea waves that are generated from hurricanes. For this to occur, the islands only need to be a low stretch of sand or even a shallow sandbar. The presence of the islands and the relatively shallow water of the Mississippi Sound between the islands and the mainland prevent the sea waves from maintaining their considerable size as they move towards the mainland. Sea waves, often reported at heights of 40 feet and higher in large storms, would break as they approach the chain of islands. The open water between the islands and the mainland, generally ten miles or more, would have enough fetch for waves to regenerate, but at a much lower height due to the shallower water. The generally accepted relationship between water depth and wave height is that the wave can sustain itself at a height that is one half the depth of the water.

An environmental impact of the islands continuing to diminish in size is to allow salinity increases in the Mississippi Sound. Mississippi Sound would be classified as a 'bar-built' estuary as opposed to a 'drowned river valley' (like Mobile Bay). The physics of bar-built estuaries is very different from others and you would expect to see broad zones of 'salinities' with the estuary which respond greatly to both river flow and wind conditions. Should the 'bars' go away, then the estuary is totally lost because in general an estuary is considered part of the coast as opposed to forming the coast. Under current conditions, the islands provide a natural boundary between the water's salinity [~33 parts per thousand (ppt)] of the open Gulf of Mexico and the brackish water found in Mississippi Sound. Salinity in the Sound during low flow periods range from 10 to 30 ppt. Highest salinities occur just south of Pascagoula and Gulfport and the lowest salinities in the Lake Borgne-Pearl River area. Several studies have investigated the impacts of diverting freshwater 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 are sensitive to specific ranges of salinity. Additional modeling and study would be required to determine impacts to salinity from the loss of the barrier islands.

One restoration option for the barrier islands would be to re-establish the vegetation that was destroyed by Hurricane Katrina. This option could involve environmental restoration of the existing islands through adding sand dunes on the beaches along with planted vegetation, planting of marshes and maritime forests, and planting sea grasses in the near-shore areas of the islands. This plan would not involve adding any land mass to the islands other than the possibility of adding to the dune system. The addition of vegetation from sea oats up to trees would aid in reducing erosion of the sand from wind thus helping in maintaining the stability of the islands. The vegetation would also aid in preventing erosion by water in the event that the islands get overtopped by storm surge in a large hurricane. Sources of this sand could be from the beach area behind the dunes or from sources off the island. Historically, large areas of sea grass existed north of the islands. Much of this sea grass is now gone and the loss of these areas have been mapped. Replanting the grasses and other vegetation will aid in establishing valuable habitat that was lost from the ecological system. Figure 3.1.2.1-5 shows the extent of vegetation on Horn Island prior to Hurricane Katrina.

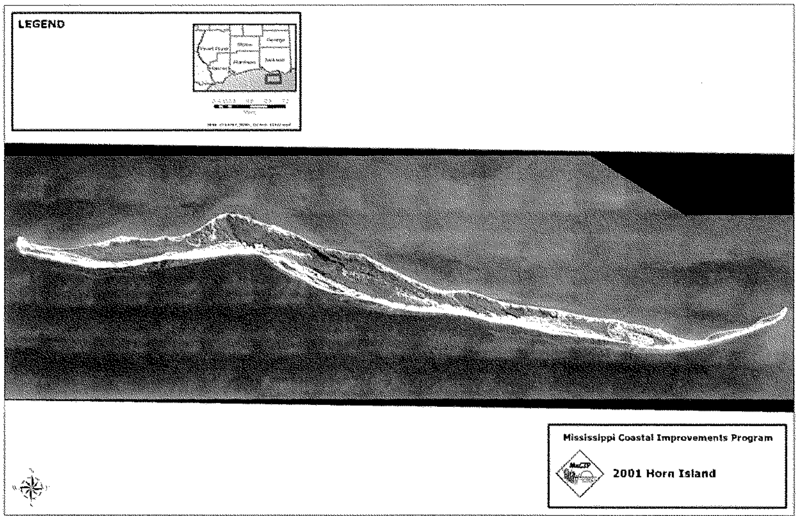


Figure 3.1.2.1-5. Aerial photo of Horn Island. The darker areas are vegetation consisting of maritime forest and marsh grasses.

As discussed in Section 3.1.1, an additional restoration option has been added that will fill and close Camille Cut between West and East Ship Island. In addition to providing some storm damage reduction, this option will provide some protection to two historical sites on West and East Ship Island, respectively. This option will require additional study to model the desired results of slowing erosion near the two sites. During coordination with the NPS, agreements have been reached that will provide positive affects to the barrier islands. These proposals have been incorporated into an alternative based on LOD-1 Options C and G. This alternative consists of adding sand into the littoral zone and closing the breach between West and East Ship island. This alternative is fully described in a separate appendix based on this combination of options titled the Comprehebsive Barrier Island Restoration Plan. A working paper that documents the NPS position on the barrier islands (NPS, Sept. 2007) along with other cooperating agencies is included in the Barrier Island Appendix. An important result of the NPS agreement was that any work that involved direct placement of any sand into Camille Cut would be a one-time event without additional O&M sand placement. In accordance with 2006 NPS Management Policies (see Barrier Isalnd Appendix Chapter 2, the NPS Vision Statement Section III), the NPS has concluded that this one time placement of sand would most directly counteract the long term reduction in sand supply which has resulted in Ship Island being dimished to the point where it may have lost the ability to restore and maintain itselt s in the historical past. Natural re-building and maintenance of the barrier islands in the long term would then be supported by the continuing placement of sand back into the littoral zone during future maintenance dredging of navigation channels. Areas where continuing beneficial placement could be employed will be identified during additional sediment transport modeling conducted during the Engineering and Design phase prior to a contract award.

3.1.2.2 Location

The barrier islands of Mississippi are located 10 to 15 miles south of the mainland. Currently, there are five islands in the chain that extends for 45 miles west from a point south of the Alabama – Mississippi state line along the coast. Currently, Ship Island exists as two islands separated by Camille Cut. It was breached during Hurricane Camille in 1969 and remains today as West and East Ship Island. Two maintained navigation channels pass through the chain of islands. The Gulfport channel passes near the west end of West Ship Island and the Pascagoula channel passes near the end of Petit Bois Island. The present day location of the channels prevents any further westward migration of either island.

3.1.2.3 Existing Conditions

As is typical of most barrier island systems, the Mississippi islands are an ever-changing and dynamic landscape. Data shows that the islands have lost approximately 20 to 25 percent of their land mass since pre-Camille times. The islands have been heavily influenced by the various hurricanes including even the lower intensity ones. Hurricane George, in 1998, even though a small hurricane, proved to be devastating to the islands due heavy erosion from waves. Many of the higher dunes systems on the islands were destroyed and much of the elevation the islands once had is gone. Most of the islands are now very susceptible to over-wash during storms. Another result of being submerged during Hurricane Katrina was the loss of much of the maritime pine forest that existed on the islands. The trees, mostly now dead from the salt water submergence, played a major role in preventing erosion both from wind and any surges against the islands.

The westernmost island, Cat Island, has a similar origin from the other islands in the chain, but isolated from the littoral current by a historical birds-foot delta from the Mississippi River that cut off the path of the historical littoral zone. A change in wave climate has formed a T-shaped configuration. Sorting of the sediments has created a beach on the east facing portion of the island. Results of the sediment budget completed as part of this study indicates that little or no sand is being added to Cat Island from the littoral drift system that supplies sand to the other islands in the chain. The remainder of the islands have a westward drift that is more pronounced from the eastern-most Petit Bois Island and decreasing respectively to the west to West Ship Island.

3.1.2.4 Coastal and Hydraulic Data

The barrier islands protecting the Mississippi Sound experience a low energy wave climate, with average significant wave height at National Data Buoy Center (NDBC) Buoy 42007 (22 nautical miles south-southeast of Biloxi, in 45 ft depth) averaging 2.0 and 1.3 feet in the winter and summer months, with associated average peak wave periods of 4.0 to 3.5 s, respectively. Wave transformation modeling by Cipriani and Stone (2001) indicated that breaking wave heights on the barrier islands range from 1.0 to 2.0 feet. Waves in the Mississippi Sound are fetch and depth-limited. The Coastal Studies Institute's Wave-Current Surge Information System (WAVCIS) gage CSI-13 located at Ship Island Pass (23 foot depth) from June 1998 through July 2005 measured an average significant wave height of 0.3 feet and associated average wave period of 2.5 sec.

Tides in the Mississippi Sound are diurnal, with a tidal range of 1.5 and 2.8 feet for the mean and spring tides at Biloxi, Mississippi, respectively. However, the relatively shallow and large area of the Mississippi Sound create strong currents in the tidal passes between the barrier islands, ranging from 1.6 to 3.3 feet/sec and 6.0 to 11.5 feet/sec on flood and ebb tides, respectively (Foxworth et al. 1962). In the winter months, winds from the same direction and of a sufficient magnitude are capable of lowering water surface elevations in the bays and nearshore from 3.6 to 2.0 feet (U.S. Army Corps of Engineers Mobile District 1984).

For the Gulf barrier island beaches, net longshore sediment transport is from east to west, although local reversals in the net transport occur adjacent to the tidal passes. The primary sources of sediment are longshore sediment transport from east to west, and, potentially, the offshore shelf (Otvos 1979, Cipriani and Stone 2001). Cipriani and Stone (2001) discussed that a well-defined cellular structure exists for each barrier island in which, over historic times, little sand transfer exists between islands. However, dredging records at Horn Island and Ship Island Passes (called Pascagoula Bar Channel and Gulfport Bar Channel, respectively) suggest that infilling of sand from adjacent barrier islands occurs, indicating the potential for transport of sand between islands. Eastern Dauphin Island, with a Pleistocene core, is more stable than the other barriers although eastern Dauphin Island has been eroding in response to the dominant westerly-directed transport. Based on grain size analysis, Cipriani and Stone (2001) inferred that offshore sources may provide some sediment to central Petit Bois Island. The Mississippi Sound barrier islands range from very well vegetated, with maritime forests on east Dauphin Island, to low elevation barriers that are overwashed and breached during hurricanes. Long-term relative sea level rise for Dauphin Island, Alabama from 1966 to 1997 was 0.12 inch/year +/- 0.02 inch/year.

3.1.2.5 Option A – Restore Pre-Camille Island Footprint

As part of the Seven Step Strategy developed by the Governor of Mississippi, an option was developed to look at restoring the barrier islands to a pre-Camillr footprint. The pre-Camille footprint of the islands was obtained from historical records and the amount of area that has been lost to coastal erosion since that time was computed. Without accurate topography of the islands an assumption was made that some dunes had a top of elevation of 20 feet. It should be noted that some of the islands have migrated and any reconstruction would be to increase their footprint at their present location and not move them back to historical locations. Figures 3.1.2.1-1 through 3.1.2.1-4 showed the changes in the land mass of the islands from a pre-Camille condition to a post-Katrina condition. It was also recognized that NPS support for this option was unlikely due to conflicts with that agencies 2006 Management Policies and statutory responsibilities.

Several approaches to restoration of the islands were considered. This option will only include new land mass that is being added to the islands by using sand dredged and transported from an off-shore location. The shaping of the sand into beaches, dunes and marsh areas will not affect the existing islands other than that narrow strip of land that will form the boundary between the existing island and the new land mass. This option can be used in combination with other options under this line of defense should it be desired to restore habitat on the existing islands.

Restoration of Ship Island to a pre-Camille configuration includes closing the post-Katrina, 3-mile long breach to a 2000-foot width and with elevation 20.0 dunes, along with some rebuilding of the other islands to a larger land area. The land mass of each of the islands was estimated in a pre-Hurricane Camille condition using historical aerial photography. The difference in the size of the islands was then computed based on post-Hurricane Katrina aerial photography. The results of this are as follows:

The difference in the land mass over this period was then converted to an acreage that it would take to restore the size of the footprint. The width of the islands was maintained with the additional land mass being added as length. Each of the surface areas was converted to a quantity by using an average water depth of seven feet and raising the sand up to elevation of 10.0. It was assumed that approximately 25 percent loss of the material would occur during the process of placement.

Sand of sufficient quality in the quantities required for this type of project is not known to occur in close proximity to the islands. Proposed geophysical studies may locate sources near the existing islands. Prior studies of the St. Bernard Shoals (Oral Communication, USGS, 2006) are probably the best source of the sand. Additional studies and sampling will be required to ensure the source. As previously described, St. Bernard Shoals are a series of submerged barrier islands. The average water depth over the shoals is 60 feet which puts the sand within reach of a hopper type dredge, however the water depth near the islands is too shallow for the draft of hopper dredge that would be used in this type of operation. In order to accomplish this, a basin would be dredged near each of the islands to discharge the sand being transported from the borrow area. Any suitable sand (if encountered in sufficient quantities) would be added as part of the fill, otherwise the material will be transported to approved disposal areas per the Regional Sediment Management guidelines. Using this procedure, the hopper dredge could enter the basin and bottom dump the sand. This would be much faster than pumping off the sand. Doing this would also allow the basin be placed outside the boundaries of the National Seashore. As the basin is filled, a suction dredge would be mobilized to the site and using this type of the equipment, the sand could be moved to the area where the material is needed to create additional land mass. As the sand is placed on the new land mass, it would be sculpted into dunes and swales which would vary from elevation 0 (NAVD 88) up to heights of 20 feet. The amount of new land mass at each of the islands would be approximately the same as the amount shown as lost in Table 3.1.2.5-1. The anticipated amount of sand required for each island is as follows:

Cat Island – 14,600,000 cubic yards

Ship Island – 21,240,000 cubic yards

Horn Island – 21,240,000 cubic yards

Petit Bois Island – 9,300,000 cubic yards

Table 3.1.2.5-1.
The Amount of Land Mass Lost from each of the Mississippi Barrier Islands from pre-Camille conditions to post-Katrina Conditions

Island	Pre-Camille (acres)	Post-Katrina (acres)	Land Loss (acres)
Cat	2,344	1,957	387
Ship	1,172	631 (East and West)	541
Horn	3,612	3,077	535
Petit Bois	1,329	1,098	231

As the new land mass is added to the existing islands, portions of the new island will be planted with various type of vegetation to provide habitat and to aid against erosion. Review of photographs of the islands prior to Hurricane Katrina has provided data on the percentages of the islands that were associated with maritime forest, marsh, dunes, and open beach. The percentage of maritime forest varied among the islands from one percent up to 23 percent. For the new land mass of the islands under Option A additions, it was decided to use a quantity of 20 percent of the land mass for planting the trees consisting of longleaf pine. The lower elevations of the new land mass would be planted with emerging marsh species that would cover 38 percent of the area. This would include Spartina alterniflora, Spartina patens, and Juncus romerianus. Dunes planted with sea oats would make up two percent of the area and the beach areas would be left as open berms. With time, the dunes would transform themselves into a more natural state as wind shifted the sand and the planted vegetation established itself similar to the dunes shown in Figure 3.1.2.5-1.

3.1.2.5.1 Interior Drainage

The type of work anticipated for adding sand to increase the land mass of the islands will not require any type of drainage system. The addition of sand under this operation will be with dredge pipe discharge and all water will be allowed to run back to the sea.

Figure 3.1.2.5-1. Typical sands dunes on gulf coast barrier island

3.1.2.5.2 Geotechnical Data

The barrier islands are composed of Holocene aged deposits, mostly sand. These deposits formed after erosion of the Pleistocene formations during the last regression and transgression of the sea. This occurred during the Wisconsinan glacial stage during the Late Pleistocene. As the sea regressed, rivers incised channels and transported sediments southward. When the sea level returned to present condition, sediments filled the river channels and started to cover the area that would become the Mississippi Sound. Sandy deposits that had been transported into the Gulf began to move westward from northwest Florida as wind driven littoral currents formed numerous barrier islands across the northern Gulf Coast, including most of those in coastal Mississippi. As the sea level continued to rise, the bays and associated river channels into the gulf also began to fill with these deposits.

The actual Sound formed as an estuary after littoral drift of sandy sediments from the Alabama coast formed a shoal south of the Mississippi mainland. These shoals became barrier islands as currents, waves and wind pushed the sand above the water surface. The sand is typically medium grained, white to light grey in color with well rounded particle shape. Within the interior of the islands, marshes and fresh water lakes have created highly organic soils with a peat-like character. These deposits, as shown in Figure 3.1.2.5-2, can be observed as beach outcrops on the southern shore of East Ship Island after the island has migrated northward. This process was added by formation of the St. Bernard delta of the Mississippi River that enclosed the western end of the Sound. The western-most island in the chain, Cat Island, is a product of the historic St. Bernard delta lobe. What remains today is a beach front face of the island where waves have sorted the material leaving the sand and deltaic deposits behind the beach.

Figure 3.1.2.5-2. Peat-like organic soils outcropping on the south beach of East Ship Island. These deposits are the remains of sediments and organic matter that settle in the bottom of the marshes and lakes that occur on the barrier islands. The deposits are exposed as the islands migrate northward.

East and West Ship Island, Horn Island and Petit Bois Island are migrating over Pleistocene formations that created a relatively stable platform for the constantly moving islands. Other Holocene deposits provide a relatively thin cover on the bottom of the Mississippi Sound and some areas south of the Islands and consist of a muddy mixture of sand and clay along with shell fragments or buried oyster shell beds.

After the islands formed, the Sound became a brackish estuary and deposits of mostly fine grained, muddy sediments began forming in the Sound. Other than Cat Island, the other islands such as they exist today, are migrating along the littoral drift and are mostly composed of sand. Local layers of peat-like organic soil that are forming in the inter-island lakes and marshes and can become exposed on the beaches as the sand migrates.

If increasing the land mass of the islands, it would be desirable to maintain the same quality sand that now makes up the existing islands. Sources of sand in the quantity that would be required for this option are extremely large, especially when considering the quality standard that must be met. Potential sources for sand were investigated both inland and offshore. Of concern is matching the sand to the sand on the beaches of the National Seashore. Samples taken from Dauphin and Pelican Island in Alabama are in the same island chain and have been tested for color, grain size and particle shape. These results, included in this section as Table 3.1.2.5-2 and Figures 3.1.2.5-3 and 3.1.2.5-4, can be used to match potential sand sources.

Table 3.1.2.5-2.
Munsell Soil Color Evaluation of Sand Samples Taken from the Barrier Islands of Alabama that is within the Littoral Drift Zone of the Mississippi Barrier Islands

Sample ID	Hue	Value	Chroma	Color
Composite 1	5YR	6	3	Pale Olive
Composite 2	10YR	8	1	White
Composite 3	10YR	8	2	White
Composite 4	2.5 YR	7	2	Light Grey

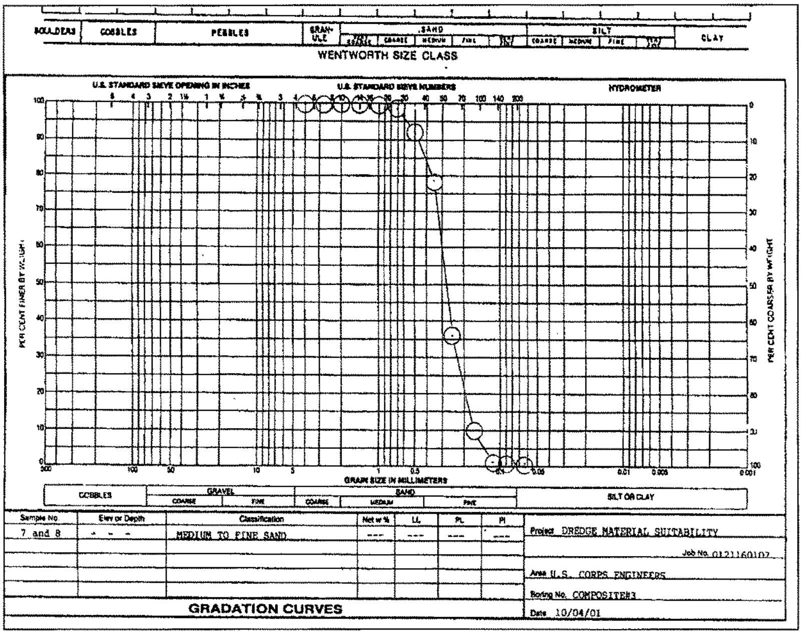


Figure 3.1.2.5-3. Composite gradation from sieve analysis of sand taken from the barrier islands of Alabama that is within the littoral drift zone of the Mississippi barrier islands.

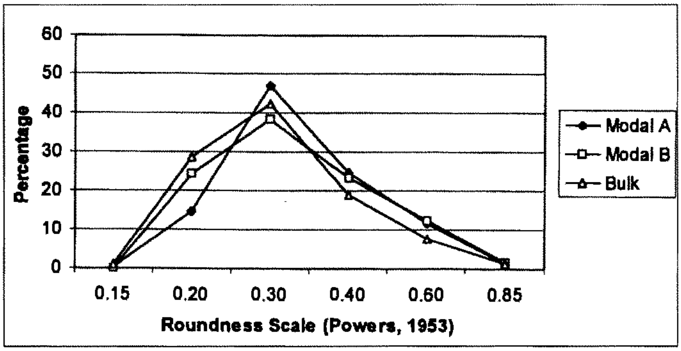


Figure 3.1.2.5-4. Grain Sphericity of composite sand sample taken the barrier islands of Alabama that are within the littoral drift zone of the Mississippi barrier islands Values for sphericity (roundness) are .15 - very angular, .20 - angular, .30 - sub-angular, .40 - sub-rounded, .60 – rounded, and .85 – well rounded.

These beaches are used for nesting by endangered sea turtles where grain size, particle shape and color of the sand are very important. The sand from inland river sources is not a perfect match to any of these criteria and its use was discounted for direct application on the islands. Using sand from the littoral drift zone around and between the islands would certainly be a good match, but it was generally felt that removing the quantity of sand required would be harmful to the future natural accretion of the islands in the future. Discussions with the USGS revealed that previous work by there agency has potentially identified a large source of high quality sand south of the existing islands. This source is a submerged chain of islands named St. Bernard Shoals, created when the sea level was lower in an interglacial period (see Figure 3.1.2.5-5). These islands are believed to have a sand of quality similar to what is found in the present day Mississippi islands and sufficient quantity to meet the needs of this option. Presently, limited geophysical profiling and samples have been completed, but additional work is being conducted by the USGS under a grant to the State of Mississippi by the Minerals Management Agency. This source is located approximately 45 miles south of the barrier islands and lies in about 60 feet of water.

3.1.2.5.3 Structural, Mechanical and Electrical

This option will have no structural, mechanical or electrical components.

3.1.2.5.4 HTRW

Due to the extent of the islands and lack of prior development, no preliminary assessment was performed to identify the possibility of hazardous waste on the sites. These studies will be conducted during the next phase of work after the final siting of the various structures. The construction costs appearing in this report therefore will not reflect any costs for remediation design and/or treatment and/or removal or disposal of these materials in the baseline cost estimate.

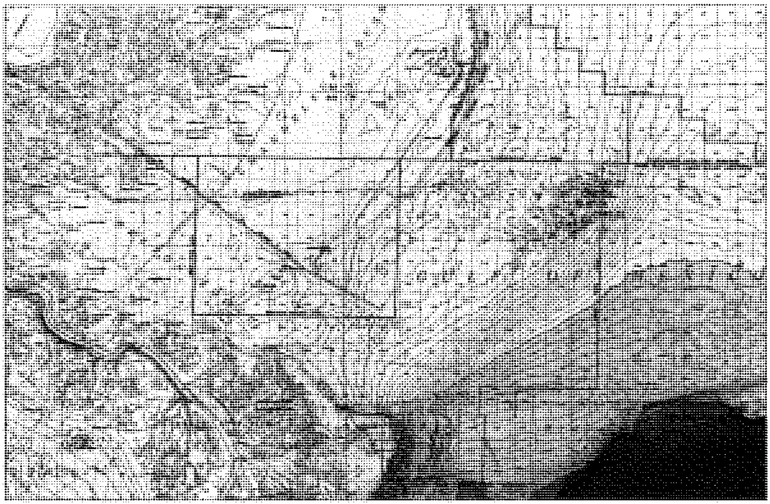


Figure 3.1.2.5-5. St. Bernard Shoals is shown as the area in the center right of the map with the numbered borings that were taken in the past to sample the sand sediments located there. Note the southern end of the Chandeleur Islands northwest of the Shoals.

3.1.2.5.5 Construction Procedures and Water Control Plan

To increase the size of the footprint of each island and restore them back to a pre-Camille footprint will involve several different operations, some of which can take place concurrently. The source of sand that has been designated as the potential borrow area will require additional investigation using both geophysical techniques and physical sampling. The sand is expected to be in submerged shoals that will have to be located and mapped prior to any removal of the sand. This will be completed during design and before the construction begins.

Each of the islands will require that a "dump basin" be excavated by dredging before any sand is transported from the borrow areas which is located about 45 miles south of the islands. These basin are required due to the depth of the water which is too shallow for the dredges to approach the islands. The basins will typically be located about one mile from the beach of the respective island where sand is being added to surrounding waters. These basins will be of sufficient size to allow a large quantity of sand to be stored after being bottom dumped from a hopper dredge. The material dredged from these basins is anticipated to be unsuitable for placement on the islands and is expected to be transported to permitted disposal areas. As each basin is completed, a hopper dredge can begin to remove sand from the borrow area and transport it to the basin where it can be quickly dumped, allowing the dredge to have minimal delays between trips. When the sand in a basin reaches a set capacity, a cutterhead, suction dredge will move the sand from the basin to the area where the sand is needed. Where needed, booster pumps will be utilized. The discharge from the suction dredge will be moved over the areas where the size of the island is being increased. As an area is filled to the desired grade, the sand will be shaped into dunes, basins and beaches. As this earthwork is completed for a given area, planting can begin. The suction dredge will be moved as needed to accommodate the excavation of the basins and the transfer of the sand from the basins to the islands. It is anticipated that the suction dredge will be moved, then remobilized several times during the entire process for completing an islands enlargement.

3.1.2.5.6 Project Security

The Protocol for security measures for this study has been performed in general accordance with the Risk Assessment Methodology for Dams (RAM-D) developed by the Interagency Forum for Infrastructure Protection (IFIP). This methodology has been used for physical security for the critical infrastructure throughout the Corps of Engineers. The determination of the level of physical security provided for each facility is based on the following critical elements: 1) threat assessment of the likelihood that an adversary will attack a critical asset, 2) consequence assessment should an adversary be successful in disrupting, disabling or destroying the asset and 3) effectiveness to prevent a successful attack against an operational component.

The lowest level of physical security (Level 1) was selected for use in this study. Level 1 Security provides no improved security for the selected asset. This security level would be applied to the barrier islands and the sand dunes. These features present a very low threat level of attack and basically no consequence if an attack occurred and is not applicable to this option.

3.1.2.5.7 Operations and Maintenance

The placement of sand to increase the land mass of each of the islands will be a one-time event. Per an agreement with the National Park Service, no additional beach maintenance will be performed in the future. This project will provide a one-time supplement of the sand supply of the islands and the littoral system, after which, natural processes will be allowed to maintain and shape the islands in accordance with 2006 NPS Management Policies. Therefore, there will be no costs associated with operations and maintenance for this option.

3.1.2.5.8 Cost Estimate

The costs for the various options included in this measure are presented in Section 3.1.2.11, Cost Summary. Total project costs for the various options are included in Table 3.1.2.11-1. Estimates are comparative-Level "Parametric Type" and are based on Historical Data, Recent Pricing, and Estimator's Judgment. Quantities listed within the estimates represent Major Elements of the Project Scope and were furnished by the Project Delivery Team. Price Level of Estimate is April 07. Estimates excludes project Escalation and HTRW Cost. The costs include real estate, engineering design (E&D), construction management, and contingencies. The E&D cost for preparation of construction contract plans and specifications includes a detailed contract survey, preparation of contract specifications and plan drawings, estimating bid quantities, preparation of bid estimate, preparation of final submittal and contract advertisement package, project engineering and coordination, supervision technical review, computer costs and reproduction. Contingency developed and assigned at 25% to cover the Cost Growth of the project.

3.1.2.5.9 Schedule for Design and Construction

This option will require extensive coordination with both state and Federal agencies to acquire the necessary permits that allow construction of this option. It is also anticipated that during the design process additional modeling will be required to assist in determining the most appropriate configuration of the additional land mass. Once the design is complete, construction may require several years due to the large quantity of sand that would be required and the distance from the borrow site to the island. Planting of vegetation can be concurrent with sand placement and shaping.

3.1.2.6 Option B – Replenish Sand in Littoral Zone, Inland Source

Another consideration to help restore the islands is to supplement the sand in the littoral system. This could be accomplished by adding sand in specific locations based on sediment transport modeling. This would allow the littoral currents to move the sand onto the islands where the natural process of island building could take place. This would not directly affect the present-day islands and would help mitigate any effects of dredging the ship channels that pass through the chain of islands where sand may have been lost from the system. Potential locations for sand placement are shown in Figure 3.1.2.6-1. NPS support for this option would be dependent on additional research, data collection, analysis and modeling, particularly with respect to sand compatibility and littoral zone placement.

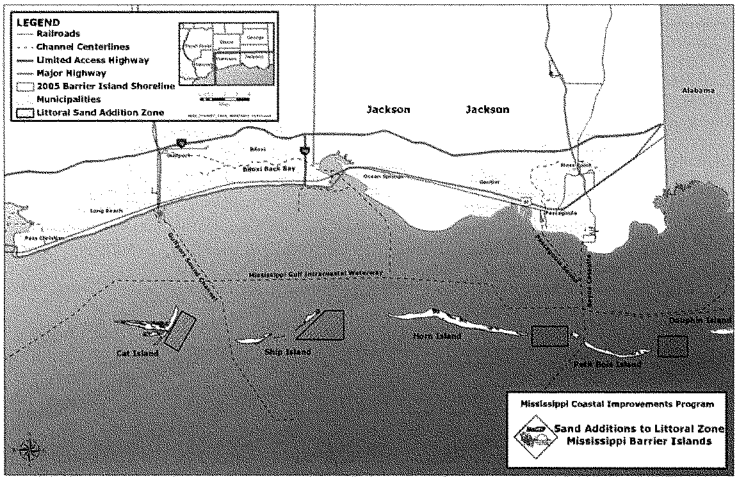


Figure 3.1.2.6-1. Potential areas for sand addition to the littoral drift zone at the Mississippi Barrier Islands. Actual locations would be based on sediment transport modeling.

As discussed in Part 1, the construction of inland waterways in Alabama and Mississippi has resulted in continuing maintenance dredging to maintain the channel depths and alignments. This dredged material is now accumulated in disposal areas along the banks of the river. Dredging of some of the areas along the river has produced large quantities of sand that have potential use for replenishment of littoral zones such as are found along the Mississippi Barrier Islands. An inventory of current disposal sites indicates that approximately 30,000,000 cubic yards of sand is available. Only disposal sites that contain a minimum of 100,000 cubic yards of sand were included in the inventory. Of interest to this study are disposal sites that are located along the Black Warrior – Tombigbee River system and the Tennessee – Tombigbee Waterway. Figure 1.5-6 showed the relationship of these disposal areas to the project sites along the Mississippi coast. Material from these sites could easily be transported by barge down the river system for use among the islands littoral zone. The cost to store this type of dredged material is high and it has recently been estimated that removing the sand from the existing disposal areas would save the Government over

$100,000,000 at today's cost. This cost is based on a recent cost estimate for all costs, real estate, construction and mitigation, required to construct additional disposal areas.

Because of the shortage of additional disposal areas, the Corps of Engineers' Operations Division has contracted for several studies on the beneficial use of the sand. Some of these studies have been targeted at using the sand for beach nourishment, (Thompson Engineering, 2001). Using sand samples from some of the inland disposal areas along the Black Warrior – Tombigbee River, a series of analyses were conducted on the samples. For comparison purposes, several samples of actual beach sand and from the littoral drift zone from coastal Alabama were taken and subjected to the same tests. These tests included grain size distribution (gradation), color and roundness. The results of the tests indicated that some of the samples may be suitable for beach nourishment. The sand from the river was typically a finer grain size than the beach sand with the predominant river size being a fine sand while the beach sand was mostly medium sand. It was also noted that the beach sand was more rounded than the river sand. The roundness of two typical samples of the river sand was described in the analyses shown in Figures 3.1.2.6-2 and 3.1.2.6-3. The majority of the sample is angular to sub-angular in particle shape.

One factor that warranted further analysis was the color difference of the river sand as compared to the beach sand. All of the river sand had a brown tint described as "very pale brown" or "light yellow brown" (see Table 3.1.2.6-1). This compared to the beach sand samples which were described as "pale olive, white or light grey". These colors were assigned along with evaluations for hue, value and chroma from a Munsell Soil Color chart which provides a standard method of assigning color to soils. The report also noted that beach sand came from a higher energy environment where any staining due the depositional environment may have been removed by abrasion due to wave action. It also noted that the sand might undergo bleaching from the ultraviolet radiation from the sun if the color was caused by a mineral staining. To test these conditions that may change the color of the sand, a series of tests were conducted on samples from the same areas that were used during the initial analyses, (Thompson, 2002). The samples were subjected to two tests. The first involved actual bleaching of the samples using a chemical oxidizer, hydrogen peroxide, for different periods of time. These tests did indicate that the bleaching process was detectable after 72 hours. Other tests were conducted to simulate the process of wave action causing an agitation of the particles which may remove any mineral coating or staining along with exposure to ultraviolet light. This process was conducted for 144 hours without a notable difference in color.

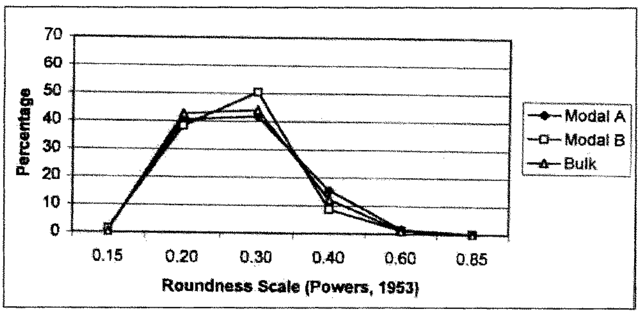


Figure 3.1.2.6-2. Grain Sphericity of composite sand sample taken from Baldbar disposal area on the Black Warrior – Tombigbee River system in Alabama. Values for sphericity (roundness) are .15 - very angular, .20 - angular, .30 - sub-angular, .40 - sub-rounded, .60 – rounded, and .85 – well rounded.

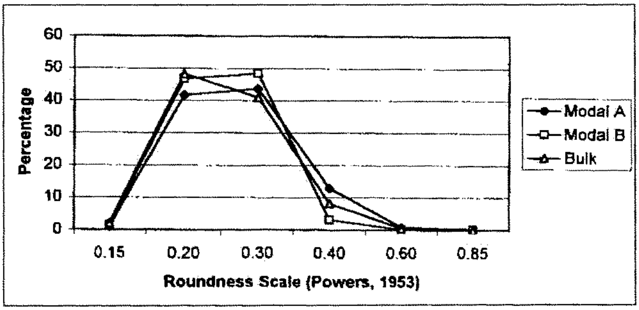


Figure 3.1.2.6-3. Grain Sphericity of composite sand sample taken from Buena disposal area on the Black Warrior – Tombigbee River system in Alabama. Values for sphericity (roundness) are .15 - very angular, .20 - angular, .30 - sub-angular, .40 - sub-rounded, .60 – rounded, and .85 – well rounded.

Table 3.1.2.6-1.
Munsell Soil Color Evaluation of Sand Samples Taken from the Alabama, Black Warrior and Tombigbee River Systems in Alabama

Sample ID	Hue	Value	Chroma	Color
Buena Vista 2 (surface)	10YR	7	3	Very Pale Brown
Buena Vista 2 (1.5" depth)	10YR	7	3	Very Pale Brown
Bald Bar/Big Sand	10YR	6	4	Light Yellow Brown
North Star Wreck	10 YR	7	4	Very Pale Brown

As discussed in Section 2.1, recent testing with a different type of abrasion process has concluded that the color of the sand is a grain surface staining should be removed as the sand abrades during littoral transport, (Baehr, 2007). The resulting sand should then be similar in color to the existing beaches. This process will be verified through additional controlled laboratory research and testing based on multiagency work group recommendations prior to any sand placement.

By spreading the sand over large areas to a small thickness, approximately one foot, the natural sediment transport process would blend the two sands together. The transport process may also tend to remove any staining from the sand grains and could help to round the individual particles through abrasion. Based on having 30,000,000 cubic yards of sand available, each of the islands was assigned a percentage of that quantity. This percentage was based on the amount of land loss (percentage of total loss) for each of the islands from pre-Camille to post-Katrina. The volumes of sand to be placed near each island are as follows:

Cat – 4,200,000 cubic yards

Ship – 9,600,000 cubic yards

Horn – 9,600,000 cubic yards

Petit Bois – 6,600,000 cubic yards

The entire process would consist of loading the sand onto river barges at the various disposal areas, moving the barges downriver and into the Mississippi Sound via tugboat tows, unloading the barges with a "hydraulic unloader", and spreading the sand with a "spreader barge". The process would require a continuous supply of loaded barges as the unloader only needs about an hour to remove the sand from a typical river barge. Staging this process from within the Mississippi Sound would also help with down time due to weather that would be more affected on the south side of the islands.

3.1.2.6.1 Interior Drainage

The type of work anticipated for adding sand into the littoral drift zone will not require any type of drainage system. The addition of sand under this operation will be with dredge pipe discharge into open water.

3.1.2.6.2 Geotechnical Data

The barrier islands are composed of Holocene aged deposits, mostly sand. These deposits formed after erosion of the Pleistocene formations during the last regression and transgression of the sea. This occurred during the Wisconsinan glacial stage during the Late Pleistocene. As the sea regressed, rivers incised channels and transported sediments southward. When the sea level returned to present condition, sediments filled the river channels and started to cover the area that would become the Mississippi Sound. Sandy deposits that had been transported into the Gulf began to move westward from northwest Florida as wind driven littoral currents formed numerous barrier islands across the northern Gulf Coast, including most of those in coastal Mississippi. As the sea level continued to rise, the bays and associated river channels into the gulf also began to fill with these deposits.

The actual Sound formed as an estuary after littoral drift of sandy sediments from the Alabama coast formed a shoal south of the Mississippi mainland. These shoals became barrier islands as currents, waves and wind pushed the sand above the water surface. The sand is typically medium grained, white to light grey in color with a sub-angular to rounded particle shape. Within the interior of the islands, marshes and fresh water lakes have created highly organic soils with a peat-like character. These deposits can be observed as beach outcrops on the southern shore of East Ship Island after the island has migrated northward. The estuary forming process was added by formation of the St. Bernard delta of the Mississippi River that enclosed the western end of the Sound. The western-most island in the chain, Cat Island, is a product of the historic St. Bernard delta lobe. What remains as Cat Island today is a beach front face of the island where waves have sorted the material leaving the sand and deltaic deposits behind the beach.

East and West Ship Island, Horn Island and Petit Bois Island are migrating within a littoral zone over Pleistocene formations that created a relatively stable platform for the constantly moving islands. By increasing the sand within the littoral zone, it would allow it to become subject to the same coastal processes that move the sand already in the system.

The beaches of the Mississippi Barrier Islands are used for nesting by endangered sea turtles where grain size, particle shape and color of the sand are very important. The sand from inland river sources is not a perfect match to these criteria, but if added into the existing system, it would be subject to the same forces that abrade the sand grains to a rounder particle shape. Using sand from the same littoral drift zone where the Mississippi Islands are located would certainly be a good match, but it was generally felt that removing the quantity of sand required would be harmful to natural accretion of the islands in the future.

3.1.2.6.3 Structural, Mechanical and Electrical

This option will have no structural, mechanical or electrical components.

3.1.2.6.4 HTRW

Due to the extent of the islands and lack of prior development, no preliminary assessment was performed to identify the possibility of hazardous waste on the sites. These studies will be conducted during the next phase of work after the final siting of the various structures. The construction costs appearing in this report therefore will not reflect any costs for remediation design and/or treatment and/or removal or disposal of these materials in the baseline cost estimate.

3.1.2.6.5 Construction Procedures

To add off-site sand into the littoral system under this option, material from inland dredged material disposal sites would be transported by barge down the river system for use among the islands littoral zones.

Each of the areas designated for adding sand will require that a staging area where barges could be unloaded and the sand spread over the selected area. The sand would be transported from each of numerous disposal sites located up the river systems. The size of the locks on the river systems and the depth of associated channels will dictate the size of barges that can be used. As the barges are unloaded at each site, the sand would be pumped to spreader barges that would be able to cover an area sufficient to control the depth of sand placement.

3.1.2.6.6 Project Security

The Protocol for security measures for this study has been performed in general accordance with the Risk Assessment Methodology for Dams (RAM-D) developed by the Interagency Forum for Infrastructure Protection (IFIP). This methodology has been used for physical security for the critical infrastructure throughout the Corps of Engineers. The determination of the level of physical security provided for each facility is based on the following critical elements: 1) threat assessment of the likelihood that an adversary will attack a critical asset, 2) consequence assessment should an adversary be successful in disrupting, disabling or destroying the asset and 3) effectiveness to prevent a successful attack against an operational component.

The lowest level of physical security (Level 1) was selected for use in this study. Level 1 Security provides no improved security for the selected asset. This security level would be applied to the barrier islands and the sand dunes. These features present a very low threat level of attack and basically no consequence if an attack occurred and is not applicable to this option.

3.1.2.6.7 Operations and Maintenance

The placement of sand into the littoral zone of each of the islands will be a one-time event. No additional beach maintenance is anticipated in the future, therefore, there will be no costs associated with operations and maintenance for this option.

3.1.2.6.8 Cost Estimate

The costs for the various options included in this measure are presented in Section 3.1.2.12, Cost Summary. Total project costs for the various options are included in Table 3.1.2.12-1. Estimates are comparative-Level "Parametric Type" and are based on Historical Data, Recent Pricing, and Estimator's Judgment. Quantities listed within the estimates represent Major Elements of the Project Scope and were furnished by the Project Delivery Team. Price Level of Estimate is April 07. Estimates excludes project Escalation and HTRW Cost. The costs include real estate, engineering design (E&D), construction management, and contingencies. The E&D cost for preparation of construction contract plans and specifications includes a detailed contract survey, preparation of contract specifications and plan drawings, estimating bid quantities, preparation of bid estimate, preparation of final submittal and contract advertisement package, project engineering and coordination, supervision technical review, computer costs and reproduction. Project Contingency developed and assigned at 25% to cover the Cost Growth of the project.

3.1.2.6.9 Schedule for Design and Construction

This option will require extensive coordination with both state and Federal agencies to acquire the necessary permits that allow implementation of this option. It is also anticipated that during the design process additional sediment transport modeling will be required to assist in determining the most appropriate locations for the addition of sand into the littoral system. Once the design is complete, construction may require several years due to the large quantity of sand that would be required and the distance from the inland borrow sites to the island.

3.1.2.7 Option C – Replenish Sand in Select Littoral Zones, Offshore and Inland River Sources

Another consideration to help restore the islands is to supplement the sand in select littoral system zones with sand obtained from both inland river and offshore borrow areas. Like Option B, this could be accomplished by adding sand in specific locations based on sediment transport modeling. Potential areas where the sand may be added was shown in Figure 3.1.2.6-1, but for this option would be limited to the areas east of Ship Island and Petit Bois Island. These two areas were selected based on cooperation between the National Park Service (NPS, 2007) and the Corps of Engineers and is based on restoration policy of natural resources with the NPS. Both of these islands are affected by the presence of navigation channels that limit westward migration. Placement of sand into these two areas would add sediment into the system and would allow the littoral currents to move the sand onto the islands where the natural process of island building could take place. The sand that could be used in this option may come from the same offshore borrow area as Option A, the St. Bernard Shoals located about 45 miles south of the barrier islands and the lower inland river sand described in Option B. A hydrographic map showing the location of St. Bernard Shoals in relationship to the southern end of the Chandeleur Islands was shown in Figure 3.1.2.5-5. The sand from the inland river sources would be from the lower-most areas shown in Figure 1.5.6. NPS support for this option would be dependent on additional research, data collection, analysis and modeling, particularly with respect to sand compatibility and littoral zone placement.

The volume of sand that could be added into the littoral zone under this option could vary based on additional modeling, but for the volumes of sand to be placed near each island are as follows:

Ship – 5,000,000 cubic yards

Petit Bois – 4,000,000 cubic yards

These volumes were computed based on records from maintenance dredging for the Pascagoula Navigation Channel and represent that total volume less the sand that would be used to fill the breach between East and west Ship Island. The higher volume of sand for the littoral zone placement at the east end of East Ship Island was based on the professional judgement of a Multiagency group (including the NPS) that is working on the barrier island measures. These volumes could change based on additional sediment transport modeling that will assist in the exact placement locations.

3.1.2.7.1 Interior Drainage

The type of work anticipated for adding sand into the littoral drift zone will not require any type of drainage system. The addition of sand under this operation will be with dredge pipe discharge into open water.

3.1.2.7.2 Geotechnical Data

The barrier islands are composed of Holocene aged deposits, mostly sand. These deposits formed after erosion of the Pleistocene formations during the last regression and transgression of the sea. This occurred during the Wisconsinan glacial stage during the Late Pleistocene. As the sea regressed, rivers incised channels and transported sediments southward. Sandy deposits that were transported into the Gulf began to move westward from northwest Florida as wind driven littoral currents formed numerous barrier islands across the northern Gulf Coast, including most of those in coastal Mississippi. As the sea level continued to rise, the bays and associated river channels into the gulf also began to fill with deposits.

The actual Sound formed as an estuary after littoral drift of sandy sediments from the Alabama coast formed a shoal south of the Mississippi mainland. These shoals became barrier islands as currents, waves and wind pushed the sand above the water surface. The sand is typically medium grained, white to light grey in color with well rounded particle shape. Within the interior of the islands, marshes and fresh water lakes have created highly organic soils with a peat-like character. These deposits can be observed as beach outcrops on the southern shore of East Ship Island after the island has migrated northward. The estuary forming process was added by formation of the St. Bernard delta of the Mississippi River that enclosed the western end of the Sound. The western-most island in the chain, Cat Island, is a product of the historic St. Bernard delta lobe migrating across the historic littoral zone. What remains of Cat Island today is a T-shaped island with an east facing beach front face of the island where waves have reshaped the island and sorted the material leaving the east-west elongated sand ridges and deposits behind the beach.

East and West Ship Island, Horn Island and Petit Bois Island are migrating over Pleistocene formations that created a relatively stable platform for the constantly moving islands. Other Holocene deposits provide a relatively thin cover on the bottom of the Mississippi Sound and some areas south of the islands and consist of a muddy mixture of sand and clay along with shell fragments or buried oyster shell beds.

If increasing the sand within the littoral zone, it is desirable to maintain the same quality sand that now makes up the existing islands. Sources of sand in the quantity that would be required for this option are large, especially when considering the quality standard that must be met. Potential sources for this sand have potentially identified both offshore and from inland river sources. These are the same borrow areas that is being considered for Option A and B. Of concern is matching the sand being added to the littoral system to the physical characteristics of the sand on the beaches of the National Seashore. As discussed in Option A for the barrier islands, sand from the St. Bernard Shoals should be of similar quality to that presently on the islands. Discussions with the USGS revealed that this source is a submerged chain of islands created when the sea level was lower in an interglacial period. These islands are believed to have a sand of quality similar to what is found in the present day Mississippi islands and sufficient quantity to meet the needs of this option. This source is located approximately 45 miles south of the barrier islands and lies in about 60 feet of water. The sand from Option B may also be suitable for this option following further testing for compatibility.

3.1.2.7.3 Structural, Mechanical and Electrical

This option will have no structural, mechanical or electrical components.

3.1.2.7.4 HTRW

Due to the extent of the islands and lack of prior development, no preliminary assessment was performed to identify the possibility of hazardous waste on the sites. These studies will be conducted during the next phase of work after the final siting of the various structures. The construction costs appearing in this report therefore will not reflect any costs for remediation design and/or treatment and/or removal or disposal of these materials in the baseline cost estimate.

3.1.2.7.5 Construction Procedures and Water Control Plan

To increase sand within the littoral zone from inshore and off-shore sources will involve several different operations, some of which can take place concurrently. The source of sand that has been designated as the potential borrow area will require additional investigation using both geophysical techniques and physical sampling. The offshore sand is expected to be dredged from submerged shoals that will have to be located and mapped prior to any removal of the sand. This will be completed during design and before the construction begins. The inland river sand will be loaded and brought down the river on barges for transportation to the area where it will be spread.

3.1.2.7.6 Project Security

The Protocol for security measures for this study has been performed in general accordance with the Risk Assessment Methodology for Dams (RAM-D) developed by the Interagency Forum for Infrastructure Protection (IFIP). This methodology has been used for physical security for the critical infrastructure throughout the Corps of Engineers. The determination of the level of physical security provided for each facility is based on the following critical elements: 1) threat assessment of the likelihood that an adversary will attack a critical asset, 2) consequence assessment should an adversary be successful in disrupting, disabling or destroying the asset and 3) effectiveness to prevent a successful attack against an operational component.

The lowest level of physical security (Level 1) was selected for use in this study. Level 1 Security provides no improved security for the selected asset. This security level would be applied to the barrier islands and the sand dunes. These features present a very low threat level of attack and basically no consequence if an attack occurred and is not applicable to this option.

3.1.2.7.7 Operations and Maintenance

The placement of sand into the littoral zone of each of the islands will be a one-time event. No additional direct beach maintenance is anticipated in the future, therefore, there will be no costs associated with operations and maintenance for this option.

3.1.2.7.8 Cost Estimate

The costs for the various options included in this measure are presented in Section 3.1.2.12, Cost Summary. Total project costs for the various options are included in Table 3.1.2.12-1. Estimates are comparative-Level "Parametric Type" and are based on Historical Data, Recent Pricing, and Estimator's Judgment. Quantities listed within the estimates represent Major Elements of the Project Scope and were furnished by the Project Delivery Team. Price Level of Estimate is April 07. Estimates excludes project Escalation and HTRW Cost. The costs include real estate, engineering design (E&D), construction management, and contingencies. The E&D cost for preparation of construction contract plans and specifications includes a detailed contract survey, preparation of contract specifications and plan drawings, estimating bid quantities, preparation of bid estimate, preparation of final submittal and contract advertisement package, project engineering and coordination, supervision technical review, computer costs and reproduction. Contingency developed and assigned at 25% to cover the Cost Growth of the project.

3.1.2.7.9 Schedule for Design and Construction

This option will require extensive coordination with both state and Federal agencies to acquire the necessary permits that allow implementation of this option. It is also anticipated that during the design process additional sediment transport modeling will be required to assist in determining the most appropriate locations for the addition of sand into the littoral system. Once the design is complete, construction may require several years due to the large quantity of sand that would be required and the distance from the inland borrow sites to the island.

3.1.2.8 Option D – Environmental Restoration w/ 2-foot Dune

This option would involve environmental restoration of the islands consisting of shaping existing sand into dunes on the beaches with planted vegetation and planting of maritime forests on the existing islands where they were mostly destroyed by Hurricane Katrina. Despite continual changes that occur, the barrier islands remain to buffer the mainland from storms and provide habitat for the rich, diverse wildlife residing within the area. On the southern portion of the islands, sea oats primarily, which are tolerant of high salt levels, thrive on the dune system which is located behind the beach area. Behind the primary dunes, trees and shrubs, such as short-leaf and long-leaf pines, can be found in the maritime forest. In the island interiors, emergent marshes collect fresh rainwater to help support its inhabitants. NPS support for this option is unlikely due to conflicts with that agency's 2006 Management Policies and statutory responsibilities.

Gulf Coast barrier islands and barrier spits can support stunted oak and yaupon shrublands. These scrub-scrub habitats are most often located on rises surrounded by black needlerush (*Juncus roemarianus*) salt marshes and have been reported from the Gulf Islands National Seashore (Natureserve Explorer 2002). Stunted slash pine may be present in the overstory, but most cover will be in a shrub layer dominated by yaupon, live oak, sand live oak, wax myrtle, saw palmetto, and salt bush (*Baccharis halimifolia*).

Immediately following Hurricane Katrina, most of the effort was spent protecting human life and securing structures throughout the impacted areas; therefore, few assessments of the vegetation impacts exist. For the barrier island system, most all of the vegetation recovered several months following Hurricane Katrina. The predominant vegetation that has long-term impacts consists of those pines found in the maritime forests. It is estimated that about 75% of these pine species were killed following the hurricane season of 2005, with most that attributable to Hurricane Katrina. The sea oats are still found in small patches due to the reduced dune system. Figure 3.1.2.8-1 is a photo of the south beach of Horn Island showing the lack of dunes and the damaged pine forest. An exception to the loss of vegetation is the emergent marsh habitat. It is thriving so well it actually looks as though hurricanes never past through the barrier island system.

One restoration option for the barrier islands would be to re-establish the vegetation that was destroyed by Hurricane Katrina. This option could involve restoration of the existing islands through adding sand dunes on the beaches along with planted vegetation (i.e. *Uniola paniculata*), planting of marshes (i.e. *Spartina alterniflora*, *Juncus roemerianus*, and Spartina patens) and maritime forests (i.e. *Pinus elliottii Engelm*, *Serenoa repens*, *Sabal minor*, etc.), and planting seagrasses (i.e. *Diplanthera wrightii*, *Cymodocea manatorum*, *Thalassia testudinum*, and *Ruppia maritime*) in the near-shore areas of the islands. Foremost, the vegetation would restore the island's natural setting, which allows for the diverse array of flora and fauna to persist. This plan would not involve adding any land mass to the islands other than the possibility of adding to the dune system. Vegetation would aid in reducing erosion from wind; thus helping in maintaining the stability of the islands. The vegetation would also aid in preventing erosion in the event that the islands gets overtopped by storm surge in a large hurricane.

Figure 3.1.2.8-1. Photo across the beach from the water on the south side of Horn Island. The wide, flat beach is now typical of the Mississippi Barrier Islands. The pine trees in the background are mostly dead, destroyed by the affects of Hurricane Katrina.

An environmental impact of the islands continuing to diminish in size is the increase in Mississippi Sound's salinity. Under current conditions, the islands provide a boundary between the sea water salinity [~33 parts per thousand (ppt)] of the open Gulf of Mexico and the brackish water found in the Sound. Salinity in the Sound during low flow periods range from 10 to 30 ppt. Highest salinities occur just south of Pascagoula and Gulfport and the lowest salinities in the Lake Borgne-Pearl River area. Loss of the islands would allow the salinity to greatly increase changing the ecological habitats that exist now. Mississippi Sound is one of the most productive systems on the Gulf coast. Changes in its salinity would impact not only fisheries but also the estuarine marshes, and the saltwedge in the area's rivers. This would impact shellfish and many other forms of marine life. Oysters currently found in concentrated Mississippi Sound areas would possibly cease to exist. At the Chandeleur Islands, loss in the island mass allows us to anticipate those potential environmental changes. Initial assessments are showing seagrasses diminishing, marsh erosion ongoing, and wave energy having no natural barrier.

The dune would be shaped from sand that would be removed from the surface between the constructed dune and the edge of the vegetation north of the dune. The dune would have a height of 2-feet, 1v to 3h slopes and a crest width of 6 feet. The dune would be continuous for the length of the gulf-side, south beach. While not designed as a structural defense against storms, the dune would be used as a platform to establish a line of sea oats that in turn would help in the natural process of creating larger and more pronounced sand dunes. The dunes would build with time as wind driven deposits of sand become trapped by the vegetation.

As previously discussed, the marsh grasses were not adversely affected by Hurricane Katrina. Island vegetation that was affected and would benefit the ecological community by a re-planting program is pine trees in the interior of the islands and sea oats on the beaches. The pines could be planted without any preparation, but the sea oats would benefit from a constructed dune to help become established. The quantities of vegetation for each island with a 2-foot constructed dune on the southern beach are shown in Table 3.1.2.8-1.

Table 3.1.2.8-1.
Quantities of Plantings for each Barrier Island

Island	2006 Acres	Pre-Katrina Acres Maritime Pine Forest	Replanting 75 Percent of Pine Forest Acres	Sea Oats - Planted 2-foot Dune Acres
Cat	1957	1% of Island	15 acres	6.3 acres
Ship (East & West)	631	3.7% of Island	18 acres	8.4 acres
Horn	3077	23% of Island	531 acres	23.4 acres
Petit Bois	1098	23%of Island	190 acres	13.2 acres

3.1.2.8.1 Interior Drainage

Interior drainage features are not applicable to the option.

3.1.2.8.2 Geotechnical Data

The barrier islands are composed of Holocene aged deposits, mostly sand. These deposits formed after erosion of the Pleistocene formations during the last regression and transgression of the sea. This occurred during the Wisconsinan glacial stage during the Late Pleistocene. As the sea regressed, rivers incised channels and transported sediments southward. When the sea level returned to present condition, sediments filled the river channels and started to cover the area that would become the Mississippi Sound. Sandy deposits that had been transported into the Gulf began to move westward from northwest Florida as wind driven littoral currents formed numerous barrier islands across the northern Gulf Coast, including most of those in coastal Mississippi. As the sea level continued to rise, the bays and associated river channels into the gulf also began to fill with these deposits.

The Mississippi Sound north of the islands formed as an estuary after littoral drift of the sandy sediments from the Alabama coast formed a shoal south of the Mississippi mainland. These shoals became barrier islands as currents, waves and wind pushed the sand above the water surface. The sand that composes the islands is typically medium grained, white to light grey in color with well rounded particle shape. Within the interior of the islands, marshes and fresh water lakes have created highly organic soils with a peat-like character. These deposits, as shown in Figure 3.1.2.5-2, can be observed as beach outcrops on the southern shore of East Ship Island after the island has migrated northward. This process was added by formation of the St. Bernard delta of the Mississippi River that enclosed the western end of the Sound. The western-most island in the chain, Cat Island, is a product of the historic St. Bernard delta lobe. What remains today is a beach front face of the island where waves have sorted the material leaving the sand and deltaic deposits behind the beach. The islands, such as they exist today, are migrating along the littoral drift and are mostly composed of sand with local layers of peat-like organic soil that are forming in the inter-island lakes and marshes.

3.1.2.8.3 Structural, Mechanical and Electrical

Structural, Mechanical and Electrical is not applicable to this option.

3.1.2.8.4 HTRW

Due to the extent of the islands and lack of prior development, no preliminary assessment was performed to identify the possibility of hazardous waste on the sites. These studies will be conducted during the next phase of work after the final selection of any sites associated with this option. The construction costs appearing in this report therefore will not reflect any costs for remediation design and/or treatment and/or removal or disposal of these materials in the baseline cost estimate.

3.1.2.8.5 Construction Procedures

This option will involve the planting of various types of vegetation in selected areas on the islands. Actual construction activities will take place only during the shaping of the small dunes on the beaches from existing the sand berm. Although the dune is of limited size, the total length of the dune construction will be approximately 30 miles for all the islands.

3.1.2.8.6 Project Security

The Protocol for security measures for this study has been performed in general accordance with the Risk Assessment Methodology for Dams (RAM-D) developed by the Interagency Forum for Infrastructure Protection (IFIP). This methodology has been used for physical security for the critical infrastructure throughout the Corps of Engineers. The determination of the level of physical security provided for each facility is based on the following critical elements: 1) threat assessment of the likelihood that an adversary will attack a critical asset, 2) consequence assessment should an adversary be successful in disrupting, disabling or destroying the asset and 3) effectiveness to prevent a successful attack against an operational component.

The lowest level of physical security (Level 1) was selected for use in this study. Level 1 Security provides no improved security for the selected asset. This security level would be applied to the barrier islands and the sand dunes. These features present a very low threat level of attack and basically no consequence if an attack occurred and is not applicable to this option.

3.1.2.8.7 Operations and Maintenance

The initial planting of the various types of vegetation will have a warranty that will insure an approved survival rate. There will be no additional maintenance of the established plants under this option.

3.1.2.8.8 Cost Estimate

The costs for the various options included in this measure are presented in Section 3.1.2.12, Cost Summary. Total project costs for the various options are included in Table 3.1.2.12-1. Estimates are comparative-Level "Parametric Type" and are based on Historical Data, Recent Pricing, and Estimator's Judgment. Quantities listed within the estimates represent Major Elements of the Project Scope and were furnished by the Project Delivery Team. Price Level of Estimate is April 07. Estimates excludes project Escalation and HTRW Cost. The costs include real estate, engineering design (E&D), construction management, and contingencies. The E&D cost for preparation of construction contract plans and specifications includes a detailed contract survey, preparation of contract specifications and plan drawings, estimating bid quantities, preparation of bid estimate, preparation of final submittal and contract advertisement package, project engineering and coordination, supervision technical review, computer costs and reproduction. Contingency developed and assigned at 25% to cover the Cost Growth of the project.

3.1.2.8.9 Schedule for Design and Construction

This option will require extensive coordination with both state and Federal agencies to acquire the necessary permits that allow implementation of this option. The actual design will be straight-forward with designated areas for the different types of planting vegetation and general guidance for the dune construction. The actual construction will require coordination with suppliers to furnish the large number of plants that are required for this option.

3.1.2.9 Option E – Environmental Restoration w/ 6-foot Dune

This option would involve environmental restoration of the islands consisting of shaping existing sand into dunes on the beaches with planted vegetation and planting of maritime forests on the existing islands where they were mostly destroyed by Hurricane Katrina. The sand required to construct a dune of this size would be more than could be removed from the existing beach berm and would come from the same offshore borrow area as the sand used in Option A. Placement of the sand would require moving the sand from a hopper dredge to a staging area on the beach, then moving the sand to the area of placement along the beach.

Despite continual changes that occur, the barrier islands remain to buffer the mainland from storms and provide habitat for the rich, diverse wildlife residing within the area. On the southern portion of the islands, sea oats primarily, which are tolerant of high salt levels, thrive on the dune system which is located behind the beach area. Behind the primary dunes, trees and shrubs, such as short-leaf and long-leaf pines, can be found in the maritime forest. In the island interiors, emergent marshes collect fresh rainwater to help support its inhabitants. NPS support for This option is unlikely due to conflicts with agency natural resources management policies.

Gulf Coast barrier islands and barrier spits can support stunted oak and yaupon shrublands. These scrub-scrub habitats are most often located on rises surrounded by black needlerush (*Juncus roemarianus*) salt marshes and have been reported from the Gulf Islands National Seashore (Natureserve Explorer 2002). Stunted slash pine may be present in the overstory, but most cover will be in a shrub layer dominated by yaupon, live oak, sand live oak, wax myrtle, saw palmetto, and salt bush (*Baccharis halimifolia*).

Immediately following Hurricane Katrina, most of the effort was spent protecting human life and securing structures throughout the impacted areas; therefore, few assessments of the vegetation impacts exist. For the barrier island system, most all of the vegetation recovered several months following Hurricane Katrina. The predominant vegetation that has long-term impacts consists of those pines found in the maritime forests. It is estimated that about 75% of these pine species were killed following the hurricane season of 2005, with most that attributable to Hurricane Katrina. The sea oats are still found in small patches due to the reduced dune system. An exception to the loss of vegetation is the emergent marsh habitat. It is thriving so well it actually looks as though hurricanes never past through the barrier island system.

One restoration option for the barrier islands with be to re-establish the vegetation that was destroyed by Hurricane Katrina. This option could involve restoration of the existing islands through adding sand dunes on the beaches along with planted vegetation (i.e. *Uniola paniculata*), planting of marshes (i.e. *Spartina alterniflora, Juncus roemerianus*, and *Spartina patens*) and maritime forests (i.e. *Pinus elliottii Engelm, Serenoa repens, Sabal minor*, etc.), and planting seagrasses (i.e. *Diplanthera wrightii, Cymodocea manatorum, Thalassia testudinum*, and *Ruppia maritime*) in the near-shore areas of the islands. Foremost, the vegetation would restore the island's natural setting, which allows for the diverse array of flora and fauna to persist. This plan would not involve adding any land mass to the islands other than the possibility of adding to the dune system. Vegetation would aid in reducing erosion from wind; thus helping in maintaining the stability of the islands. The vegetation would also aid in preventing erosion in the event that the islands gets overtopped by storm surge in a large hurricane.

An environmental impact of the islands continuing to diminish in size is the increase in Mississippi Sound's salinity. Under current conditions, the islands provide a boundary between the sea water salinity [~33 parts per thousand (ppt)] of the open Gulf of Mexico and the brackish water found in the Sound. Salinity in the Sound during low flow periods range from 10 to 30 ppt. Highest salinities occur just south of Pascagoula and Gulfport and the lowest salinities in the Lake Borgne-Pearl River area.

Loss of the islands would allow the salinity to greatly increase changing the ecological habitats that exist now. Mississippi Sound is one of the most productive systems on the Gulf coast. Changes in its salinity would impact not only fisheries but also the estuarine marshes, and the saltwedge in the area's rivers. This would impact shellfish and many other forms of marine life. Oysters currently found in concentrated Mississippi Sound areas would possibly cease to exist. At the Chandeleur Islands, loss in the island mass allows us to anticipate those potential environmental changes. Initial assessments are showing seagrasses diminishing, marsh erosion ongoing, and wave energy having no natural barrier.

The dune would be shaped from sand that would be removed from the surface between the constructed dune and the edge of the vegetation north of the dune. The dune would have a height of 6-feet, 1v to 3h slopes and a crest width of 6 feet. The dune would be continuous for the length of the gulf-side, south beach. While not designed as a structural defense against storms, the dune would be used as a platform to establish a line of sea oats that in turn would help in the natural process of creating larger and more pronounced sand dunes. The dunes would build with time as wind driven deposits of sand become trapped by the vegetation.

As previously discussed, the marsh grasses were not adversely affected by Hurricane Katrina. Island vegetation that was affected and would benefit the ecological community by a re-planting program is pine trees in the interior of the islands and sea oats on the beaches. The pines could be planted without any preparation, but the sea oats would benefit from a constructed dune to help become established. The quantities of vegetation for each island with a 6-foot high constructed dune on the southern beach are shown in Table 3.1.2.9-1.

Table 3.1.2.9-1.
Quantities of Plantings for each Barrier Island

Island	2006 Acres	Pre-Katrina Acres Maritime Pine Forest	Replanting 75 Percent of Pine Forest Acres	Sea Oats - Planted 6-foot Dune Acres
Cat	1957	1% of Island	15 acres	14.9 acres
Ship (East & West)	631	3.7% of Island	18 acres	19.9 acres
Horn	3077	23% of Island	531 acres	55.3 acres
Petit Bois	1098	23%of Island	190 acres	31.2 acres

3.1.2.9.1 Interior Drainage

Interior drainage features are not applicable to the option.

3.1.2.9.2 Geotechnical Data

The barrier islands are composed of Holocene aged deposits, mostly sand. These deposits formed after erosion of the Pleistocene formations during the last regression and transgression of the sea. This occurred during the Wisconsinan glacial stage during the Late Pleistocene. As the sea regressed, rivers incised channels and transported sediments southward. When the sea level returned to present condition, sediments filled the river channels and started to cover the area that would become the Mississippi Sound. Sandy deposits that had been transported into the Gulf began to move westward from northwest Florida as wind driven littoral currents formed numerous barrier islands across the northern Gulf Coast, including most of those in coastal Mississippi. As the sea level continued to rise, the bays and associated river channels into the gulf also began to fill with these deposits.

The Mississippi Sound north of the islands formed as an estuary after littoral drift of the sandy sediments from the Alabama coast formed a shoal south of the Mississippi mainland. These shoals became barrier islands as currents, waves and wind pushed the sand above the water surface. The sand that composes the islands is typically medium grained, white to light grey in color with well rounded particle shape. Within the interior of the islands, marshes and fresh water lakes have created highly organic soils with a peat-like character. These deposits can be observed as beach outcrops on the southern shore of East Ship Island after the island has migrated northward. This process was added by formation of the St. Bernard delta of the Mississippi River that enclosed the western end of the Sound. The western-most island in the chain, Cat Island, is a product of the historic St. Bernard delta lobe. What remains today is a beach front face of the island where waves have sorted the material leaving the sand and deltaic deposits behind the beach. The islands, such as they exist today, are migrating along the littoral drift and are mostly composed of sand with local layers of peat-like organic soil that are forming in the inter-island lakes and marshes.

3.1.2.9.3 Structural, Mechanical and Electrical

Structural, Mechanical and Electrical is not applicable to this option.

3.1.2.9.4 HTRW

Due to the extent of the islands and lack of prior development, no preliminary assessment was performed to identify the possibility of hazardous waste on the sites. These studies will be conducted during the next phase of work after the final selection of sites associated with this option. The construction costs appearing in this report therefore will not reflect any costs for remediation design and/or treatment and/or removal or disposal of these materials in the baseline cost estimate.

3.1.2.9.5 Construction Procedures

This option will involve placement of dredged material onto the existing beaches and shaping the sand into low dunes as described. Other activities will involve the planting of various types of vegetation in selected areas on the islands.

3.1.2.9.6 Project Security

The Protocol for security measures for this study has been performed in general accordance with the Risk Assessment Methodology for Dams (RAM-D) developed by the Interagency Forum for Infrastructure Protection (IFIP). This methodology has been used for physical security for the critical infrastructure throughout the Corps of Engineers. The determination of the level of physical security provided for each facility is based on the following critical elements: 1) threat assessment of the likelihood that an adversary will attack a critical asset, 2) consequence assessment should an adversary be successful in disrupting, disabling or destroying the asset and 3) effectiveness to prevent a successful attack against an operational component.

The lowest level of physical security (Level 1) was selected for use in this study. Level 1 Security provides no improved security for the selected asset. This security level would be applied to the barrier islands and the sand dunes. These features present a very low threat level of attack and basically no consequence if an attack occurred and is not applicable to this option.

3.1.2.9.7 Operations and Maintenance

The initial planting of the various types of vegetation will have a warranty that will insure an approved survival rate. There will be no additional maintenance of the established plants under this option.

3.1.2.9.8 Cost Estimate

The costs for the various options included in this measure are presented in Section 3.1.2.12, Cost Summary. Total project costs for the various options are included in Table 3.1.2.12-1. Estimates are comparative-Level "Parametric Type" and are based on Historical Data, Recent Pricing, and Estimator's Judgment. Quantities listed within the estimates represent Major Elements of the Project Scope and were furnished by the Project Delivery Team. Price Level of Estimate is April 07. Estimates excludes project Escalation and HTRW Cost. The costs include real estate, engineering design (E&D), construction management, and contingencies. The E&D cost for preparation of construction contract plans and specifications includes a detailed contract survey, preparation of contract specifications and plan drawings, estimating bid quantities, preparation of bid estimate, preparation of final submittal and contract advertisement package, project engineering and coordination, supervision technical review, computer costs and reproduction. Contingency developed and assigned at 25% to cover the Cost Growth of the project.

3.1.2.9.9 Schedule for Design and Construction

This option will require extensive coordination with both state and Federal agencies to acquire the necessary permits that allow implementation of this option. The actual design will be straight-forward with designated areas for the different types of planting vegetation and general guidance for the dune construction. The actual construction will require coordination with suppliers to furnish the large number of plants that are required for this option. The quantity of sand required for this project, while not extremely large will require an off-shore source and could take considerable time to dredge, transport and place.

3.1.2.10 Option F – Environmental Restoration of Sea Grass Beds

This option would involve environmental restoration of the sea grass beds that have historically existed on the north side of the islands in the Mississippi Sound as shown in Figure 3.1.2.10-1. Despite continual changes that occur, the barrier islands remain to buffer the mainland from storms and provide habitat for the rich, diverse wildlife residing within the area. Knowledge of submerged aquatic vegetation (SAVs) is limited to reports by Humm (1956) and Humm and Caylor (1957) before the Gulf of Mexico Estuarine Inventory (GMEI) Study (1973). They reported the occurrence of five flowering species known as "seagrasses" and 77 algal species all along the Mississippi barrier islands. Studies carried out by the GMEI personnel revealed that there were about 17,000 acres of SAVs in Mississippi Sound.

High turbidity and lack of suitable substrate have limited distribution of SAVs in Mississippi. SAVs have been restricted to relatively quiet waters along the mainland and barrier island shores. Isolated patches occur only several hundred acres in size along mostly the northern portions of the barrier islands. In turbid waters of the Sound, seagrass beds are typically found in shallow water less than six feet in depth, most in two or less. With the exception of shoal grass (*Halodule wrightii*), which grows on hard sandy bottoms, the species characteristic of Mississippi Sound area prefer soft muddy substrates. A study of the Mississippi portion of Mississippi Sound by Eleuterius in 1969 indicated that about 17,000 acres of SAVs were present including turtle grass (*Thalassia testudinum*), manatee grass (*Cymodocea manatorum*), shoal grass, *Halophilia engelmanni* (no common name), and widgeon grass (*Ruppia maritima*). In 1969, Hurricane Camille destroyed the majority of SAVs along the Mississippi Gulf coast (Eleuterius 1973). Moncreiff (1998) identified the northern shorelines of Ship, Horn, and Petit Bois Islands as potential habitat for seagrass beds. These areas have historically supported populations of shoal grass, *Halophila engelmannii*, manatee grass, and turtle grass. Currently, these locations only appear to support beds of shoal grass. In areas where SAVs are present, significant quantities of benthic and epibenthic macroalgae are found, such as red, brown, and green species.

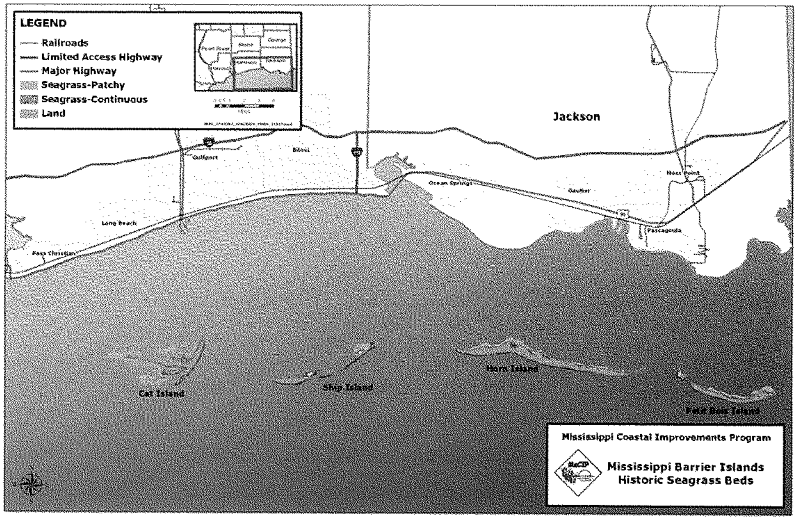


Figure 3.1.2.10-1. Location of Historical Sea Grass Beds near the Mississippi Barrier Islands

The Mississippi Department of Marine Resources (DMR) has provided the estimated pre-Camille acreage of the grass beds and the current amount of beds that exist today. The types of grass that would be planted include Diplanthera wrightii (i.e Shoal Grass), Cymodocea manatorum (i.e. Manatee Grass), Thalassia testudinum (i.e. Turtle Grass) and Ruppia maritima (i.e. widgeon grass). The planting would occur at selected locations in coordination with DMR and would cover 50 percent of the historical acreage. Due to the large number of plants required for this option, the supply of available stock would have to be matched to the planting schedule. The amount of acres of sea grasses to be planted at each island, based on 50 percent of pre-Camille acreage, is as follows:

Cat – 210 acres

Ship – 760 acres

Horn – 2,650 acres

Petit Bois – 780 acres

3.1.2.10.1 Interior Drainage

Interior drainage is not applicable to this option.

3.1.2.10.2 Geotechnical Data

The actual Sound formed as an estuary after littoral drift of sandy sediments from the Alabama coast formed a shoal south of the Mississippi mainland. These shoals became barrier islands as currents, waves and wind pushed the sand above the water surface. East and West Ship Island, Horn Island and Petit Bois Island are migrating over Pleistocene formations that created a relatively stable platform for the constantly moving islands. Other Holocene deposits provide a relatively thin cover on the bottom of the Mississippi Sound and some areas south of the Islands and consist of a muddy mixture of sand and clay along with shell fragments or buried oyster shell beds.

3.1.2.10.3 Structural, Mechanical and Electrical

Structural, Mechanical and Electrical is not applicable to this option.

3.1.2.10.4 HTRW

Due to the extent of the islands and lack of prior development, no preliminary assessment was performed to identify the possibility of hazardous waste at the sites. These studies, if deemed necessary, will be conducted during the next phase of work after the final selection of sites. The construction costs appearing in this report therefore will not reflect any costs for remediation design and/or treatment and/or removal or disposal of these materials in the baseline cost estimate.

3.1.2.10.5 Construction Procedures

This option will only involve the planting of various types of marine aquatic vegetation in selected areas around the islands. No actual construction activities will take place. The extremely large quantity of plants required for this type of project would require that the project would have to have an extended project life to allow the procurement of the vegetation that would not be readily available in today's market.

3.1.2.10.6 Project Security

The Protocol for security measures for this study has been performed in general accordance with the Risk Assessment Methodology for Dams (RAM-D) developed by the Interagency Forum for Infrastructure Protection (IFIP). This methodology has been used for physical security for the critical infrastructure throughout the Corps of Engineers. The determination of the level of physical security provided for each facility is based on the following critical elements: 1) threat assessment of the likelihood that an adversary will attack a critical asset, 2) consequence assessment should an adversary be successful in disrupting, disabling or destroying the asset and 3) effectiveness to prevent a successful attack against an operational component.

The lowest level of physical security (Level 1) was selected for use in this study. Level 1 Security provides no improved security for the selected asset. This security level would be applied to the barrier islands and the sand dunes. These features present a very low threat level of attack and basically no consequence if an attack occurred and is not applicable to this option.

3.1.2.10.7 Operations and Maintenance

The initial planting of the various types of sea grass will have a warranty that will insure an approved survival rate. There will be no additional maintenance of the established plants under this option.

3.1.2.10.8 Cost Estimate

The costs for the various options included in this measure are presented in Section 3.1.2.12, Cost Summary. Total project costs for the various options are included in Table 3.1.2.12-1. Estimates are comparative-Level "Parametric Type" and are based on Historical Data, Recent Pricing, and Estimator's Judgment. Quantities listed within the estimates represent Major Elements of the Project Scope and were furnished by the Project Delivery Team. Price Level of Estimate is April 07. Estimates excludes project Escalation and HTRW Cost. The costs include real estate, engineering design (E&D), construction management, and contingencies. The E&D cost for preparation of construction contract plans and specifications includes a detailed contract survey, preparation of contract specifications and plan drawings, estimating bid quantities, preparation of bid estimate, preparation of final submittal and contract advertisement package, project engineering and coordination, supervision technical review, computer costs and reproduction. Contingency developed and assigned at 25% to cover the Cost Growth of the project.

3.1.2.11 Option G – Restore Ship Island Breach

The most predominate affect of Hurricane Katrina on the Mississippi Barrier Islands was the large increase in size of the breach in Ship Island commonly known as the Camille Cut, (see Figure 3.1.2.11-1). This photo was taken after Hurricane Katrina, but, would be similar to conditions after Hurricane Camille.

The pre-Camille footprint of Ship Island was obtained from historical records and this data shows the area that was breached during Hurricane Camille now forming two separate islands, West and East Ship Island. Two major historic sites, one on each island, are in danger from the continuing erosion of the barrier islands. Current studies by the Corps indicate that restoring the two islands to a single island, pre-Camille condition may prevent the rapid erosion of the beaches that is now occurring as well as potentially helping to provide wave erosion on the mainland. Estimates indicated that the total restoration of Ship Island to a pre-Camille footprint, single land mass off the Mississippi coast will involve approximately 21 million cubic yards of sand. Other variances of filling only the breach and some areas along the northern shores with lesser quantities of sand may also provide opportunity for a natural healing of the island. This limited sand placement, approximately 13,000,000 cubic yards, has the support of the NPS (NPS, 2007) and will be the basis of this option. This volume is based on computing the the sand needed to fill the breach to a 1,000-foot width and to a elevation of 2.0. The total volume of sediment removed during all historical maintenance dredging for the Pascagoula Navigation Channel was compiled and the balance of that total will be used for littoral zone placements under Option C as previously described. As happened during Hurricane Camille, the breach was opened during Hurricane Katrina leaving two islands with approximately three miles of open water between the remaining portions. This portion of the island has also been breached during other prior hurricanes and while most of the island has reformed to a low bar over time, it never gained enough sand to form dunes and establish vegetation along this center portion. Consequently, even small storms easily washed over and eroded this part of the island and reopened the breach. Natural healing from the littoral drift is hindered by the large amount of sand that must rebuild the bar across the breach from the east. This is further aggravated by the fact that Ship Island is the last island in a littoral system that extends westward from its main source of sand on the panhandle of Florida, a distance of about 250 miles. Numerous opportunities exist along this pathway for the amount of sand in the system to be diminished. An additional consideration is the ebb tidal flushing in the deeper portion of the pass just east of West Ship Island when sand is moved southward thus starving the northern shore of West Ship Island. To mitigate this problem, the breach could be filled as single operation with planted dune vegetation that will become established and promote stable dune growth. With an understanding that all barrier islands are dynamic in nature and change constantly, the object of restoration would be to establish the island with sufficient sand mass and enough vegetation to again have the island as a somewhat stable member in the island chain. Fort Massachusetts located on the northern shore of West Ship Island and the French Warehouse located on the northern shore of East Ship Island would benefit from this option. Both of these sites are endangered by on-going erosion of the shoreline with Mississippi Sound. Another site, known as the Quarantine Station, has already been lost to erosion as shown in comparing Figure 3.1.2.11-1 and Figure 3.1.2.11-2.

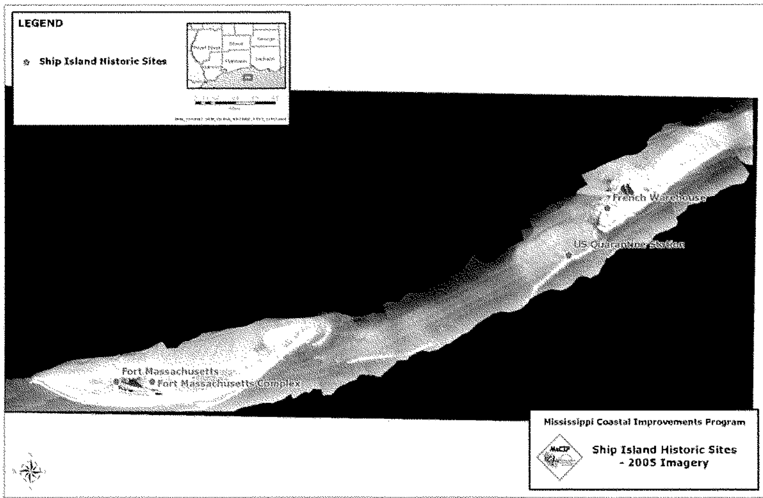


Figure 3.1.2.11-1. Aerial photo of West and East Ship Island taken in 2005 after Hurricane Katrina showing the locations of listed historical sites.

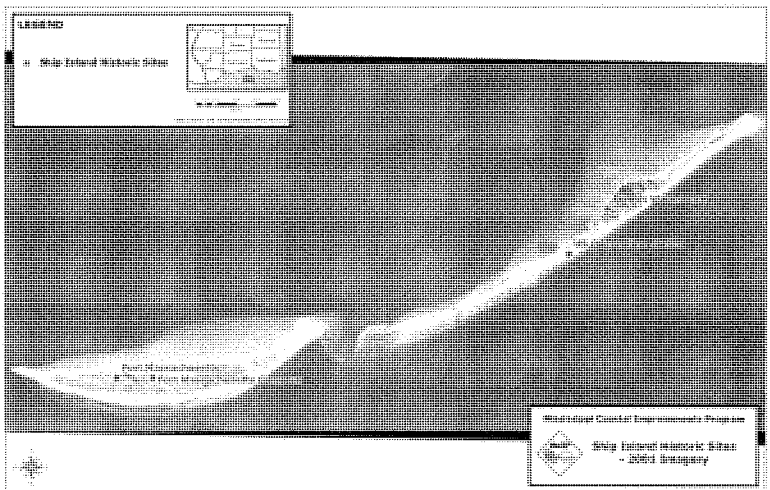


Figure 3.1.2.11-2. Aerial photo of West and East Ship Island taken in 2001. Note the sand spit extending westward from East Ship Island and the pass between the two islands.

Fort Massachusetts was originally built on the western tip of Ship Island. The westward migration of sand along the southern shore and erosion of the northern shore now has put the fort almost a mile from the western tip of the island, but dangerously close to being in the Sound (see Figure 3.1.2.11-3). Several emergency beach re-nourishments have taken place over the last 35 years through use of the beneficial use of dredged material from maintenance of the federally authorized Gulfport Harbor Navigation Project to protect the fort from wave action during winter storms. At present, the NPS is again requesting that the Corps place sand along the shore near the fort in conjunction with dredging operations at the Federal Gulfport Harbor navigation channel. This emergency placement of sand is being repeated about every five to six years. Figure 3.1.2.11-3 shows that in July, 2007, the north side of the fort showing and the relationship of the shore to the structure. Note the small jetty that has created severe scour at the down-current end.

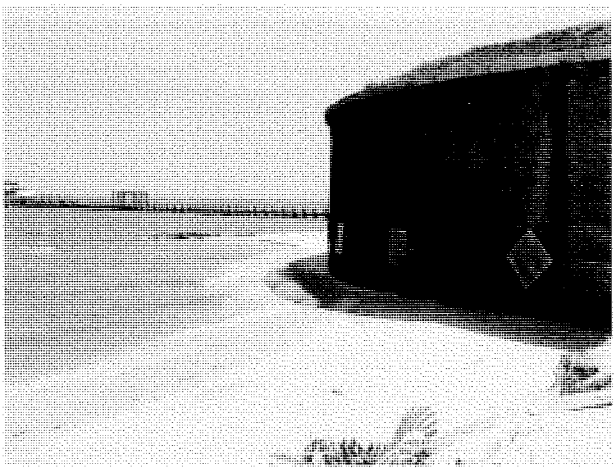


Figure 3.1.2.11-3. Photo of erosion on north side of Fort Massachusetts showing relationship to encroaching waters to the structure. Note the small jetty that has created severe scour at the down-current end.

The French Warehouse site has not had any sand placement on its shoreline in the past. The erosive process is slower at that location, but now there are concerns from the NPS about the integrity of the site. Unlike the location of the fort, the warehouse site is covered by maritime forest which may be contributing to slowing the erosion of the shore due to the vegetation and the higher surface elevation.

The filling of the Camille Cut to provide a longer term solution to the erosion on the northern shores will require modeling to better understand the benefits that are believed to be associated with this plan. The costs will be substantial due to the large quantities of high quality sand that will be required to fill the breach. Initial estimates for sand requirements are approximately 8 million cubic yards. The fill would be expected to prevent the continuing loss of sand to West Ship Island, but it is also understood that the islands are a dynamic system, ever changing to nature's forces. As well as the sand placement, this plan would include planting sea oats or other dune grasses to restore dune habitat on the newly created land. The volume of sand estimated for this project is based on an assumed average water depth of 5-feet in the existing breach.

There are many characteristics for the sand that must be considered during the design of the projects. Ideally, any sand used for beach construction or re-nourishment would come from the same littoral system so it would have the same gradation, particle shape and color. Ship Island is but one of many barrier islands that extend westward toward Louisiana that is located within a continuous littoral drift zone originating in Florida. The sand that migrates along this drift zone could be envisioned as moving from one island to another over very long periods of time. With this in mind, any sand of similar quality that is added into the drift zone would become part of the migration and be mixed with existing material. This added sand would also be available to the islands as a source for their beaches during the natural process of aggradations.

Sand of sufficient quality in the quantities required for this type of project is not known to occur in close proximity to the islands. Proposed geophysical studies may locate sources near the western end of West Ship Island, but this source has not yet been confirmed. Review of literature indicates that suitable sand can be obtained from St. Bernard Shoals which is a chain of submerged barrier islands that are located about 45 miles south of Ship Island. This sand should be very high quality material and could be used in the island reconstruction Prior studies of the St. Bernard Shoals (Oral Communication, USGS, 2006) are probably the best source of the sand. Additional studies and sampling will be required to ensure the source. As previously described, St. Bernard Shoals are a series of submerged barrier islands. The average water depth over the shoals is 60 feet which puts the sand within reach of a hopper type dredge, however the water depth near the islands is shallow for the draft of hopper dredge that would be used in this type of operation. In order to accomplish this, the dredge will have to pump-off from an offshore location.

Another source of sand could be sand from inland river systems. This sand could be considered as a source for direct placement, but the material stored on the lower Tombigbee River would require additional testing of physical characteristics to assure it meets the required quality standards. As discussed under Option B, dredging of the inland rivers produces large quantities of well sorted sand that may have potential use for sand replacement as described above. An inventory of current disposal sites on the Mobile River system indicates that approximately 30,000,000 cubic yards of sand is available. Only disposal sites that contain a minimum of 100,000 cubic yards of sand were included in the inventory. Of interest to this study are disposal sites that are located along the lower Tombigbee River which contain over 8,000,000 cubic yards of sand. Material from these sites could easily be transported by barge down the river system for use.

The sand selected for use, regardless of the source, would have a quality control program to ensure that it meets any established criteria prior to placement. The existing breach on Ship Island is approximately three miles in length. With an average water depth of five feet, an island width of approximately 1,000 feet the project will take 8,000,000 cubic yards of sand including a typical 30% loss of material during placement. Some of this material would also be placed along the north shore on either side of Camille Cut to repair existing erosion. Planting of the newly created land surface would be initiated when placement progress allowed. The planting would include dune grasses in two strips, one on each shoreline. The planting would consist of plants on 30-inch centers with the width of the planted strips set at 60-feet. The planted strips would extend along all shorelines where new beach is being created. With time, the dunes grasses will trap wind-blown sand and create dunes. The newly formed land mass will transform itself into a more natural state as wind shifts the sand and the planted vegetation establishes dunes similar to the beach scene shown in Figure 3.1.2.11-4.

Figure 3.1.2.11-4. Typical Mature Dands Funes on Gulf Coast Barrier Island

This potential option as a stand-alone measure will not provide any appreciable storm surge benefits based on modeling of the islands, but will provide benefits from storm induced wave damage on the shoreline. In addition, the role of the islands in maintaining the ecology of the Mississippi Sound has been realized and this alone may well be justification for additional study of filling Camille Cut. With this area under the control of the NPS, their endorsement is valuable to continued study.

3.1.2.11.1 Interior Drainage

The type of work anticipated for adding sand to increase the land mass of the islands will not require any type of drainage system. The addition of sand under this operation will be with dredge pipe discharge and all water will be allowed to run back to the sea.

3.1.2.11.2 Geotechnical Data

The barrier islands are composed of Holocene aged deposits, mostly sand. These deposits formed after erosion of the Pleistocene formations during the last regression and transgression of the sea. This occurred during the Wisconsinan glacial stage during the Late Pleistocene. As the sea regressed, rivers incised channels and transported sediments southward. When the sea level returned to present condition, sediments filled the river channels and started to cover the area that would become the Mississippi Sound. Sandy deposits that had been transported into the Gulf began to move westward from northwest Florida as wind driven littoral currents formed numerous barrier islands across the northern Gulf Coast, including most of those in coastal Mississippi. As the sea level continued to rise, the bays and associated river channels into the gulf also began to fill with these deposits.

The actual Sound formed as an estuary after littoral drift of sandy sediments from the Alabama coast formed a shoal south of the Mississippi mainland. These shoals became barrier islands as currents, waves and wind pushed the sand above the water surface. The sand is typically medium grained, white to light grey in color with well rounded particle shape. Within the interior of the islands, marshes and fresh water lakes have created highly organic soils with a peat-like character. These deposits, as shown in Figure 3.1.2.11-5, can be observed as beach outcrops on the southern shore of East Ship Island after the island has migrated northward.

Figure 3.1.2.11-5. Peat-like organic soils outcropping on the south beach of East Ship Island. These deposits are the remains of sediments and organic matter that settle in the bottom of the marshes and lakes that occur on the barrier islands. The deposits are exposed as the islands migrate northward.

East and West Ship Island are migrating over Pleistocene formations that created a relatively stable platform for the constantly moving islands. Other Holocene deposits provide a relatively thin cover on the bottom of the Mississippi Sound and some areas south of the Islands and consist of a muddy mixture of sand and clay along with shell fragments or buried oyster shell beds.

If increasing the land mass of the islands, it would be desirable to maintain the same quality sand that now makes up the existing islands. Sources of sand in the quantity that would be required for this option are extremely large, especially when considering the quality standard that must be met. Potential sources for sand were investigated both inland and offshore. Of concern is matching the sand to the sand on the beaches of the National Seashore. Samples taken from Dauphin and Pelican Island in Alabama are in the same island chain and have been tested for color, grain size and particle shape. These results, included in this section, can be used to match potential sand sources.

3.1.2.11.3 Structural, Mechanical and Electrical

This option will have no structural, mechanical or electrical components.

3.1.2.11.4 HTRW

Due to the extent of the islands and lack of prior development, no preliminary assessment was performed to identify the possibility of hazardous waste on the sites. These studies will be conducted during the next phase of work after the final siting of the various structures. The construction costs appearing in this report therefore will not reflect any costs for remediation design and/or treatment and/or removal or disposal of these materials in the baseline cost estimate.

3.1.2.11.5 Construction Procedures and Water Control Plan

Prior to any additional detailed design, this project will require extensive modeling to predict the effects of partially or completely filling the breach. The modeling will be conducted to assist in location of sand placement, quantities of sand that may be required for a partial filling, and to help predict the amount of sand that would be required for future re-nourishment of the island's north shore.

To fill the breach and associated shorelines will involve several different operations, some of which can take place concurrently. The source of sand that has been designated as the potential borrow area will require additional investigation using both geophysical techniques and physical sampling. The sand is expected to be in submerged shoals that will have to be located and mapped prior to any removal of the sand. This will be completed during design and before the construction begins.

3.1.2.11.6 Project Security

The Protocol for security measures for this study has been performed in general accordance with the Risk Assessment Methodology for Dams (RAM-D) developed by the Interagency Forum for Infrastructure Protection (IFIP). This methodology has been used for physical security for the critical infrastructure throughout the Corps of Engineers. The determination of the level of physical security provided for each facility is based on the following critical elements: 1) threat assessment of the likelihood that an adversary will attack a critical asset, 2) consequence assessment should an adversary be successful in disrupting, disabling or destroying the asset and 3) effectiveness to prevent a successful attack against an operational component.

The lowest level of physical security (Level 1) was selected for use in this study. Level 1 Security provides no improved security for the selected asset. This security level would be applied to the barrier islands and the sand dunes. These features present a very low threat level of attack and basically no consequence if an attack occurred and is not applicable to this option.

3.1.2.11.7 Operations and Maintenance

The direct placement of sand to fill Camille Cut and will be a one-time event. Per an agreement with the National Park Service, no additional beach maintenance will be performed in the future. This project will provide a boost in the existing sand within the littoral system, then in accordance with the 2006 NPS Management Policies, nature will take it course. Therefore, there will be no costs associated with operations and maintenance for this option. Changes in future maintenance dredging practices at both Gulfport and Pascagoula Navigation Channels will ensure that more sand in the littoral zone will be available for natural beach building. This option will not preclude the NPS from performing sand additions at Fort Massachusetts or the French Warehouse to protect these structures from erosion of beaches that endangers these historic sites.

3.1.2.11.8 Cost Estimate

The costs for the various options included in this measure are presented in Section 3.1.2.12 Cost Summary. Total project costs for the various options are included in Table 3.1.2.12-1. Estimates are comparative-Level "Parametric Type" and are based on Historical Data, Recent Pricing, and Estimator's Judgment. Quantities listed within the estimates represent Major Elements of the Project Scope and were furnished by the Project Delivery Team. Price Level of Estimate is April 07. Estimates excludes project Escalation and HTRW Cost. The costs include real estate, engineering design (E&D), construction management, and contingencies. The E&D cost for preparation of construction contract plans and specifications includes a detailed contract survey, preparation of contract specifications and plan drawings, estimating bid quantities, preparation of bid estimate, preparation of final submittal and contract advertisement package, project engineering and coordination, supervision technical review, computer costs and reproduction. Contingency developed and assigned at 25% to cover the Cost Growth of the project.

3.1.2.11.9 Schedule for Design and Construction

This project will require additional study and investigation to verify borrow areas. These can be accomplished within a one-year time frame after funding at which time placement of sand can be initiated pending all required permits.

3.1.2.12 Cost Estimate Summary

The total project costs for all options are shown in Table 3.1.2.12-1. Estimates are comparative-Level "Parametric Type" and are based on Historical Data, Recent Pricing, and Estimator's Judgment. Quantities listed within the estimates represent Major Elements of the Project Scope and were furnished by the Project Delivery Team. Price Level of Estimate is April 07. Estimates excludes project Escalation and HTRW Cost.

Table 3.1.2.12-1.
Summary of Total Project Costs

Option	Total Project Costs
Option A – Restoration of Island Footprints	$942,200,000
Option B – Replenish Littoral Zone w/ Inland River Sand	$1,013,800,000
Option C – Replenish Littoral Zone w/ Off-shore Sand	$147,400,000
Option D – Environmental Restoration w/ 2-foot Dune	$14,200,000
Option E – Environmental Restoration w/ 6-foot Dune	$39,200,000
Option F – Environmental Restoration of Sea Grass Beds	$264,500,000
Option G – Restore Ship Island Breach	$181,400,000

Note: There are no Operational and Maintenance costs for the barrier island options.

3.1.2.13 References

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3.2 Line of Defense 2 – Beach/Dune Construction

3.2.1 General

The Mississippi Mainland shoreline extends approximately 68 miles, and is divided into three coastal counties: Jackson, Harrison, and Hancock Counties, Figure 3.2.1-1. The Mississippi coast beaches are a valuable asset and provide vital environmental, cultural, recreational, and economic resources; they assist in maintaining the health and productivity of adjacent waters and provide for diverse cultural and recreational activities. They are also important in limiting infrastructure damage and providing protection to the seawalls along the coast (Schmid 2002). This study evaluated berm and dune options for approximately 35 miles of shoreline along the three Mississippi coastal counties as outlined in Figure 3.2.1-1. The coastal processes modeling analysis to evaluate the future without and with project berm and dune systems were conducted through application of the engineering-economic model Beach-fx. The purpose of the analysis was to evaluate the physical performance of the beach and dune system for anticipated future without-project and with project conditions. The development of the coastal processes input data and physical performance results of the Beach-fx analysis are provided in detail in Section 2.3 of this report. For this study, the exploration of the costal processes and economic inventorying was conducted. Further study would be required to combine the observed data and to evaluate the eleven alternatives previously mentioned. More detail on the further study can be found in the MsCIP Comprehensive Plan Main Report.

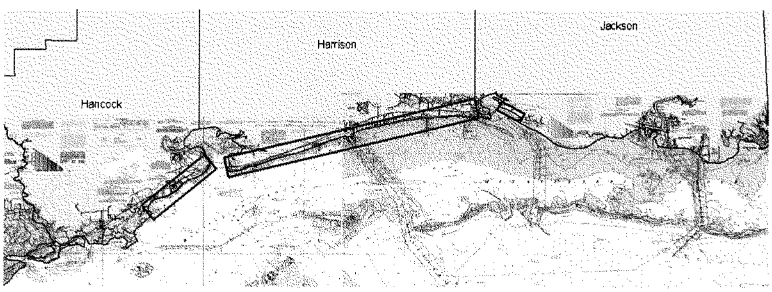


Figure 3.2.1-1. Project Location, Mississippi Coast Beach Evaluations

3.2.2 Hancock County Beaches

3.2.2.1 General

The purpose of this section is to provide engineering information and data for the planning and design of shore protection and restoration to the shoreline along Hancock County, MS following impacts from Hurricane Katrina, 29 August 2005. Hurricane Katrina severely damaged approximately six miles of public beaches along the shoreline from the US 90 bridge extending southwest to Beach Road.

3.2.2.2 Location

The Mississippi mainland shoreline is divided into three coastal counties: Jackson, Harrison, and Hancock Counties. Hancock County, Figure 3.2.2-1, is the western-most coastal county in Mississippi and is located approximately 95 miles west of Mobile, Alabama and approximately 40-miles east of New Orleans, Louisiana. Hancock County is bordered to the east by Harrison County, MS, and to the west by the Mississippi-Louisiana state line. The County consists of two municipalities: Bay St. Louis and Waveland. The beaches along the Hancock County shoreline, Figure 3.2.2-1, are separated in two sections: the reach extending approximately 6-miles from Grand Bayou in Waveland to the US 90 bridge in Bay St Louis, and the reach extending northeastward approximately 1-mile from Cadet Bayou.

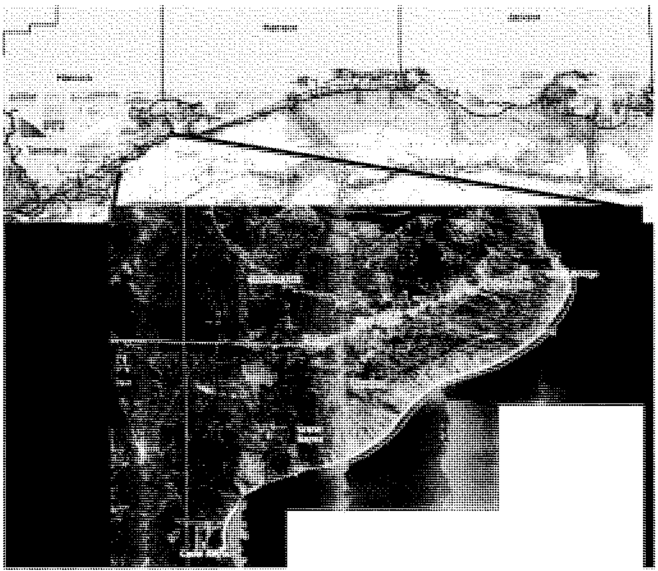


Figure 3.2.2-1. Project Location, Hancock County Beaches

3.2.2.3 Existing Conditions

The Hancock County shoreline south of the US 90 bridge is protected by an 8 mile long, approximately+ 5 ft elevation seawall extending from the US 90 bridge to Cadet Bayou. The Hancock County beaches were constructed for shore protection; however, the area provides added outdoor recreation and environmental benefits. The area experienced wave and wind erosion and is therefore periodically maintained or renourished with sand. The elevation of the seawall ranges between +3.8 and +5.0 feet (NAVD). The seawall fronting the downtown Bay St Louis beaches is significantly higher. A sand beach was constructed along approximately 6 miles of the seawall in 1967 as part of the emergency repair and protection following Hurricane Betsy (September 1965).

The approximate 1 mile section of beach fronting the downtown Bay St Louis area was constructed during the construction of the US 90 bridge. The 1 mile section extending from Bayou Cadet was constructed in 2005.

The Hancock County beaches were renourished in 1994 with material from a borrow area located approximately 1000 feet offshore. The beaches fronting downtown Bay St Louis, the northeast section of the beaches, were again renourished in 1996 with material from a borrow area located on the north side of the US 90 bridge. After renourishment, beach width was maintained by scraping upper portions of the beach and moving sediment to widen the beach (Schmidt 2002).

The existing Hancock County beach profile consists of a berm only feature which extends approximately 150 ft from the seawall to the Mississippi Sound. The berm elevation varies from approximately 5.0 ft at the seawall to 3.5 ft at the slope break to the Mississippi Sound. The downtown Bay St Louis area beaches include a bluff with an elevation of about +12 feet. Access ramps and pavements are located along the beach, and storm water culverts pass beneath the roadway adjacent to the beach to the shoreline to drain sections of Hancock County. A typical cross section for the existing condition is shown in Figure 3.2.2-2.

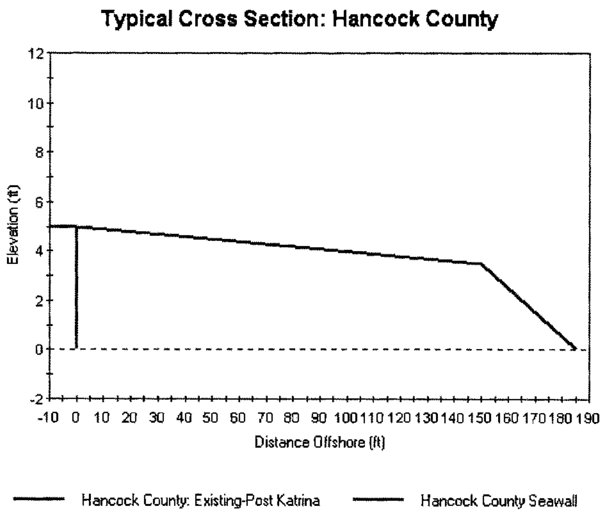


Figure 3.2.2-2. Typical Cross Section, Hancock County Existing Conditions

3.2.2.4 Coastal and Hydraulic Data

The climate in the project area is subtropical, characterized by warm summers and short, mild winters. Average temperatures are 82 degrees Fahrenheit for the summer months and 53 degrees Fahrenheit for the winter months. The average annual rainfall is about 60 inches, and is fairly evenly distributed throughout the year. Precipitation records also indicate July as the wettest month, while October is the driest.

Mississippi Sound is a shallow coastal lagoon extending 80 miles along the coast of the Gulf of Mexico from Mobile Bay, Alabama westward to Lake Borgne, Louisiana. The average depth in the sound is 10 feet, and 99 percent of the sound is less than 29 feet deep.

Circulation patterns within the vicinity of the study area are controlled by astronomical tides, winds, and freshwater discharges. The mean diurnal tide range in St. Louis Bay is 1.6 feet, and the extreme (except during storms) is about 3.5 feet. The velocity of normal tidal currents ranges from 0.5 to 1.0 ft per second (fps) and their direction is generally east to west. Predominant winds average eight miles per hour (mph) from the south during the summer and from the northeast during the winter. Though the tides produced by astronomical forces are relatively small in magnitude, the wind can produce larger variations. Strong winds from the north can evacuate the sound causing current velocities of several knots in the passes to the gulf. Winds from the southeast can produce high tides, piling water up against the shoreline. The study area has been impacted by several tropical storms and hurricanes, most recently from Hurricane Katrina in 2005. Post-Hurricane Katrina high water mark measurements in the area suggest storm surges on the order of 20 to 25 feet or more.

Transport is generally from northeast to southwest, although there are areas with reversals. From 1994 and 2000, 60 percent of the shoreline eroded at least -5.0 feet/year (ft/yr) which corresponds to volumetric losses of approximately -12,000 CY/yr. A portion of this erosion was likely due to adjustment of the renourished beaches in 1993-1994 and 1996. From 1997 to 2001, a period without post-nourishment adjustment, only 30 percent of the beach retreated at rates higher than -5.0 ft/yr. Schmidt estimated that renourishment would be required in 2012 if present retreat rates continued. For the Bay St Louis Downtown beach, more than 2/3 was retreating at rates greater than -5.0 ft/yr /yr, and Schmidt estimated that renourishment would be required earlier than 2012.

3.2.2.5 Future Without-Project Conditions

The future without-project conditions assumed continuation of the present maintenance activities in Hancock County; maintenance occurs on an annual basis by truck haul placement. Two cross sections or scenarios were considered as future without project conditions. The first scenario examined continued maintenance of the existing post-Katrina cross section which included a berm only feature, Figure 3.2.2-2 and Figure 3.2.2-3. Scenario 1, continued maintenance of the post-Katrina berm only feature, consists of a berm which extends approximately 150 ft from the seawall to the Mississippi Sound. The berm elevation varies from approximately 5.0 ft at the seawall to 3.5 ft at the slope break to the Mississippi Sound. The downtown Bay St Louis area beaches include a bluff with an elevation of about +12 feet. A typical cross section for the post-Katrina existing condition is shown in Figure 3.2.2-3.

The second scenario included a dune feature and was identified as an interim project to this study with funding appropriated for construction. Therefore both scenarios were considered in the evaluation of future without-project conditions. Scenario 2 consists of a 7 ft (NAVD 88) dune elevation with a 10 ft wide dune crest comprised of approximately 1.6 CY/ft of sand. The dune would be constructed approximately 50 ft seaward of the existing seawall. To provide environmental habitat and to reduce sand transport due to the strong winds, which frequently occur during storms, the dunes will be vegetated and protected with sand fencing. A typical cross section for Scenario 2 is shown in Figure 3.2.2-3.

3.2.2.5.1 Results-Future Without-Project Conditions

The coastal processes modeling analysis to evaluate the future without project berm and dune systems were conducted through application of the engineering-economic model Beach-*fx*. The purpose of the analysis was to evaluate the physical performance of the beach and dune system for anticipated future without-project project conditions. The development of the coastal processes input data for the Beach-*fx* analysis are provided in Section 2.3 of this report. The economic results of the Beach-*fx* analysis are documented in the Economic Appendices of this report.

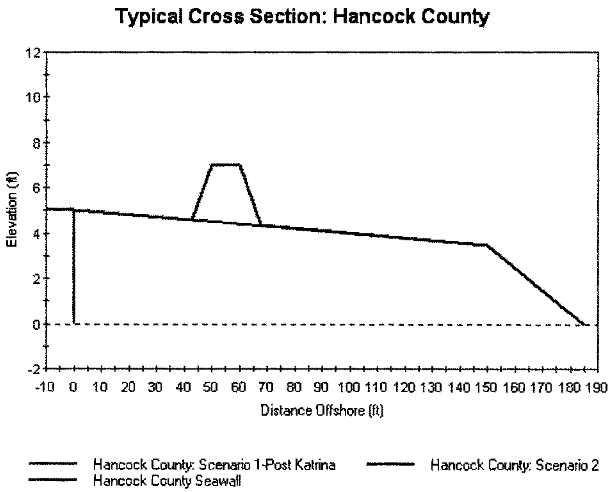


Figure 3.2.2-3. Typical Cross Sections, Hancock County Scenarios 1 and 2

Table 3.2.2-1 summarizes the results of the Hancock County without-project Beach-*fx* simulations. The data in Table 3.2.2-1 indicate that existing beach maintenance practices will require approximately 304 CY/ft of beach over a 100 year project life assuming the existing rate of sea level rise persists into the future. If the future rate of sea level rise increases, the simulations indicate that the potential moderate rate of future sea level rise will result in about a 51 percent increase in volume requirements, whereas, a high rate of future sea level rise will result in about a 69 percent increase in project volume requirements.

Table 3.2.2-1.
Hancock County Without-Project Summary

	Number of Nourishments				Nourishment Volume (CY/ft)			
Scenario Name[1]	**mean**	**sd**	**max**	**min**	**mean**	**sd**	**max**	**min**
Scenario 1 ESLR	100	0	100	100	297.7	28.1	379.7	250
Scenario 2 ESLR	100	0	100	100	310.3	31.6	396.9	250
Scenario 1 MSLR	100	0	100	100	443.7	47.0	581.7	302.9
Scenario 2 MSLR	100	0	100	100	473.1	53.5	607.0	285.7
Scenario 1 HSLR	100	0	100	100	497.2	53.1	654.8	351.9
Scenario 2 HSLR	100	0	100	100	531.5	32.1	619.7	452.1

[1] ESLR refers to "existing" sea level rise, MSLR refers to a "moderate" potential future sea level rise rate, and HSLR refers to a "high" potential future sea level rise rate.

As a result of the difference in maintenance cycles in Harrison and Hancock counties the project volume requirements in Hancock County exceed those in Harrison County by approximately 225 percent for without project conditions under existing sea level rise conditions. For the potential future sea level rise scenarios the increase in volume requirement is about 180 percent.

3.2.2.6 Future With-Project Options

The future with-project evaluations for Hancock County included 11 options which were evaluated for environmental restoration and enhancement of environmental habitat. Options A through D include four design cross-sections with varying dune and berm configurations. The berm and dune options would be constructed adjacent to the seawall along the length of the beach. For environmental and economic purposes, Options E through H further evaluated the four design cross-sections to include sand fencing and plantings on the dune to provide environmental habitat and to reduce sand transport due to the strong winds, which frequently occur during storms. The wider dune features would provide for a larger spatial extent with which to create environmental habitat. Options A through H were evaluated in conjunction with the Line of Defense 3 seawall.

Option A consists of a 10 ft dune elevation, 40 ft dune crest width, with a dune slope of 1:3, and a berm with an 80 ft width, an upper berm elevation of 5.5 ft, and seaward berm elevation of 3.5 ft, and a foreshore slope of 1:10. Option B consists of an 8 ft dune elevation, 50 ft dune crest width, with a dune slope of 1:3, and a berm with an 80 ft width, an upper berm elevation of 5.5 ft, and seaward berm elevation of 3.5 ft, and a foreshore slope of 1:10. Option C consists of a 10 ft dune elevation, 20 ft dune crest width, with a dune slope of 1:3, and a berm with a 100 ft width, an upper berm elevation of 5.5 ft, and seaward berm elevation of 3.5 ft, and a foreshore slope of 1:10. Option D consists of an 8 ft dune elevation, 30 ft dune crest width, with a dune slope of 1:3, and a berm with a 100 ft width, an upper berm elevation of 5.5 ft, and seaward berm elevation of 3.5 ft, and a foreshore slope of 1:10. Dune volumes for the Hancock County design options are 10.7 CY/ft, 7.3 CY/ft, 6.6 CY/ft, and 4.7 CY/ft, for Options A, B, C, and D, respectively. Typical cross sections for Options A through D are shown in Figure 3.2.2-4. The same cross sections were used for Options E through H. For Options E through H, sea oats would be planted on the seaward dune face in an 18 by 18 inch grid pattern, with a total of three rows of plants starting at the seaward toe of the dune.

Options I and J are comparative with-project options, for future evaluation, consisting of a design cross-section which includes a dune and berm constructed as a stand alone project which does not incorporate the Line of Defense 3 seawall. Option I consists of a dune feature constructed approximately 50 ft seaward of the seawall at an elevation of 10 ft (NAVD 88), with a crest width of 55 ft, and a dune slope of 1:3. The berm width would be extended to accommodate the placement of the dune feature. Sand fencing would be placed on the dunes to reduce sand transport due to the strong winds which frequently occur during storms. The cross section for Option J is the same as Option I; however the dune would be planted to provide for additional environmental habitat. For Option J, sea oats would be planted on both the landward and seaward dune face in an 18 by 18 inch grid pattern, with a total of three rows of plants starting at the landward and seaward toes of the dune. The dunes will require initial and continued maintenance of vegetation and sand fencing. A typical cross section for Options I and J is shown in Figure 3.2.2-5.

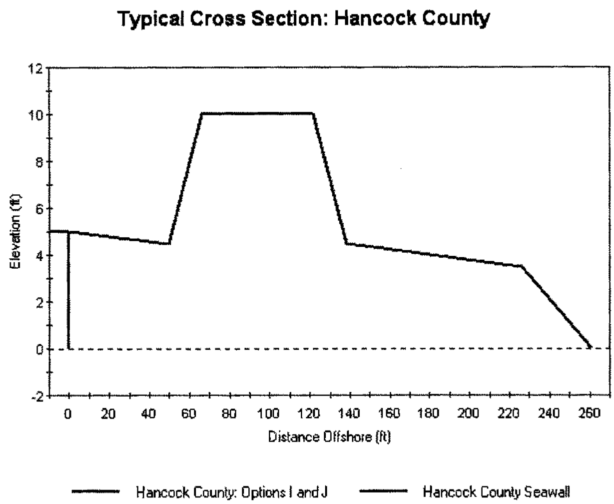


Figure 3.2.2-4. Typical Cross Sections, Hancock County Options A-D and E-H

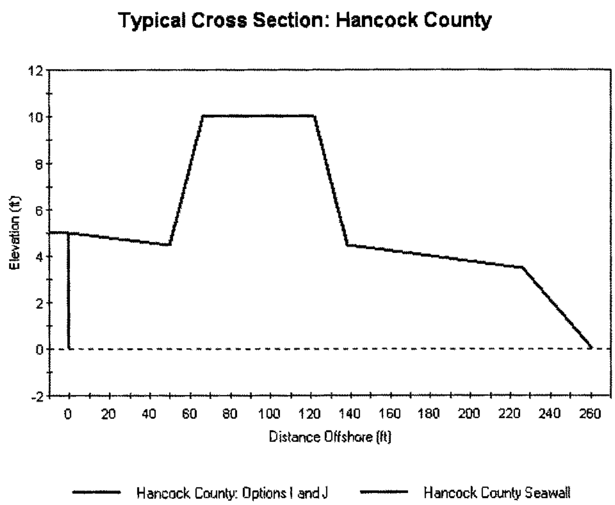


Figure 3.2.2-5. Typical Cross Section, Hancock County Comparative Dune Options I and J

Option K is also an option for future evaluation which consists of an elevated berm section constructed primarily for the creation of environmental habitat. Option K would be constructed as a stand alone option which does not incorporate the Line of Defense 3 seawall. The elevated berm section would be constructed approximately 50 ft seaward of the existing seawall to an elevation 2 ft above the existing berm with a width of approximately 60 ft. The berm width would not be extended to accommodate the placement of the elevated berm feature. The new feature would be vegetated and sand fencing would be placed to create environmental habitat and to reduce sand transport due to the strong winds which frequently occur during storms. For Option K, sea oats would be planted in a 30 by 30 inch grid pattern over the entire elevated berm area. The new feature will require initial and continued maintenance of vegetation and sand fencing. A typical cross section for Option K is shown in Figure 3.2.2-6.

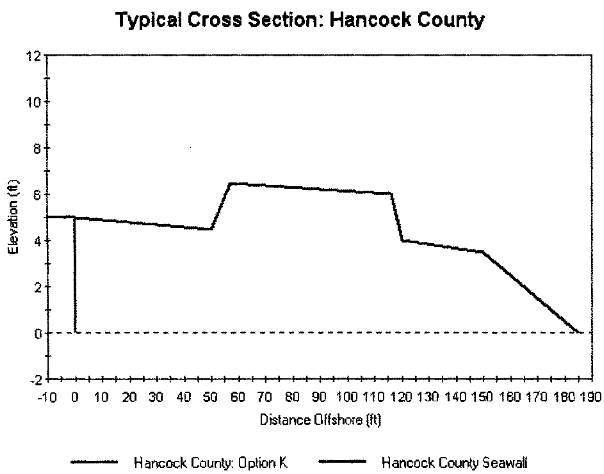


Figure 3.2.2-6. Typical Cross Section, Hancock County Option K

3.2.2.6.1 Results-Future With-Project Options

The coastal processes modeling analysis to evaluate the future with project berm and dune systems, Options A through D, were conducted through application of the engineering-economic model Beach-*fx*. The purpose of the analysis was to evaluate the physical performance of the beach and dune system for anticipated future with-project conditions and to estimate the economic costs and benefits of each. The development of the coastal processes input data for the Beach-*fx* analysis are provided in Section 2.3 of this report. The economic results of the Beach-*fx* analysis are documented in the Economic Appendices of this report. The environmental benefits of Line of Defense 2 are documented in the Environmental Appendices of this report.

Table 3.2.2-2 summarizes the Hancock County with-project Beach-*fx* simulations. The data in Table 3.2.2-2 indicate that with-project nourishment volumes for the existing rate of sea level rise are approximately 369 CY/ft of beach over a 100-year project life. If the future rate of sea level rise increases, the simulations indicate that the potential moderate rate of future sea level rise will result in about a 75 percent increase in volume requirements. A high rate of future sea level rise will result in about a 102 percent increase in project volume requirements.

Table 3.2.2-2.
Hancock County With-Project Summary

	Number of Nourishments				Nourishment Volume (CY/ft)			
Option Name[1]	**mean**	**sd**	**max**	**min**	**mean**	**sd**	**max**	**min**
Option AESLR	100	0	100	100	384.1	68.3	829.8	283.6
Option B ESLR	100	0	100	100	380.6	65.8	748.8	294.7
Option C ESLR	100	0	100	100	352.9	61.8	758.5	272.0
Option D ESLR	100	0	100	100	358.1	75.7	1,117.7	279.3
Option A MSLR	100	0	100	100	690.1	121.9	1,034.5	445.8
Option B MSLR	100	0	100	100	674.1	136.3	1,059.4	410.3
Option C MSLR	100	0	100	100	587.5	93.0	877.4	404.7
Option D MSLR	100	0	100	100	587.4	100.1	887.6	371.6
Option AHSLR	100	0	100	100	835.8	107.6	1,252.4	624.3
Option B HSLR	100	0	100	100	704.0	80.5	1,012.8	549.6
Option C HSLR	100	0	100	100	682.1	77.3	883.9	490.9
Option D HSLR	100	0	100	100	599.9	63.7	853.2	449.3

[1] ESLR refers to "existing" sea level rise, MSLR refers to a "moderate" potential future sea level rise rate, and HSLR refers to a "high" potential future sea level rise rate.

3.2.2.6.2 Summary-Future With-Project Options

The coastal processes analysis conducted as a part of this study has provided a number of useful insights with respect to morphology change, coastal evolution, and the primary drivers for storm-induced damages along the Mississippi Sound shoreline. First, the Mississippi Sound shoreline is primarily a stable, low energy coast that is dramatically impacted by tropical storm events. In the absence of tropical storm events the shoreline is expected to be only slightly erosive with shoreline change rates on the order of -1 ft/year. In general, moderate storm events produce more coastal erosion and volumetric beach change along the Mississippi Sound shoreline than do major hurricanes. This is because the large storm surge associated with the very intense storms completely inundates the beach system and protects it from the high energy dissipation associated with wave breaking, which results in less overall shoreline change and volumetric erosion of the beach. Damages to upland infrastructure are largely driven by inundation and direct wave attack as opposed to erosion, partly because most of the infrastructure is located landward of the sea wall that runs along Highway 90 in Harrison County and Beach Boulevard in Hancock County.

For with project conditions, the volume requirements in Hancock County exceed those in Harrison County by approximately 190 percent. Because the beach is restored to design conditions every year, if needed, in Hancock County the volume requirements are much larger than the volume requirements in Harrison County. In Harrison County, the beach is restored to design conditions once every 12 years. If the beach in Harrison County is damaged by a major storm in the year following reconstruction of the design template the beach remains vulnerable for the remainder of the 11 year nourishment cycle. Essentially, the present analysis indicates that the nourishment cycle in Harrison County should be shortened or augmented with a provision for emergency dune reconstruction after the occurrence of a major storm event.

3.2.2.6.3 Interior Drainage

This section is not applicable.

3.2.2.6.4 Geotechnical Data

Geology. The Prairie formation is found southward of the Citronelle formation and is of Pleistocene age. This formation consists of fluvial and floodplain sediments that extend southward from the outcrop of the Citronelle formation to or near the mainland coastline. Sand found within this formation has an economic value as beach fill due to its color and quality. Southward from its outcrop area, the formation extends under the overlying Holocene deposits out into the Mississippi Sound.

The Gulfport Formation is found along the coastline in Jackson County at Belle Fontaine Beach. This formation of Pleistocene age overlies the Prairie formation and is present as well sorted sands that mark the edge of the coastline during the last high sea level stage of the Sangamonian Interglacial period. It does not extend under the Mississippi Sound.

Geotechnical. The Line 2 defense provides for the installation of dunes on the Mississippi Sound side of the existing seawalls. These dunes are intended to provide toe protection for the seawall when subjected to storm surges in the range of 3 to 5 ft. The dune slopes will be constructed to one vertical to three horizontal side slopes with a ten ft crest. The dunes for Options E through H and J thorough K will be reinforced with plantings of native sea grasses and fencing. The sand used for the dune construction would come from upland sources within 10 miles of the work area. The sands will be compatible with the existing sand with respect to grain size and color.

3.2.2.6.5 Structural, Mechanical and Electrical

This section is not applicable.

3.2.2.6.6 HTRW

Due to the extent and large number of real estate parcels along with the potential for re-alignment of the structural aspects of this project, no preliminary assessment was performed to identify the possibility of hazardous waste on the sites. These studies will be conducted during the next phase of work after the final siting of the various structures. The real estate costs appearing in this report therefore will not reflect any costs for remediation design and/or treatment and/or removal or disposal of these materials in the baseline cost estimate.

3.2.2.6.7 Construction Procedures and Water Control Plan

Respects in that the easement limits must be established and staked in the field, the work area cleared of all structures, pavements, etc. and the foundation prepared for the new work. Access ramps shall be created and temporary haul routes shall be established. All temporary haul routes shall be regraded upon completion of the work.

3.2.2.6.8 Project Security

Infrastructure Protection (IFIP). This methodology has been used for physical security for the critical infrastructure throughout the Corps of Engineers. The determination of the level of physical security provided for each facility is based on the following critical elements: 1) threat assessment of the likelihood that an adversary will attack a critical asset, 2) consequence assessment should an adversary be successful in disrupting, disabling or destroying the asset and 3) effectiveness to prevent a successful attack against an operational component.

Three levels of physical security were selected for use in this study:

Level 1 Security provides no improved security for the selected asset. This security level would be applied to the barrier islands and the sand dunes. These features present a very low threat level of attack and basically no consequence if an attack occurred and is not applicable to this option.

3.2.2.6.9 Operations and Maintenance

The features that require periodic operations will be the regrading of the dune materials within the beach system and the replacement of any appreciable loss of the sea grasses and the replacement of any damaged fence sections.

3.2.2.6.10 Cost Estimate

The costs for the various options are presented in Section 3.2.2.7 Cost Estimate Summary. Total project costs for the various options are included in Table 3.2.2-3 and costs for the annualized Operation and Maintenance of the options are included in Table 3.2.2-4. Estimates are comparative-Level "Parametric Type" and are based on Historical Data, Recent Pricing, and Estimator's Judgment. Quantities listed within the estimates represent Major Elements of the Project Scope and were furnished by the Project Delivery Team. Price Level of Estimate is April 2007. Estimates excludes project Escalation and HTRW Cost. The project costs include real estate, engineering design (E&D), construction management, and contingencies. The E&D cost for preparation of construction contract plans and specifications includes a detailed contract survey, preparation of contract specifications and plan drawings, estimating bid quantities, preparation of bid estimate, preparation of final submittal and contract advertisement package, project engineering and coordination, supervision technical review, computer costs and reproduction. Contingency developed and assigned at 25 percent to cover the Cost Growth of the project.

3.2.2.6.11 Schedule and Design for Construction

After the authority for the design has been issued and funds have been provided, the design of these structures will require approximately 12 months to complete comprehensive plans and specifications, independent reviews and subsequent revisions. The construction of this option should require approximately one year.

3.2.2.7 Cost Estimate Summary

Construction costs for the various options are included in Table 3.2.2-3 and costs for the annualized Operation and Maintenance (O&M) of the options are included in Table 3.2.2-4. Estimates are comparative-Level "Parametric Type" and are based on Historical Data, Recent Pricing, and Estimator's Judgment. Quantities listed within the estimates represent Major Elements of the Project Scope and were furnished by the Project Delivery Team. Price Level of Estimate is April 2007. Estimates excludes project Escalation and HTRW Cost.

3.2.2.8 References

Schmidt, K. 2002. Biennial report of sand beaches, Hancock County, 2001. Mississippi Department of Environmental Quality, Office of Geology, Open-File Report 110B, April, 53 p.

Table 3.2.2-3.
Hancock County LOD2 - Project Cost

Option	Description						Project Cost
	Dune			Berm			
	Elevation (ft)	Width (ft)	Side Slope	Width (ft)	Plantings	Sand Fencing	
A*	10	40	1:3	80			$8,070,000
B*	8	50	1:3	80			$6,100,000
C*	10	20	1:3	100			$4,960,000
D*	8	30	1:3	80			$4,030,000
E*	10	40	1:3	80	X	X	$8,400,000
F*	8	50	1:3	80	X	X	$6,440,000
G*	10	20	1:3	100	X	X	$5,300,000
H*	8	30	1:3	100	X	X	$4,360,000
I**	10	55	1:3	Extend to accommodate		X	$19,100,000
J**	10	55	1:3	Extend to accommodate	X	X	$19,450,000
K**				Add 2ft, 60 ft width	X	X	$4,640,000

* Options are in conjunction with the LOD3 Seawall
** Options are without a seawall

Table 3.2.2-4.
Hancock County LOD2 – Operation and Maintenance Cost

Option	Description						O&M Cost
	Dune			Berm			
	Elevation (ft)	Width (ft)	Side Slope	Width (ft)	Plantings	Sand Fencing	
A*	10	40	1:3	80			$2,167,694
B*	8	50	1:3	80			$1,638,530
C*	10	20	1:3	100			$1,332,313
D*	8	30	1:3	80			$1,082,504
E*	10	40	1:3	80	X	X	$2,256,336
F*	8	50	1:3	80	X	X	$1,729,857
G*	10	20	1:3	100	X	X	$1,423,640
H*	8	30	1:3	100	X	X	$1,171,146
I**	10	55	1:3	Extend to accommodate		X	$5,130,478
J**	10	55	1:3	Extend to accommodate	X	X	$5,224,492
K**				Add 2ft, 60 ft width	X	X	N/A

* Options are in conjunction with the LOD3 Seawall
** Options are without a seawall

3.2.3 Harrison County Beaches

3.2.3.1 General

The purpose of this section is to provide engineering information and data for the planning and design of shore protection and restoration to the shoreline along Harrison County, MS following impacts from Hurricane Katrina, 29 August 2005. Hurricane Katrina severely damaged approximately 26 miles of public beaches along the shoreline across the entire coastline of the county's shoreline.

3.2.3.2 Location

The Mississippi mainland shoreline is divided into three coastal counties: Jackson, Harrison, and Hancock Counties. Harrison County, Figure 3.2.3-1, extends approximately 27-miles, has the largest population, and the greatest number of municipalities. It is bordered on the east by industrialized Jackson County, on the west by Hancock County and the John C. Stennis Space Center and to the north by primarily rural Stone County. The County consists of five municipalities: Biloxi, D'Iberville, Gulfport, Long Beach, and Pass Christian. The Harrison County Federal Shore Protection Project, Figure 3.2.3-1, extends approximately 26-miles from Biloxi on the east to Henderson Point on the west.

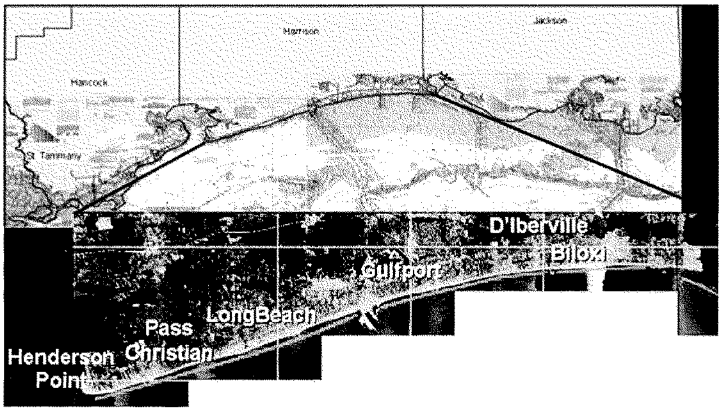


Figure 3.2.3-1. Project Location, Harrison County Beaches

3.2.3.3 Existing Conditions

As a result of the 1915 hurricane which destroyed half of U.S. 90, a seawall was constructed to protect the roadway and beach front property. After the hurricane in 1947 and due to ongoing loss of sediment, the Harrison County, Mississippi Federal Beach Erosion Control Project was constructed in 1952 under the Section 2 authority of the River and Harbor Act approved July 3, 1930. The project was constructed to protect the seawall and US 90, which provides an evacuation route for residents. Broken concrete groins were constructed to compartmentalize the beach, and a total of 6 million CY of fill was hydraulically pumped from borrow areas offshore of Gulfport Harbor.

The authorized Harrison County project provides for a beach profile consisting of a berm only feature which extends approximately 265 ft from the seawall to mean sea level (MSL). The berm elevation varies from an elevation of approximately 7.2 ft (NAVD 88) at the seawall to 3.5 ft at the slope break to the Mississippi Sound. An approximately 10 ft wide boardwalk, located adjacent to the seawall, extends along most of the Harrison County seawall. Access ramps and pavements are located along the beach, and storm water culverts pass beneath US 90 to the shoreline to drain sections of Biloxi, Long Beach, and Pass Christian. A typical cross section for the existing condition is shown in Figure 3.2.3-2.

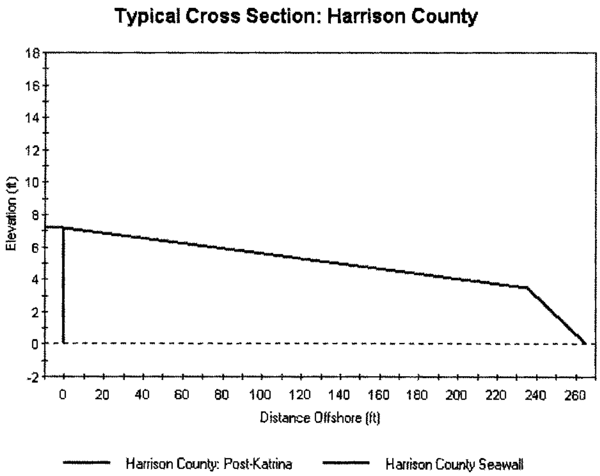


Figure 3.2.3-2. Typical Cross Section, Harrison County Existing Conditions

The Harrison County beaches were last renourished in 2001, which placed approximately 1.1 million CY of beach quality sand obtained from borrows sites located about 1,500 ft offshore of the Harrison County shoreline.

During Hurricane Katrina on 29 August 2005, the project experienced erosional damage due to wind driven waves, debris scour, storm surge and subsequent return flow after the hurricane.

3.2.3.4 Coastal and Hydraulic Data

The climate in the project area is subtropical, characterized by warm summers and short, mild winters. Average temperatures are 82 degrees Fahrenheit for the summer months and 53 degrees Fahrenheit for the winter months. The average annual rainfall is about 60 inches, and is fairly evenly distributed throughout the year. Precipitation records also indicate July as the wettest month, while October is the driest.

Mississippi Sound is a shallow coastal lagoon extending 80 miles along the coast of the Gulf of Mexico from Mobile Bay, Alabama westward to Lake Borgne, Louisiana. The average depth in the sound is 10 ft, with the majority of the sound less than 30 ft deep. The offshore slope of the Sound is relatively flat with the 6 ft contour located a few hundred yards offshore to as far as 1.5 miles offshore. Bed materials are primarily fine grained sands and silt, with some areas of clay content and others, particularly offshore of Bay St. Louis, occupied by expansive oyster beds.

Circulation patterns within the vicinity of the study area are controlled by astronomical tides and winds. The mean diurnal tide range is 1.6 ft, and the extreme (except during storms) is about 3.5 ft.

The velocity of normal tidal currents ranges from 0.5 to 1.0 ft per second (fps) and their direction is generally east to west. Predominant winds average eight miles per hour (mph) from the south during the summer and from the northeast during the winter. Though the tides produced by astronomical forces are relatively small in magnitude, the wind can produce larger variations. Strong winds from the north can evacuate the sound causing current velocities of several knots in the passes to the gulf. Winds from the southeast can produce high tides, piling water up against the shoreline. The study area has been impacted by several tropical storms and hurricanes, most recently from Hurricane Katrina in 2005. Post-Hurricane Katrina high water mark measurements in the area suggest storm surges on the order of 20 to 25 ft or more.

In General, longshore sediment transport is low in magnitude and directed from east to east, although seasonal reversals can occur. Areas dominated by marsh vegetation have minimal or no longshore transport. In some sections groins or drainage structures reduce or block sediment transport.

Sand accumulated to the east of each groin indicating a weak net transport direction to the west, and a series of five profiles taken within each groin compartment indicated losses from the beach extending from Henderson Point to the Biloxi lighthouse from 1951 to 1953 were approximately 32, 500 CY/year.

Byrnes et al. (1993a, 1993b) evaluated shoreline position change rates for the mainland beach in Harrison County from 1851/52 to 1986, and found that long-term beach change has been minor (0.7 ft/yr), with change from 1951-1986 erosive at -1.6 ft/year. The greatest shoreline change has been associated with beach nourishment projects and impoundment or erosion at recently-constructed littoral barriers. The coastal highway was protected by construction of a seawall in 1928, and thus shoreline retreat has been limited by the structure. Seven geomorphic zones defined by coastal structures and harbor complexes essentially block littoral transport from the east to the west across each structure. The analysis showed impoundment of sand on the east side and erosion west of each complex or structure, indicating littoral transport from east-to-west. More than 100 smaller structures (e.g., water drainage pipes and canals that block littoral transport) and periodic beach scraping resulted in variability in shoreline position within each geomorphic zone.

3.2.3.5 Future Without-Project Conditions

The future without-project conditions assumed continuation of the present maintenance activities in Harrison County; maintenance occurs on a 12 year interval at which time the without project template is restored by hydraulic placement of fill material obtained from offshore sand sources. Two cross sections or scenarios were considered as future without project conditions. The first scenario examined continued maintenance of the existing post-Katrina cross section which included a berm only feature, Figure 3.2.3-2 and Figure 3.2.3-3. Scenario 1, continued maintenance of the post-Katrina berm only feature, consists of a berm which extends approximately 230 ft from the seawall to the Mississippi Sound. The berm elevation varies from approximately 7.2 ft (NAVD 88) at the seawall to 3.5 ft at the slope break to the Mississippi Sound. A typical cross section for the post-Katrina existing condition is shown in Figure 3.2.3-3.

The second scenario included a dune feature and was identified as an interim project to this study with funding appropriated for construction. Therefore both scenarios were considered in the evaluation of future without-project conditions. Scenario 2 consists of a 10 ft (NAVD 88) dune elevation with a 10 ft wide dune crest comprised of approximately 2.9 CY/ft of sand. The dune would be constructed approximately 50 ft seaward of the existing seawall. To provide environmental habitat and to reduce sand transport due to the strong winds, which frequently occur during storms, the dunes will be vegetated and protected with sand fencing. A typical cross section for Scenario 2 is shown in Figure 3.2.3-3.

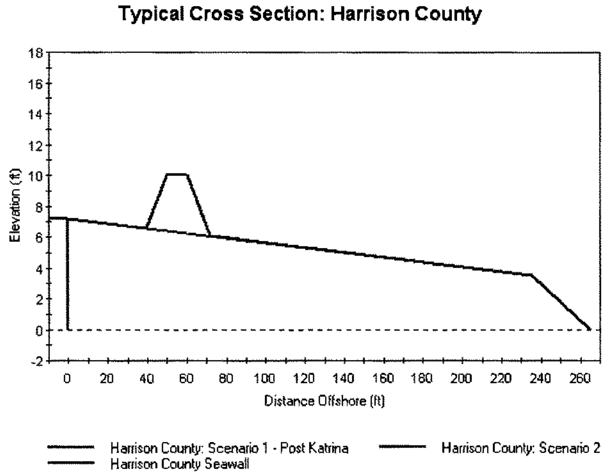


Figure 3.2.3-3. Typical Cross Sections, Harrison County Scenarios 1 and 2

3.2.3.5.1 Results-Future Without-Project Conditions

Table 3.2.3-1 summarizes the results of the Harrison County without-project Beach-*fx* simulations. The data in Table 3.2.3-1 indicate that existing beach maintenance practices will require approximately 130 CY/ft of beach over a 100 year project life assuming the existing rate of sea level rise persists into the future. If the future rate of sea level rise increases, the simulations indicate that the potential moderate rate of future sea level rise will result in about a 90 percent increase in volume requirements, whereas, a high rate of future sea level rise will result in about a 115 percent increase in project volume requirements.

Table 3.2.3-1.
Harrison County Without-Project Summary

	Number of Nourishments				Nourishment Volume (CY/ft)			
Scenario Name[1]	**mean**	**sd**	**max**	**min**	**mean**	**sd**	**max**	**min**
Scenario 1 ESLR	6	1	8	4	142.3	22.0	214.7	85.6
Scenario 2 ESLR	7	1	8	5	124.9	22.1	208.6	72.5
Scenario 1 MSLR	8	1	8	5	278.1	36.6	385.3	179.6
Scenario 2 MSLR	8	0	8	7	229.2	26.1	310.4	169.4
Scenario 1 HSLR	8	0	8	6	324.4	39.2	437.7	211.3
Scenario 1 HSLR	8	0	8	7	248.9	28.5	338.9	192.1

[1] ESLR refers to "existing" sea level rise, MSLR refers to a "moderate" potential future sea level rise rate, and HSLR refers to a "high" potential future sea level rise rate.

As a result of the difference in maintenance cycles in Harrison and Hancock counties the project volume requirements in Hancock County exceed those in Harrison County by approximately 225 percent for without project conditions under existing sea level rise conditions. For the potential future sea level rise scenarios the increase in volume requirement is about 180 percent.

3.2.3.6 Future With-Project Options

The future with-project evaluations for Harrison County included 11 options which were evaluated for environmental restoration and enhancement of environmental habitat. Options A through D included four design cross-sections with varying dune and berm configurations. The berm and dune options would be constructed adjacent to the seawall along the length of the beach. For environmental and economic purposes, Options E through H further evaluated the four design cross-sections to include sand fencing and plantings on the dune to provide environmental habitat and to reduce sand transport due to the strong winds, which frequently occur during storms. The wider dune features would provide for a larger spatial extent with which to create environmental habitat. Options A through H were evaluated in conjunction with the Line of Defense 3 seawall.

Option A consists of a 15 ft dune elevation, 35 ft dune crest width, with a dune slope of 1:3, and a berm with a 160 ft width, an upper berm elevation of 7.2 ft, and seaward berm elevation of 3.5 ft, and a foreshore slope of 1:10. Option B consists of a 13 ft dune elevation, 45 ft dune crest width, with a dune slope of 1:3, and a berm with a 160 ft width, an upper berm elevation of 7.2 ft, and seaward berm elevation of 3.5 ft, and a foreshore slope of 1:10. Option C consists of a 15 ft dune elevation, 25 ft dune crest width, with a dune slope of 1:3, and berm with a 170 ft width, an upper berm elevation of 7.2 ft, and seaward berm elevation of 3.5 ft, and a foreshore slope of 1:10. Option D consists of a 13 ft dune elevation, 15 ft dune crest width, with a dune slope of 1:3, and a berm with a 160 ft width, an upper berm elevation of 7.2 ft, and seaward berm elevation of 3.5 ft, and a foreshore slope of 1:10. Dune volumes for the Hancock County design options are 10.7 CY/ft, 7.3 CY/ft, 6.6 CY/ft, and 4.7 CY/ft, for Options A, B, C, and D, respectively. The dunes will be constructed to accommodate the approximately 10 ft wide boardwalk which extends along most of the Harrison County seawall. Typical cross sections for Options A through D are shown in Figure 3.2.3-4. The same cross sections were used for Options E through H. For Options E through H, sea oats would be planted on the seaward dune face in an 18 by 18 inch grid pattern, with a total of three rows of plants starting at the seaward toe of the dune.

Options I and J are comparative with-project options, for future evaluation, consisting of a design cross-section which includes a dune and berm constructed as a stand alone project which does not incorporate the Line of Defense 3 seawall. Option I consists of a dune feature constructed approximately 50 ft seaward of the seawall at an elevation of 15 ft (NAVD 88), with a crest width of 55 ft, and a dune slope of 1:3. The berm width would be extended to accommodate the placement of the dune feature. Sand fencing would be placed on the dunes to reduce sand transport due to the strong winds which frequently occur during storms. The cross section for Option J is the same as Option I; however the dune would be planted to provide for additional environmental habitat. For Option J, sea oats would be planted on both the landward and seaward dune face in an 18 by 18 inch grid pattern, with a total of three rows of plants starting at the landward and seaward toes of the dune. The dunes will require initial and continued maintenance of vegetation and sand fencing. A typical cross section for Options I and J is shown in Figure 3.2.3-5.

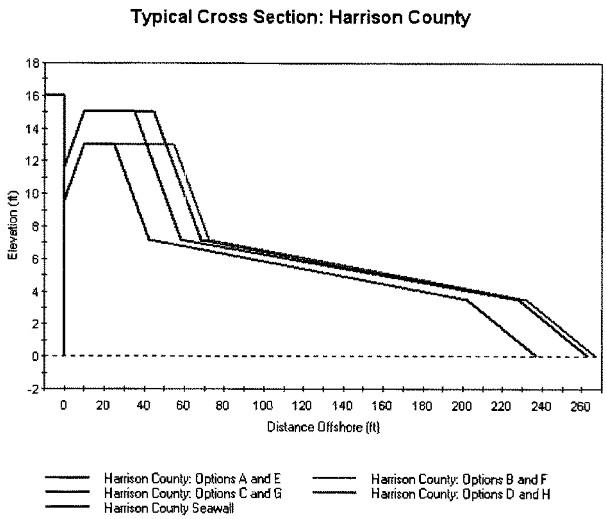


Figure 3.2.3-4. Typical Cross Sections, Harrison County Options A-D and E- H

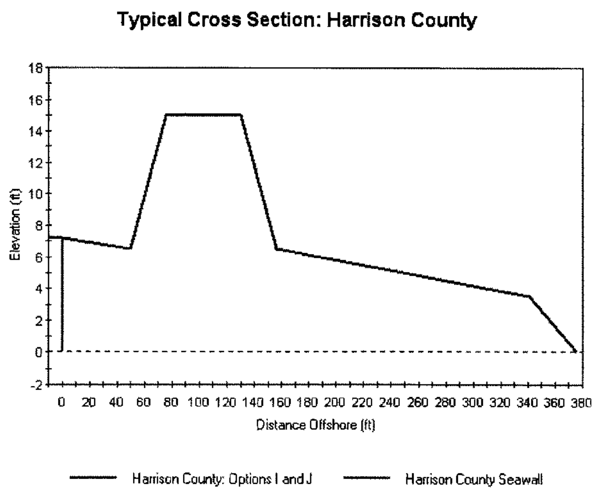


Figure 3.2.3-5. Typical Cross Section, Harrison County Comparative Dune Options I and J

Option K is also an option for future evaluation which consists of an elevated berm section constructed primarily for the creation of environmental habitat. Option K would be constructed as a stand alone option which does not incorporate the Line of Defense 3 seawall. The elevated berm section would be constructed approximately 50 ft seaward of the existing seawall to an elevation 2 ft above the existing berm with a width of approximately 60 ft. The berm width would not be extended to accommodate the placement of the elevated berm feature. The new feature would be vegetated and sand fencing would be placed to create environmental habitat and to reduce sand transport due to the strong winds which frequently occur during storms. For Option K, sea oats would be planted in a 30 by 30 inch grid pattern over the entire elevated berm area. The new feature will require initial and continued maintenance of vegetation and sand fencing. A typical cross section for Option K is shown in Figure 3.2.3-6.

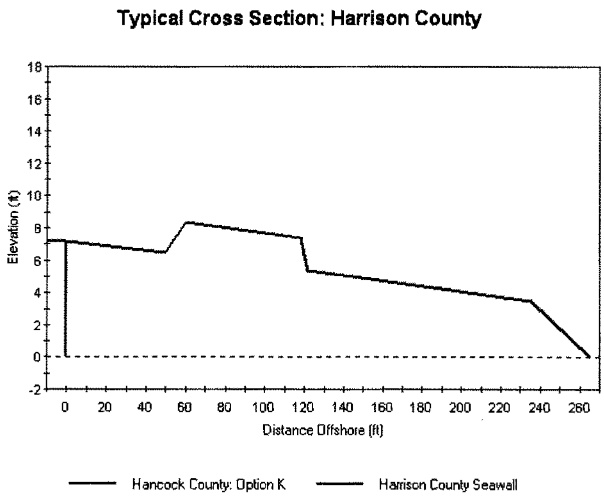


Figure 3.2.3-6. Typical Cross Section, Harrison County Option K

3.2.3.6.1 Results-Future With-Project Options

The coastal processes modeling analysis to evaluate the future with project berm and dune systems, Options A through D, were conducted through application of the engineering-economic model Beach-*fx*. The purpose of the analysis was to evaluate the physical performance of the beach and dune system for anticipated future with-project conditions and to estimate the economic costs and benefits of each. The development of the coastal processes input data for the Beach-*fx* analysis are provided in Section 2.3 of this report. The economic results of the Beach-*fx* analysis are documented in the Economic Appendices of this report. The environmental benefits of Line of Defense 2 are documented in the Environmental Appendices of this report.

Table 3.2.3-2 summarizes the Harrison County with-project Beach-*fx* simulations. The data in Table 3.2.3-2 indicate that, in general, nourishment is required at the end of every nourishment cycle (the maximum number nourishments is 9) for the moderate and high potential future sea level rise rate.

However, for the existing rate of sea level rise, on average, 2 nourishment cycles can be skipped for Option A and one nourishment cycle can be skipped for Options C and D. Nourishment volume requirements over the 100-year project life are approximately 197 CY/ft of beach assuming the existing rate of sea level rise persists into the future. If the future rate of sea level rise increases, the simulations indicate that the potential moderate rate of future sea level rise will result in about a 65 percent increase in volume requirements, whereas, a high rate of future sea level rise will result in about an 86 percent increase in project volume requirements.

Table 3.2.3-2.
Harrison County With-Project Summary

Option Name[1]	Number of Nourishments				Nourishment Volume (CY/ft)			
	mean	sd	Max	min	mean	sd	max	min
Option A ESLR	7	1	9	4	201.3	37.3	328.0	116.6
Option B ESLR	8	1	9	4	203.7	38.0	351.9	122.8
Option C ESLR	7	1	9	4	198.7	37.2	360.1	99.4
Option D ESLR	8	1	9	4	180.7	35.5	321.3	82.8
Option A MSLR	9	1	9	7	365.7	48.9	506.2	239.9
Option B MSLR	9	1	9	7	351.5	46.7	483.7	235.0
Option C MSLR	9	0	9	7	359.1	47.6	488.2	242.8
Option D MSLR	9	0	9	7	296.9	40.1	396.2	203.8
Option A HSLR	9	0	9	7	420.8	49.4	538.3	311.9
Option B HSLR	9	0	9	7	418.0	44.7	540.8	294.9
Option C HSLR	9	0	9	7	409.5	49.0	539.7	277.9
Option D HSLR	9	0	9	7	335.5	36.8	437.1	247.8

[1] ESLR refers to "existing" sea level rise, MSLR refers to a "moderate" potential future sea level rise rate, and HSLR refers to a "high" potential future sea level rise rate.

3.2.3.6.2 Summary-Future With-Project Options

The coastal processes analysis conducted as a part of this study has provided a number of useful insights with respect to morphology change, coastal evolution, and the primary drivers for storm-induced damages along the Mississippi Sound shoreline. First, the Mississippi Sound shoreline is primarily a stable, low energy coast that is dramatically impacted by tropical storm events. In the absence of tropical storm events the shoreline is expected to be only slightly erosive with shoreline change rates on the order of -1 ft/year. In general, moderate storm events produce more coastal erosion and volumetric beach change along the Mississippi Sound shoreline than do major hurricanes. This is because the large storm surge associated with the very intense storms completely inundates the beach system and protects it from the high energy dissipation associated with wave breaking, which results in less overall shoreline change and volumetric erosion of the beach. Damages to upland infrastructure are largely driven by inundation and direct wave attack as opposed to erosion, partly because most of the infrastructure is located landward of the sea wall that runs along Highway 90 in Harrison County and Beach Boulevard in Hancock County.

For with project conditions, the volume requirements in Hancock County exceed those in Harrison County by approximately 190 percent. Because the beach is restored to design conditions every year, if needed, in Hancock County the volume requirements are much larger than the volume requirements in Harrison County. In Harrison County, the beach is restored to design conditions once every 12 years. If the beach in Harrison County is damaged by a major storm in the year following reconstruction of the design template the beach remains vulnerable for the remainder of the 11 year nourishment cycle. Essentially, the present analysis indicates that the nourishment cycle in Harrison County should be shortened or augmented with a provision for emergency dune reconstruction after the occurrence of a major storm event.

3.2.3.6.3 Interior Drainage

This option will not require any interior drainage considerations.

3.2.3.6.4 Geotechnical Data

Geology. The Prairie formation is found southward of the Citronelle formation and is of Pleistocene age. This formation consists of fluvial and floodplain sediments that extend southward from the outcrop of the Citronelle formation to or near the mainland coastline. Sand found within this formation has an economic value as beach fill due to its color and quality. Southward from its outcrop area, the formation extends under the overlying Holocene deposits out into the Mississippi Sound.

The Gulfport Formation is found along the coastline in Jackson County at Belle Fontaine Beach. This formation of Pleistocene age overlies the Prairie formation and is present as well sorted sands that mark the edge of the coastline during the last high sea level stage of the Sangamonian Interglacial period. It does not extend under the Mississippi Sound.

Geotechnical. The Line 2 defense provides for the installation of dunes on the Mississippi Sound side of the existing seawalls. These dunes are intended to provide toe protection for the seawall when subjected to storm surges in the range of 3 to 5 ft. The dune slopes will be constructed to one vertical to three horizontal side slopes with a ten ft crest. The dunes for Options E through H and J thorough K will be reinforced with plantings of native sea grasses and fencing. The sand used for the dune construction would come from established off shore sources within one mile of the work area. The sands will be compatible with the existing with respect to grain size and color.

3.2.3.6.5 Structural, Mechanical and Electrical

This section is not applicable.

3.2.3.6.6 HTRW

Due to the extent and large number of real estate parcels along with the potential for re-alignment of the structural aspects of this project, no preliminary assessment was performed to identify the possibility of hazardous waste on the sites. These studies will be conducted during the next phase of work after the final siting of the various structures. The real estate costs appearing in this report therefore will not reflect any costs for remediation design and/or treatment and/or removal or disposal of these materials in the baseline cost estimate.

3.2.3.6.7 Construction Procedures and Water Control Plan

The construction procedures required for this option are similar to general construction in many respects in that the easement limits must be established and staked in the field, the work area cleared of all structures, pavements, etc. and the foundation prepared for the new work. Access ramps shall be created and temporary haul routes shall be established. All temporary haul routes shall be regraded upon completion of the work.

3.2.3.6.8 Project Security

Infrastructure Protection (IFIP). This methodology has been used for physical security for the critical infrastructure throughout the Corps of Engineers. The determination of the level of physical security provided for each facility is based on the following critical elements: 1) threat assessment of the likelihood that an adversary will attack a critical asset, 2) consequence assessment should an adversary be successful in disrupting, disabling or destroying the asset and 3) effectiveness to prevent a successful attack against an operational component.

Three levels of physical security were selected for use in this study:

Level 1 Security provides no improved security for the selected asset. This security level would be applied to the barrier islands and the sand dunes. These features present a very low threat level of attack and basically no consequence if an attack occurred and is not applicable to this option.

3.2.3.6.9 Operations and Maintenance

The features that require periodic operations will be the regarding of the dune materials within the beach system and the replacement of any appreciable loss of the sea grasses and the replacement of any damaged fence sections.

3.2.3.6.10 Cost Estimate

The costs for the various options included in this measure are presented in Section 3.2.3.7 Cost Summary. Total project costs for the various options are included in Table 3.2.3-3 and costs for the annualized Operation and Maintenance of the options are included in Table 3.2.3-4. Estimates are comparative-Level "Parametric Type" and are based on Historical Data, Recent Pricing, and Estimator's Judgment. Quantities listed within the estimates represent Major Elements of the Project Scope and were furnished by the Project Delivery Team. Price Level of Estimate is April 2007. Estimates excludes project Escalation and HTRW Cost. The total project costs include real estate, engineering design (E&D), construction management, and contingencies. The E&D cost for preparation of construction contract plans and specifications includes a detailed contract survey, preparation of contract specifications and plan drawings, estimating bid quantities, preparation of bid estimate, preparation of final submittal and contract advertisement package, project engineering and coordination, supervision technical review, computer costs and reproduction. Contingency developed and assigned at 25 percent to cover the Cost Growth of the project.

3.2.3.6.11 Schedule and Design for Construction

After the authority for the design has been issued and funds have been provided, the design of these structures will require approximately 12 months to complete comprehensive plans and specifications, independent reviews and subsequent revisions. The construction of this option should require in approximately one year.

3.2.3.7 Cost Estimate Summary

Total project costs for the various options are included in Table 3.2.3-3 and costs for the annualized Operation and Maintenance (O&M) of the options are included in Table 3.2.3-4. Estimates are comparative-Level "Parametric Type" and are based on Historical Data, Recent Pricing, and Estimator's Judgment. Quantities listed within the estimates represent Major Elements of the Project Scope and were furnished by the Project Delivery Team. Price Level of Estimate is April 2007. Estimates excludes project Escalation and HTRW Cost.

Table 3.2.3-3.
Harrison County LOD2 - Project Cost

Option	Description						Project Cost
	Dune			Berm			
	Elevation (ft)	Width (ft)	Side Slope	Width (ft)	Plantings	Sand Fencing	
A*	15	35	1:3	160			$21,840,000
B*	13	45	1:3	160			$18,600,000
C*	15	25	1:3	170			$18,100,000
D*	13	15	1:3	160			$10,400,000
E*	15	35	1:3	160	X	X	$22,970,000
F*	13	45	1:3	80	X	X	$19,760,000
G*	15	25	1:3	170	X	X	$19,210,000
H*	13	15	1:3	160	X	X	$11,520,000
I**	15	55	1:3	Extend to accommodate		X	$40,290,000
J**	15	55	1:3	Extend to accommodate	X	X	$41,460,000
K**				Add 2ft, 60 ft width	X	X	$9,680,000

* Options are in conjunction with the LOD3 Seawall
** Options are without a seawall

Table 3.2.3-4.
Harrison County LOD2 – Operation and Maintenance Cost

Option	Description						O&M Cost
	Dune			Berm			
	Elevation (ft)	Width (ft)	Side Slope	Width (ft)	Plantings	Sand Fencing	
A*	15	35	1:3	160			$5,866,473
B*	13	45	1:3	160			$4,996,172
C*	15	25	1:3	170			$4,861,867
D*	13	15	1:3	160			$2,793,559
E*	15	35	1:3	160	X	X	$6,170,004
F*	13	45	1:3	80	X	X	$5,307,761
G*	15	25	1:3	170	X	X	$5,160,025
H*	13	15	1:3	160	X	X	$3,094,403
I**	15	55	1:3	Extend to accommodate		X	$10,822,354
J**	15	55	1:3	Extend to accommodate	X	X	$11,136,629
K**				Add 2ft, 60 ft width	X	X	N/A

* Options are in conjunction with the LOD3 Seawall
** Options are without a seawall

3.2.3.8 References

Byrnes, M.R., M.W. Hiland, and R.A. McBride. 1993a. Historical shoreline position change for the mainland beach in Harrison County, Mississippi. Proceedings, Coastal Zone '93, American Shore and Beach Preservation Association, ASCE, July 19-23, 1408-1419.

Byrnes, M.R., M.W. Hiland, and R.A. McBride. 1993b. Harrison County, Mississippi, pilot erosion rate study: phase III. Prepared for Federal Emergency Management Administration, Office of Risk Assessment, Washington, D.C., under Cooperative Agreement No. EMW-90-K-3267, 45 p.

3.2.4 Jackson County Beaches

3.2.4.1 General

The purpose of this section is to provide engineering information and data for the planning and design of shore protection and restoration to the shoreline along Jackson County, MS following impacts from Hurricane Katrina, 29 August 2005. Hurricane Katrina severely damaged approximately 7 miles of public beaches.

3.2.4.2 Location

The Mississippi mainland shoreline is divided into three coastal counties: Jackson, Harrison, and Hancock Counties. Jackson County, Figure 3.2.4-1, is the eastern-most coastal county in Mississippi and is bordered on the east by the Mississippi-Alabama state line and on the west by Harrison County. Jackson County consists of four municipalities: Pascagoula, Moss Point, Gautier, and Ocean Springs. Unlike the beaches of Harrison County, the Ocean Springs beaches are off of US 90 with less traffic and congestion. The beaches along the Ocean Springs shoreline are divided into two reaches: Front Beach extending approximately 1 mile southeastward from US 90 along Front Beach drive to the Ocean Springs Harbor, and East Beach extending approximately 1 mile from the Ocean Springs Harbor to Halstead Road, Figure 3.2.4-1.

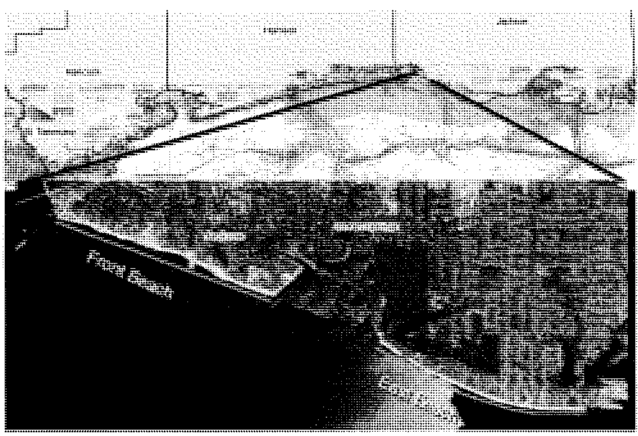


Figure 3.2.4-1. Project Location, Jackson County Beaches

3.2.4.3 Existing Conditions

The shoreline of Ocean Springs, Mississippi has undergone many changes since seaside tourism first became popular in the area a century ago. Discontinuous Pleistocene dune bluffs, interspersed with wetland-fringed bayous, were formerly fronted by muddy tidal flats containing varying amounts of shell material. Seawalls were constructed along the shoreline fronting the developed sections of Ocean Springs in the late 1920s. Two decades later, beach nourishment projects created sand beaches in front of two seawall segments, and the modern shoreline reaches of Front Beach and East Beach became named. Front Beach, more exposed to wave and tidal forces, experienced greater levels of erosion, and renourishment with dredged material was conducted in the 1970s. At wave-sheltered East Beach, marsh vegetation colonized the beachfront intertidal zone and thus assisted in the stabilization of the shoreline. These new wetlands became modified by routine beach maintenance activity in the 1980s, and shoreline retreat appears to have become more pronounced by the early 1990s (Meyer-Arendt, 1992).

Both Front Beach and East Beach systems only consist of a berm with landward elevations ranging from approximately 2.5 to 5 ft and berm widths of about 100 ft. Access ramps and pavements are located along the beach, and storm water culverts pass beneath the roadway adjacent to the beach to the shoreline to drain sections of Jackson County.

3.2.4.4 Coastal and Hydraulic Data

The climate in the project area is subtropical, characterized by warm summers and short, mild winters. The average daily temperature ranges in the summer and winter are 72–89 and 42–63 degrees Fahrenheit, respectively. The average annual rainfall is about 64 inches, and is well distributed throughout the year. Precipitation records indicate July as the wettest month, while October is the driest.

Circulation patterns within the vicinity of the project site are controlled by astronomical tides, winds, and freshwater discharges. The mean diurnal tide range in Mississippi Sound is 1.6 ft, and the extreme (except during storms) is about 3.5 ft. The magnitude of normal tidal currents ranges from 0.5 to 1.0 ft per second (fps) and their direction is generally east to west. Predominant winds average eight miles per hour (mph) from the south during the summer and from the northeast during the winter. Though the tides produced by astronomical forces are relatively small in magnitude, the wind can produce larger variations. Strong winds from the north can evacuate the sound causing current velocities of several knots in the passes to the gulf. Winds from the southeast can produce high tides, piling water up against the shoreline. Freshwater discharge into Mississippi Sound comes primarily from the Pearl River and averages approximately 12,800 cubic ft per second (cfs). Wave heights in Mississippi Sound exceed 5 ft more than 20 percent of the time in winter, but only 5 percent of the time in summer. The project area has been impacted by several tropical storms and hurricanes, most recently from Tropical Storms Arlene and Cindy, and Hurricanes Dennis and Katrina, all in 2005.

3.2.4.5 Future Without-Project Conditions

Evaluation of the Jackson County beaches was based on the analysis of the Hancock and Harrison County beaches, and information was extracted and transferred to this study area. Therefore, the reader is referred to Sections 3.2.2.5 and 3.2.2.5.1 for information regarding future without project conditions for Hancock County.

3.2.4.6 Future With-Project Options

Evaluation of the Jackson County beaches was based on the analysis of the Hancock County beaches, and information was extracted and transferred to this study area. The Jackson County beach options are the same design as the Hancock County beaches; therefore, the reader is referred to Section 3.2.2.6 for information regarding the Hancock County future with-project options.

3.2.4.6.1 Interior Drainage

This option will not require any interior drainage considerations.

3.2.4.6.2 Geotechnical Data

Geology. The Prairie formation is found southward of the Citronelle formation and is of Pleistocene age. This formation consists of fluvial and floodplain sediments that extend southward from the outcrop of the Citronelle formation to or near the mainland coastline. Sand found within this formation has an economic value as beach fill due to its color and quality. Southward from its outcrop area, the formation extends under the overlying Holocene deposits out into the Mississippi Sound.

The Gulfport Formation is found along the coastline in Jackson County at Belle Fontaine Beach. This formation of Pleistocene age overlies the Prairie formation and is present as well sorted sands that mark the edge of the coastline during the last high sea level stage of the Sangamonian Interglacial period. It does not extend under the Mississippi Sound.

Geotechnical. The Line 2 defense provides for the installation of dunes on the Mississippi Sound side of the existing seawalls. These dunes are intended to provide toe protection for the seawall when subjected to storm surges in the range of 3 to 5 ft. The dune slopes will be constructed to one vertical to three horizontal side slopes with a ten ft crest. The dunes for Options E through H and J thorough K will be reinforced with plantings of native sea grasses and fencing. The sand used for the dune construction would come from upland sources within 10 miles of the work area. The sands will be compatible with the existing sand with respect to grain size and color.

3.2.4.6.3 Structural, Mechanical and Electrical

This section is not applicable.

3.2.4.6.4 HTRW

Due to the extent and large number of real estate parcels along with the potential for re-alignment of the structural aspects of this project, no preliminary assessment was performed to identify the possibility of hazardous waste on the sites. These studies will be conducted during the next phase of work after the final siting of the various structures. The real estate costs appearing in this report therefore will not reflect any costs for remediation design and/or treatment and/or removal or disposal of these materials in the baseline cost estimate.

3.2.4.6.5 Construction Procedures and Water Control Plan

The construction procedures required for this option are similar to general construction in many respects in that the easement limits must be established and staked in the field, the work area cleared of all structures, pavements, etc. and the foundation prepared for the new work. Access ramps shall be created and temporary haul routes shall be established. All temporary haul routes shall be regraded upon completion of the work.

3.2.4.6.6 Project Security

Infrastructure Protection (IFIP). This methodology has been used for physical security for the critical infrastructure throughout the Corps of Engineers. The determination of the level of physical security provided for each facility is based on the following critical elements: 1) threat assessment of the likelihood that an adversary will attack a critical asset, 2) consequence assessment should an adversary be successful in disrupting, disabling or destroying the asset and 3) effectiveness to prevent a successful attack against an operational component.

Three levels of physical security were selected for use in this study:

Level 1 Security provides no improved security for the selected asset. This security level would be applied to the barrier islands and the sand dunes. These features present a very low threat level of attack and basically no consequence if an attack occurred and is not applicable to this option.

3.2.4.6.7 Operations and Maintenance

The features that require periodic operations will be the regarding of the dune materials within the beach system and the replacement of any appreciable loss of the sea grasses and the replacement of any damaged fence sections.

3.2.4.6.8 Cost Estimate

The costs for the various options included in this measure are presented in Section 3.2.4.7 Cost Summary. Total project costs for the various options are included in Table 3.2.4-1 and costs for the annualized Operation and Maintenance of the options are included in Table 3.2.4-2. Estimates are comparative-Level "Parametric Type" and are based on Historical Data, Recent Pricing, and Estimator's Judgment. Quantities listed within the estimates represent Major Elements of the Project Scope and were furnished by the Project Delivery Team. Price Level of Estimate is April 2007. Estimates excludes project Escalation and HTRW Cost. The total project costs include real estate, engineering design (E&D), construction management, and contingencies. The E&D cost for preparation of construction contract plans and specifications includes a detailed contract survey, preparation of contract specifications and plan drawings, estimating bid quantities, preparation of bid estimate, preparation of final submittal and contract advertisement package, project engineering and coordination, supervision technical review, computer costs and reproduction. Contingency developed and assigned at 25 percent to cover the Cost Growth of the project.

3.2.4.6.9 Schedule and Design for Construction

After the authority for the design has been issued and funds have been provided, the design of these structures will require approximately 12 months to complete comprehensive plans and specifications, independent reviews and subsequent revisions. The construction of this option should require in approximately one year.

3.2.4.7 Cost Estimate Summary

Total project costs for the various options are included in Table 3.2.4-1 and costs for the annualized Operation and Maintenance (O&M) of the options are included in Table 3.2.4-2. Estimates are comparative-Level "Parametric Type" and are based on Historical Data, Recent Pricing, and Estimator's Judgment. Quantities listed within the estimates represent Major Elements of the Project Scope and were furnished by the Project Delivery Team. Price Level of Estimate is April 2007. Estimates excludes project Escalation and HTRW Cost.

Table 3.2.4-1.
Jackson County LOD2 - Project Cost

Option	Description						Project Cost
	Dune			Berm			
	Elevation (ft)	Width (ft)	Side Slope	Width (ft)	Plantings	Sand Fencing	
A*	10	40	1:3	80			$1,910,000
B*	8	50	1:3	80			$1,450,000
C*	10	20	1:3	100			$1,180,000
D*	8	30	1:3	80			$960,000
E*	10	40	1:3	80	X	X	$1,990,000
F*	8	50	1:3	80	X	X	$1,530,000
G*	10	20	1:3	100	X	X	$1,260,000
H*	8	30	1:3	100	X	X	$1,040,000
I**	10	55	1:3	Extend to accommodate		X	$4,490,000
J**	10	55	1:3	Extend to accommodate	X	X	$4,570,000
K**				Add 2ft, 60 ft width	X	X	$1,110,000

* Options are in conjunction with the LOD3 Seawall
** Options are without a seawall

Table 3.2.4-2.
Jackson County LOD2 – Operation and Maintenance Cost

Option	Description						O&M Cost
	Dune			Berm			
	Elevation (ft)	Width (ft)	Side Slope	Width (ft)	Plantings	Sand Fencing	
A*	10	40	1:3	80			$513,048
B*	8	50	1:3	80			$389,487
C*	10	20	1:3	100			$316,961
D*	8	30	1:3	80			$257,867
E*	10	40	1:3	80	X	X	$534,537
F*	8	50	1:3	80	X	X	$410,975
G*	10	20	1:3	100	X	X	$338,450
H*	8	30	1:3	100	X	X	$279,356
I**	10	55	1:3	Extend to accommodate		X	$1,206,065
J**	10	55	1:3	Extend to accommodate	X	X	$1,227,554
K**				Add 2ft, 60ft width	X	X	N/A

* Options are in conjunction with the LOD3 Seawall
** Options are without a seawall

3.2.4.8 References

Meyer-Arendt, K. J., 1992. Shoreline Changes at Ocean Springs, Mississippi, 1900-1992: Journal of the Mississippi Academy of Sciences, v. 37, no. 1, p. 41

Rosati, J.D., Byrnes, M.R., Gravens, M.B., and Griffee, SF (draft). Mississippi Coastal Improvement Project Study: *Regional Sediment Budget for Mississippi Mainland and Barrier, in publication.*

Schmidt, K. 2002. Biennial report of sand beaches, Hancock County, 2001. Mississippi Department of Environmental Quality, Office of Geology, Open-File Report 110B, April, 53 p.

3.3 Line of Defense 3 – Elevated Roadways/Seawalls and Ring Levees

3.3.1 General

As previously mentioned, all of the beaches described as LOD-2 have a roadway landward of the beach. The 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 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. This line will be the first hard engineered structure that will not be affected by erosion from a storm such as a dune system.

Initial strategy was to study three elevations for the structure, elevations 12.0, 18.0 and 24.0. It was understood that due to limited heights, it would only provide protection from more frequent, smaller storms, but would be overtopped by some large storms. This coastal barrier will coincide with the beaches where they exist. Raising the beach-front road did present some engineering challenges due to the numerous intersections with other streets and roads. With several feet of elevation, the intersecting roads would require ramps that would be extremely long to have a reasonable grade. Each of these ramps would also create areas where rainfall would collect and have to be removed during a storm. It also soon became apparent that public opinion was against any structure that would block the view of the beaches and water from the roadways or adjoining properties immediately north of the roads. This was voiced in public meetings and also from agencies that were involved in the study. To maintain some level of support for this defense, it was decided to raise the roadways an average of six feet. This allowed reasonable road intersection construction and allowed the aesthetic view of the water to be maintained and would not be perceived as a high seawall along the coast. Review of the typical roadway elevations allowed raising the roadways in Jackson and Hancock County to Elevation 11.0 and Highway 90 in Harrison County to Elevation 16.0. It was decided to study these elevations without other options as the main part of LOD-3 with the understanding that these structures would not provide protection from large storms. As described above, the LOD-2 dunes could also be constructed against the elevated roadway to help protect the toe of the structural wall associated with the road.

This line of defense would be connected to Line 4, described below, at the mouth of Biloxi Bay and St. Louis Bay. It would also extend northward to higher ground or to Line 4 in Jackson County and Hancock County. The bays are an inlet for storm surge that will be controlled by surge gates that are a part of Line 4. It was also recognized that if LOD-3 was constructed without LOD-4, surge gates across the bays would have to be included as part of LOD-3.

As the first structural defense, Line 3 will exclude some areas that may be considered potential areas of retreat or have other non-structural solutions. This may be due to low population density, ecological sensitivity, areas that contain numerous waterway crossings or areas that could not function with a structural barrier in place. In Jackson County, Line 3 will encompass the southern portion of Ocean Springs, but due to extended marshes and streams, it will extend northeastward from near the eastern end of East Beach Road to higher ground. Areas east of this location contain numerous marshes, streams, and scattered development. Ring levees will be evaluated for housing developments in some areas. Further east in Jackson County are the cities of Gautier, Pascagoula and Moss Point. The presence of numerous streams and inlets will make a continuous barrier very difficult and these areas are also envisioned to have individual ring levees. While alignments were selected that provided the maximum protection for the most developed areas, some portions could be excluded due to cost and technical issues with closing off drainages. Redrawing the alignments would place some areas into a non-structural solution and could be considered as potential options for further study. These alternate alignments were drawn for Pascagoula/Moss Point, Bell Fontaine, and Gulf Park Estates.

At the western end of LOD-3, the barrier will extend down North Beach Boulevard for several miles to near Bayou Caddy and then turn north to tie in with higher ground. By following this path, the existing roadway will provide an alignment and it will encompass much of the developed waterfront from Bay St. Louis to Waveland, MS. Further west, the town of Pearlington will be evaluated for construction of a ring levee.

As with the main portion of LOD-3, the ring levees were initially considered with the same three elevations of 12.0, 18.0 and 24.0. Closer study revealed that in many cases, the elevation 12.0 was too low based on existing ground surfaces and the elevation 24.0 may not be high enough to be certified by FEMA for a 100-year storm event. The elevations to be studied for the ring levees then was changed to 20.0 and 30.0 with the assumption that the 100-year event would fall between these elevations and that the elevation 30.0 design would be sufficiently high for even a 500-year event. A 100-year minimum event is necessary for levee certification by FEMA. Having a conceptual design with cost estimates for these two elevations would allow for a cost curve to help predict the costs for certain storm events once the modeling studies were complete and stage frequency curves developed.

Modeling for storms that could hit the Mississippi Coast will define the predicted return frequency for LOD-3 structures based on the location and type of structure. While many options were reviewed for the type of structure to be used along the roadways, a simple elevated roadway associated with an extension of the existing seawall was chosen for reliability reasons. A structure that did not mainly rely on powered systems or with multiple moving systems was deemed more suitable for the purposes of this line of defense. As previously described, numerous conceptual designs were considered including inflatable barriers, concrete sidewalks or roadways that could be hydraulically rotated upwards to form a seawall, sliding panel gates within a seawall, and structural concrete seawalls. The ring levees were all designed as earthen structures. It should be understood that all of these LOD-3 structures would provide less protection than would be required for a Camille or Katrina-like storm. LOD-3 storm damage reduction levels are limited and will be determined based on public and local government acceptance and the amount of risk that Mississippi is willing to accept.

As previously mentioned, this line is dependent on having the ability of closure across the two bays to prevent the storm surge from running inside the mouths of the bays. While the plan calls for surge gates to be associated with Line 4, surge gates would also have to be incorporated with Line 3 if Line 4 was not selected as an alternative. The top elevation of surge gates used solely for Line 3 would be of an elevation that would be compatible with the rest of that barrier. To develop a cost curve for the barriers, cost estimates for elevations of 20.0, 30.0 and 40.0 have been completed and will be used in conjunction with both LOD-3 and LOD-4. More detailed discussion of the surge gates is found below under the LOD-4 section.

Interior drainage behind these barriers must be considered. Any large rainfall event would require that the water trapped behind the barrier have a means to drain or even be mechanically pumped.

The amount of storage that a given watershed could provide behind a barrier during surge conditions will vary. The means to block surge but allow drainage as the surge passes may include conduits with flap valves or gated culverts up to surge gates across large bodies of water. The areas where pumping is required are numerous, but necessary to prevent residual damages associated with this blockage of normal drainage.

The pumping stations, where required, must survive any storm damage and continue to operate until the storm event has passed. This will require hardened structures to house the pumps and power systems and be constructed to a height that corresponds to the risk associated with that line of defense.

At each point where a roadway crosses the protection line the decision must be made whether to maintain this artery and adapt the protection line to accommodate it, or to terminate the artery at the protection line and divert traffic to cross the protection line at another location. For this study it was assumed that the majority of roadways and all railways crossing the levee alignment would be retained.

Once the decision has been made to retain a particular roadway, it must then be determined how best to configure the artery to conduct traffic across the protection line. The simplest means of passing roadway traffic is to ramp the roadway over the protection line. This alternative is not always viable because of severe right-of-way restraints caused by extreme levee height, urban congestion, etc. In such instances other methods can be used including partial ramping in combination with low profile roller gates. In more restricted areas full height gates which would leave the roadway virtually unaltered might be preferable, even though this alternative would usually be more costly than ramping. In some extreme circumstances where high levees are required to pass through very congested areas, installation of tunnels with closure gates may be required. See Figures 3.3.1-1 and 3.3.1-2 for geometric plan representations of typical types of roadway crossing structures. All gates up to and including 9 feet high would be roller gates. All above 9 feet high would be dual leaf swing gates.

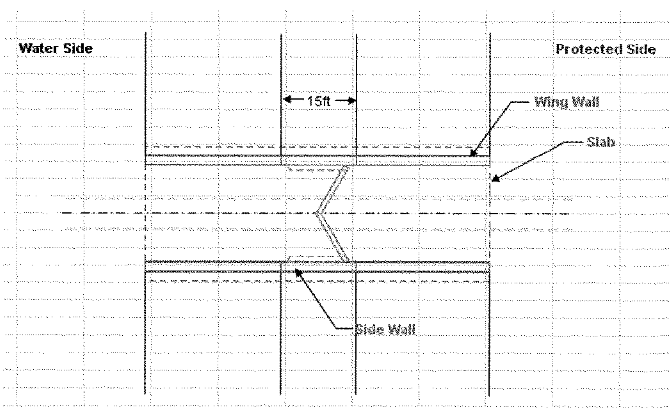


Figure 3.3.1-1. Crossings Under 9ft (two lane gate shown; gate and structure would be mirrored to provide for four-lane highway)

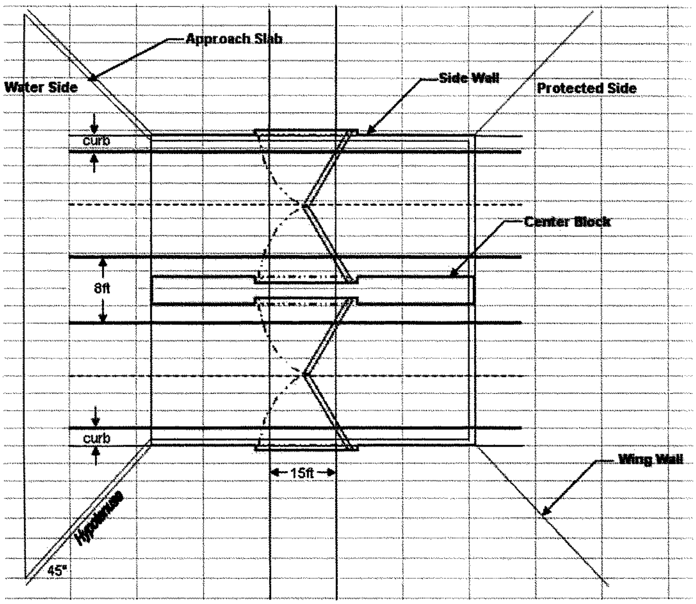


Figure 3.3.1-2. Crossing Over 9ft

Some economy could probably be achieved in this effort by combining smaller arteries and passing traffic through the protection line in fewer locations. However, this would involve detailed traffic routing studies and designs that are beyond the scope of this effort. These studies would be included in the next phase of the development of these options, should such be warranted.

Because of the extreme gradient restrictions necessarily placed on railway construction, it is practically never acceptable to elevate a railway up and over a levee. Therefore, the available alternatives would include gated pass through structures or much more expensive tunnel structures. Because of the vertical clearance requirements of railroad traffic all railroad pass through structures for this study were configured having vertical walls on either side of the railway with double swing gates extending to the full height of the levee. See Figure 3.3.1-3 for geometric plan representation of railroad crossing structures. All railroad gates were assumed to be dual leaf swing gates extending to the full height of levee.

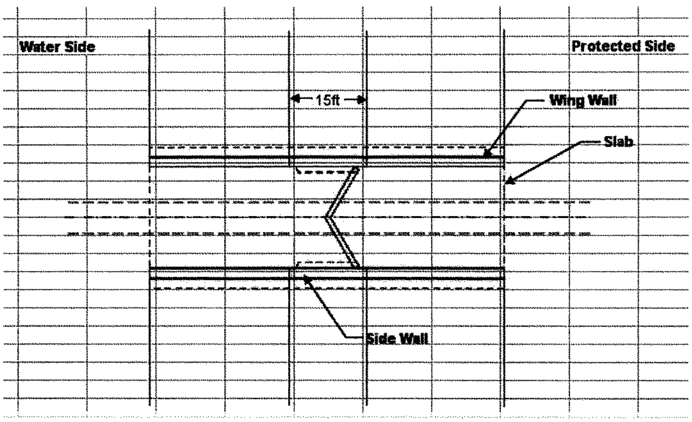


Figure 3.3.1-3. Railroad Crossings

3.3.2 Hancock County Ring Levees, Pearlington

3.3.2.1 General

Pearlington was an extremely hard hit area during the 2005 hurricane season. Water reached a depth of 10-14 ft over the whole community. An earthen ring levee was evaluated for protection of this area. The levee was evaluated at elevations 20 ft NAVD88 and 30 ft NAVD88. The top width was assumed 15 ft with sideslopes of 1 vertical to 3 horizontal. Additional options not evaluated in detail are described elsewhere in this report.

Evaluation of this protection option was done by comparing benefits computed by Hydrologic Engineering Center's (HEC) Flood Damage Analysis (FDA) computer application HEC-FDA and costs computed. HEC-FDA modeling was done comparing the study reaches using variations in expected sea-level rise and development. Details regarding the methodology are presented in Section 2.13 of the Engineering Appendix and in the Economic Appendix.

3.3.2.2 Locations

The location of the ring levee at Pearlington is shown below in Figure 3.3.2-1 and in Figure 3.3.2-2.

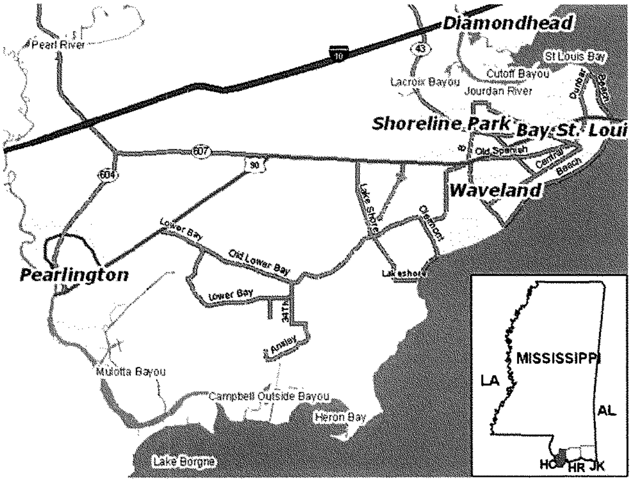


Figure 3.3.2-1. Vicinity Map, Pearlington

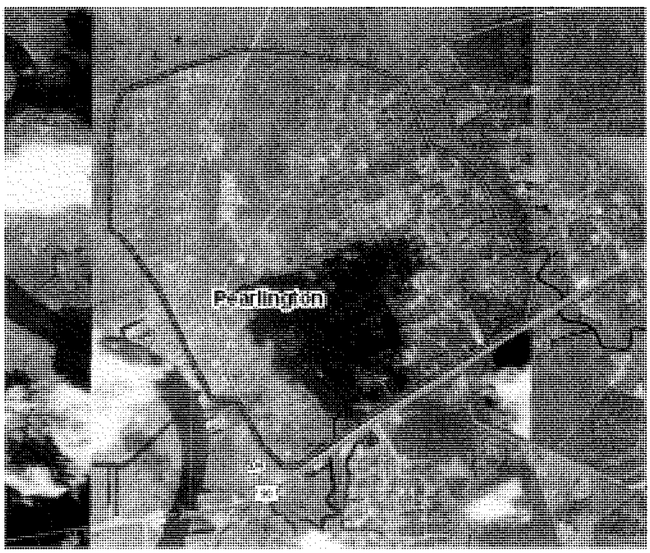


Figure 3.3.2-2. Pearlington Ring Levee

3.3.2.3 Existing Conditions

The town of Pearlington lies on the bank of the Pearl River about 5 miles from the Mississippi Sound. Ground elevations over most of the residential and business areas are very low between elevation 6-10 ft NAVD88. The city limits as well as the 4-ft(blue), 8-ft(dark green), 12-ft(green), 16-ft(brown), and 20-ft(pink) ground contour lines are shown below in Figure 3.3.2-3.

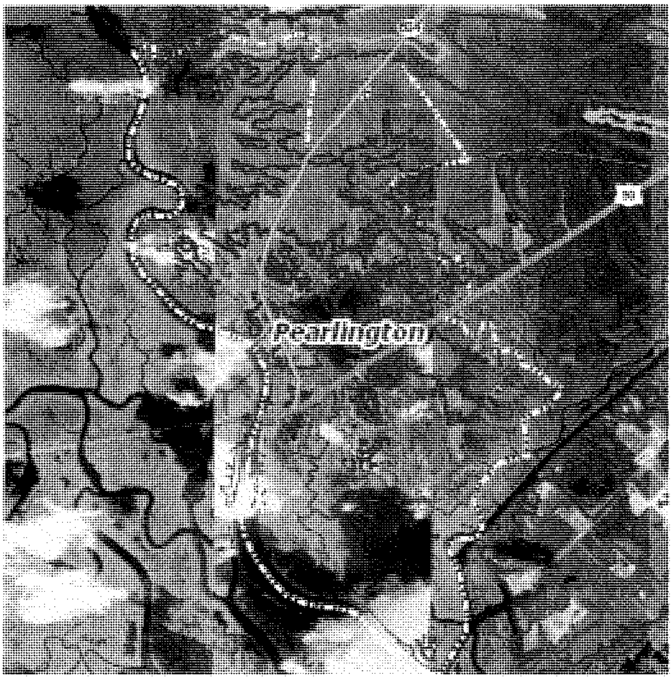


Figure 3.3.2-3. Pearlington Ground Contours and City Limits

Drainage is mostly through natural drainage ways to the Pearl River.

Impacts from hurricanes can be devastating. Damage from Hurricane Katrina in August, 2005 in the Pearlington area are shown below in Figures 3.3.2-4 and 3.3.2-5.

Source: http://ngs.woc.noaa.gov/storms/katrina/24615651.jpg

Figure 3.3.2-4. Hurricane Katrina Damage, Pearlington, MS

Source: wndyfront, http://www.flickr.com/photos/wndyfrost/230684420/

Figure 3.3.2-5. Hurricane Katrina Damage, Pearlington, MS

3.3.2.4 Coastal and Hydraulic Data

Typical coastal data are shown in Section 1.4 of this report. High water marks taken by FEMA after Hurricane Katrina in 2005 as well as the 4-ft(blue), 8-ft(dark green), 12-ft(green), 16-ft(brown), and 20-ft(pink) ground contour lines and Hurricane Katrina inundation limits are shown below in Figure 3.3.2-6. The data indicates the water was as high as 18-20 ft NAVD88 near the site, totally inundating the entire area.

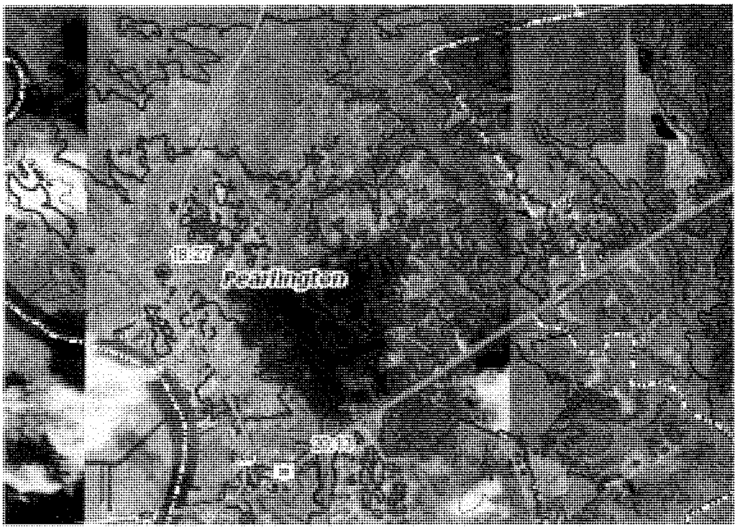


Figure 3.3.2-6. Ground Contours and Katrina High Water, Pearlington

Stage-Frequency data for a suite of severe storms using Joint Probability Method (JPM) and hydrodynamic modeling were developed by the Engineer Research and Development Center (ERDC) for 80 locations along the study area. These data were combined with historical gage frequencies for smaller storms to establish stage-frequency curves at 54 economic reaches in the study area which were entered into Hydrologic Engineering Center's (HEC) Flood Damage Analysis (HEC-FDA) application to evaluate benefits. An expanded description of the procedure is presented in Section 2.13 of the Engineering Appendix and in the Economic Appendix. Points near Pearlington at which data from hydrodynamic modeling was saved are shown below in Figure 3.3.2-7.

Existing Condition Stage –Frequency data for Save Point 62, at Highway 90 in Pearlington, is shown below in Figure 3.3.2-8. The 95% confidence limits, approximately equally to plus and minus two standard deviations, are shown bounding the median curve. The elevations are presented at 100 ft higher than actual to facilitate HEC-FDA computations.

It should be noted that the frequency curve shown above reflects only that flooding resulting from storm surge in the gulf. Riverine flooding is not incorporated into this curve.

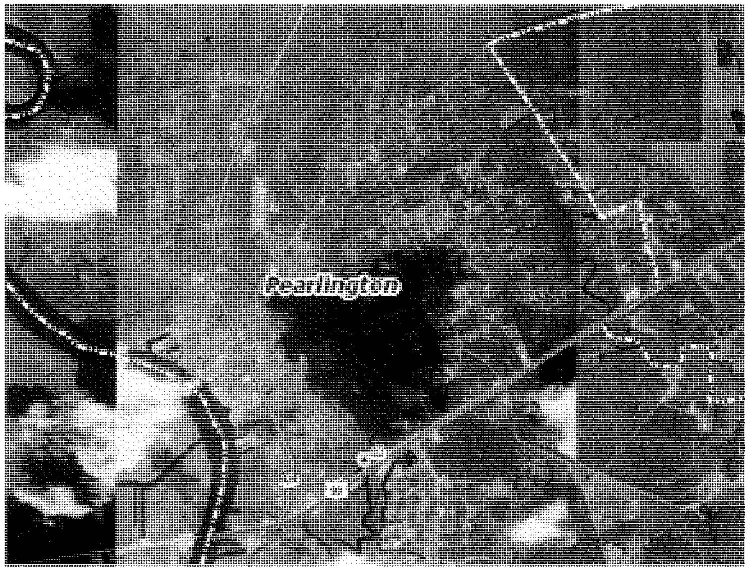


Figure 3.3.2-7. Hydrodynamic Modeling Save Point near Pearlington

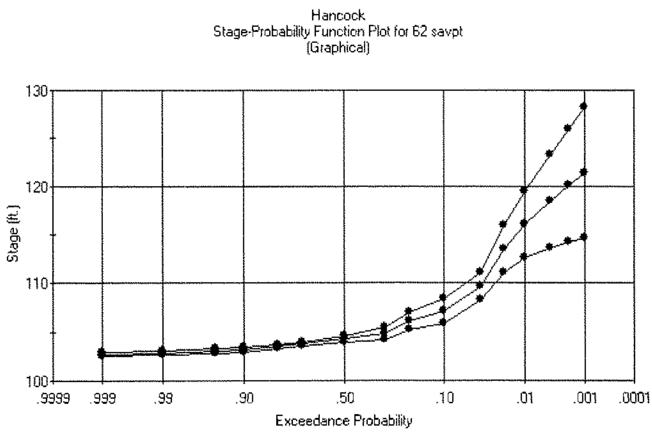


Figure 3.3.2-8. Existing Conditions at Save Point 62, near Pearlington, MS

3.3.2.5 Option A – Elevation 20 ft NAVD88

This option consists of an earthen dike enclosing an area of 1217 acres around the most densely populated areas of Pearlington as shown on the following Figure 3.3.2-9, along with the internal sub-basins and levee culvert/pump locations. The levee would have a top width of 15 ft and slopes of 1 vertical to 3 horizontal.

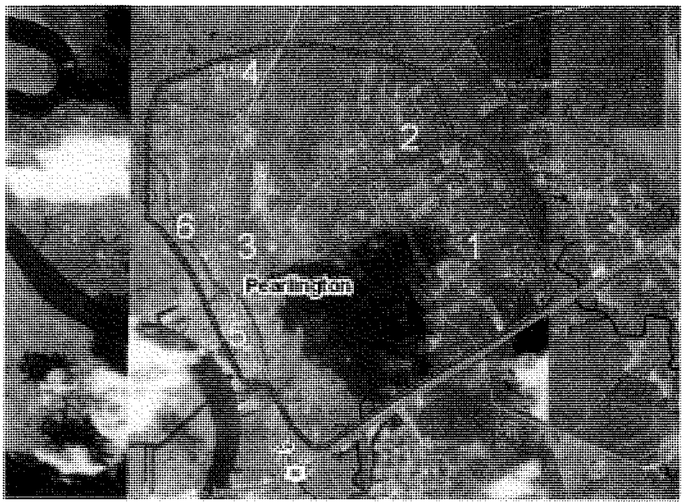


Figure 3.3.2-9. Pump/Culvert/Sub-basin Site Locations

Damage and failure by overtopping of levees could be caused by storms surges greater than the levee crest as shown below in Figure 3.3.2-10.

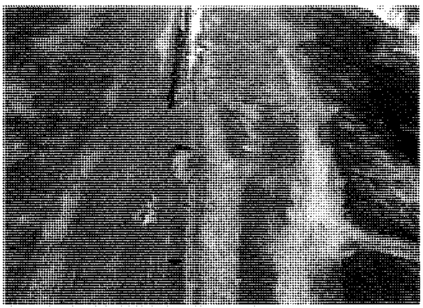
Overtopping failures are caused by the high velocity of flow on the top and back side of the levee. Although significant wave attack on the seaward side of some of the New Orleans levees occurred during Hurricane Katrina, the duration of the wave attack was for such a short time that major damage did not occur from wave action. The erosion shown below in Figure 3.3.2-11 was caused by approximately 1-2 ft of overtopping crest depth.

Revetment would be included in the levee design to prevent overtopping failure.

The levee would be protected by gabions on filter cloth as shown in Figure 3.3.2-12, extending across a drainage ditch which carries water to nearby culverts and which would also serve to dissipate some of the supercritical flow energy during overtopping conditions.

Source: Wave Overtopping Flow on Seadikes, Experimental and Theoretical Investigations, Holger Schüttrumpf, (Photo:Leichtweiss-Institute) http://kfki.baw.de/fileadmin/projects/E_35_134_Lit.pdf

Figure 3.3.2-10. North Sea, Germany, March 1976



Source: ERDC, Steven Hughes

Figure 3.3.2-11. Crown Scour from Hurricane Katrina at Mississippi River Gulf Outlet (MRGO) Levee in St. Bernard Parish, New Orleans, LA

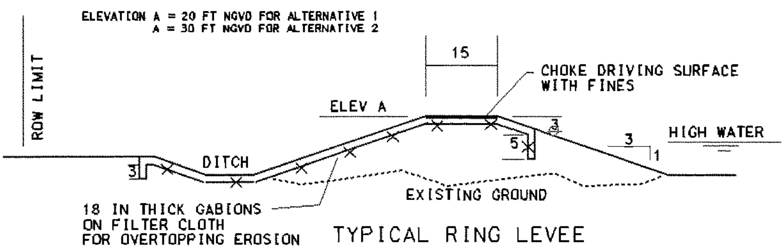


Figure 3.3.2-12. Typical Section at Ring Levee

3.3.2.5.1 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 3.3.2-13.

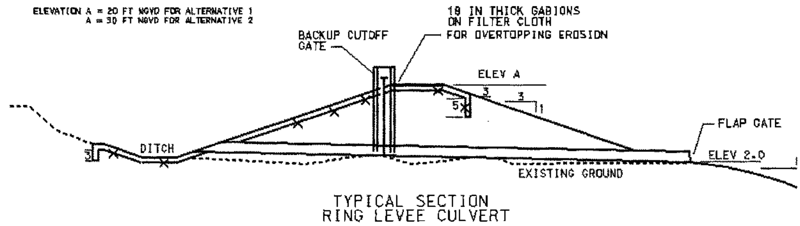


Figure 3.3.2-13. Typical Section at Culvert

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 ring levee into major sub-basins as shown below in Figure 3.3.2-14 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 are shown below in Figure 3.3.2-14.

Hydrologic soil group A soils have low runoff potential and high infiltration rates, even with thoroughly wetted and a high rate of water transmission. Hydrologic soil group B soils have moderate infiltration rates when thoroughly wetted and a moderate rate of water transmission. Hydrologic soil group C soils have low infiltration rates when thoroughly wetted and have a low rate of water transmission. Hydrologic soil group C soils have high runoff potential and a very low rate of water transmission.

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. For the culvert design, headwater elevations at the culverts were maintained at an elevation no greater than 5 ft NAVD88 with a tailwater elevation of 2.0 ft NAVD88 assumed. Drainage ditches along the toe of the levee will be required to assure that smaller basins can be drained to a culvert/pump site. These ditches were sized using a normal depth flow computation. Curve numbers, pump, and culvert capacity tables are not included in the report beyond that necessary to obtain a cost estimate. The data are considered beyond the level of detail required for this report.

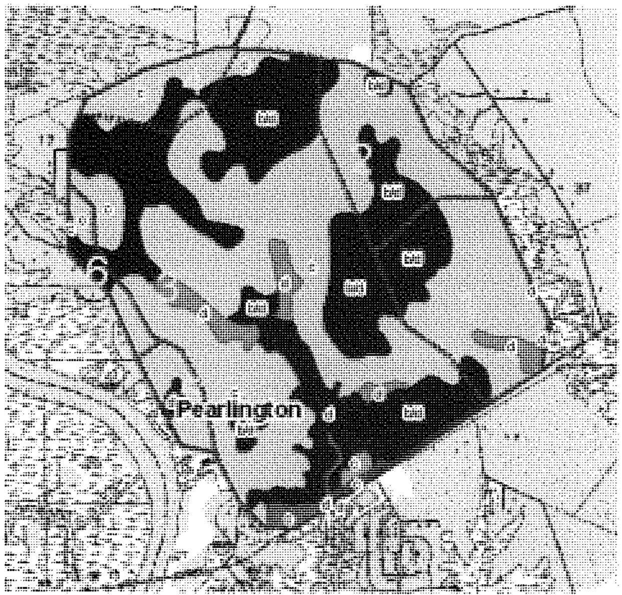


Figure 3.3.2-14. Pearlington Hydrologic Soil Groups

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. This decision was 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. However, in some of the areas, existing storage could be adequate to pond water without causing damage, even without pumps. In other areas that do have pumps, some rise in interior water during interior events greater than the 10-yr rain could occur, but may not cause damage. Designing the pumps for the peak 10-yr flow provides a significant pumping capacity. Further studies will detail the requirement for the appropriate ponding areas, pump sizes, or buyouts in the affected areas.

During non-hurricane periods of low water in the sound, when rainfall greater than the 25-yr event occurs, the pumps could also be used to augment the flow capacity of the levee culverts.

3.3.2.5.2 Geotechnical Data

Geology: Citronelle formation extends north of Interstate 10 and is a relatively thin unit of fluvial deposits of Plio-Pleistocene age consisting of gravelly sand and silty sand layers. Typically the formation is 30 to 80 feet thick, except where it has filled eroded channels in the underlying formations. The sand in the formation has a variety of colors, often associated with the presence of iron oxides in the form of hematite or goethite. Thin discontinuous clay layers are found in some areas. The iron oxide has occasionally cemented the sand into a somewhat friable sandstone, usually occurring only as a localized layer. Within the study area, this formation outcrops north of Interstate 10 and will not be encountered at project sites other than any levees that might extend northward to higher ground elevations.

The Prairie formation is found southward of the Citronelle formation and is of Pleistocene age. This formation consists of fluvial and floodplain sediments that extend southward from the outcrop of the Citronelle formation to or near the mainland coastline. Sand found within this formation has an economic value as beach fill due to its color and quality. Southward from its outcrop area, the formation extends under the overlying Holocene deposits out into the Mississippi Sound.

The Gulfport Formation is found along the coastline in most of Harrison County and western Jackson County at Belle Fontaine Beach. This formation of Pleistocene age overlies the Prairie formation and is present as well sorted sands that mark the edge of the coastline during the last high sea level stage of the Sangamonian Interglacial period. It does not extend under the Mississippi Sound.

Geotechnical: The inland barrier earthen levee section will have one vertical to three horizontal side slopes with a fifteen foot crest width. All work areas to receive the fill shall be cleared and grubbed of all trees and surface organics and all existing foundations, streets, utilities, etc. will be removed and the subsequent cavities backfilled and compacted. The levee will be constructed of sand clay materials obtained from off site commercial sources, trucked to the work area, placed in thin lifts and compacted to 95 percent of the maximum modified density. The final surface will be armored by the placement of 24 inch thick gabion mattress filled with small stone for erosion protection during an event that overtops the levee. The armoring will be anchored on the front face by trenching and extend across the downstream slope and the 25 foot easement area beyond the toe. The front side of the levee and all non critical surface areas will be subsequently covered by grassing. Road crossings will incorporate small gate structures or ramping over the embankment where the surface elevation is near that of the crest elevation. The elevation relationship of the crest and the adjacent railroad will be a governing factor. The surfaces will be paved with asphalt and the corresponding drainage will be accommodated. Those areas where the subgrade geology primarily consists of clean sands, seepage underneath the levee and the potential for erosion and instability must be considered. Final designs may require the installation of a bentonite concrete cutoff wall deep within the foundation. This condition will be investigated during any design phase and its requirement will be incorporated.

3.3.2.5.3 Structural, Mechanical and Electrical

Structural, Mechanical, and Electrical data are presented for culverts and pumping facilities. The sites are shown above.

3.3.2.5.3.1 Culverts

As any flood barrier is constructed the natural groundwater runoff would be inhibited. In order to maintain the natural runoff patterns culverts would be inserted through the protection line at appropriate locations. For this study these were configured as cast-in-place reinforced concrete box structures fitted with flap gates to minimize normal backflows and sluice gates to provide storm closure when needed. The shear number of these structures that would be required throughout the area covered by this study would dictate that an automated system be incorporated whereby the gates could be monitored and operated from some central location within defined districts. Detailed design of these monitoring and operating systems is beyond the scope of this study, however a parametric cost was developed for each site and included in the estimated construction cost for these facilities.

3.3.2.5.3.2 Pumping Facilities Structural

The layout of each pumping facility was made in conformance with Corp of Engineers Guidance document EM 1110-2-3105, Mechanical and Electrical Design of Pumping Stations. The basic plant dimensions for each site were set using approximate dimensions derived based on specific pump data (pump impeller diameter, pump bell bottom clearance, etc.). Each facility was roughly fitted to its site using existing ground elevations taken from available mapping and height of levee data. In every case the top of the pump floor was required to be above the 100 year flood elevation. Nominal sidewall and sump and pump floor thicknesses were assumed, along with wall and roof thicknesses for the pump room enclosure. Using these basic dimensions and the preliminary number and size of pumping units determined for each site, the overall plant footprint and elevations were set and quantities of basic construction materials computed. The pumping plants were configured, to the greatest extent possible with the data provided, to provide multiple pumps at each site.

Discharge piping for each plant was estimated using over the levee piping with one pipe per pumping unit. For estimating purposes the piping was sized to match the pump diameter. Each pipe was extended approximately 25 feet beyond the toe of the embankment on the discharge end to allow for energy dissipation features to be incorporated into the pipe discharge.

At the discharge end of the piping a heavy mat of grouted riprap was added as protection for the levee slope and immediately adjacent area. In each case the 4-foot deep stone mat was estimated as extending 30 feet up the levee slope and 50 feet out from the levee toe for a total width of 80 feet. The lateral extent was estimated at 10 feet per discharge pipe.

3.3.2.5.3.3 Pumping Stations Mechanical

Vertical shaft pumps were used for all of the pumping facilities. Preliminary mechanical design of the required pumping equipment was made by adaptation of manufacturer's stock pumping equipment to approximate hydraulic head and flow data developed for each pumping location. This data was coordinated with a pump manufacturer who supplied a cross check of the pump selections and cost data for use in preparation of project construction cost estimates. In consideration of the primary purpose which this equipment would serve, and in light of the widespread unavailability of electric power during and immediately after a major storm, it was determined that the pumps should be diesel engine driven.

3.3.2.5.3.4 Pumping Stations Electrical

The electrical design for these facilities would consist primarily of providing station power for the facilities. For each of the sites this would include installation of Power Poles, Cable, Power Pole Terminations, miscellaneous electrical appurtenances, and an Electrical 30 kW Diesel Generator Set for backup power.

Because of the number of pumping facilities involved and the need to closely control the pumping operations over a large area, a system of several operation and monitoring stations would be required from which the pumping facilities could be started and their operation monitored during and immediately following a storm event. The detailed design of this monitoring and operation system is beyond the scope of this study, however a parametric estimate of the cost involved in developing and installing such a system was made and included in the estimate of construction costs for these facilities.

3.3.2.5.3.5 Pumping Stations. Flow and Pump Sizes

Design hydraulic heads derived for the 6 pumping facilities included in the Pearlington Ring Levee system for the elevation 20 protection level were constant at approximately 15 feet and the corresponding flows required varied from 47,127 to 594,701 gallons per minute. The plants thus derived varied in size from a plant having one 42-inch diameter, 290 horsepower pumps, to one having eight 60-inch diameter pumps each running at 560 horsepower.

3.3.2.5.3.6 Roadways

At each point where a roadway crosses the protection line the decision must be made whether to maintain this artery and adapt the protection line to accommodate it, or to terminate the artery at the protection line and divert traffic to cross the protection line at another location. For this study it was assumed that all roadways and railways crossing the levee alignment would be retained except where it was very evident that traffic could be combined without undue congestion.

Once the decision has been made to retain a particular roadway, it must then be determined how best to configure the artery to conduct traffic across the protection line. The simplest means of passing roadway traffic is to ramp the roadway over the protection line. This alternative is not always viable because of severe right-of-way restraints caused by extreme levee height, urban congestion, etc. In such instances other methods can be used including partial ramping in combination with low profile roller gates. In more restricted areas full height gates which would leave the roadway virtually unaltered might be preferable, even though this alternative would usually be more costly than ramping. In some extreme circumstances where high levees are required to pass through very congested areas, installation of tunnels with closure gates may be required.

Some economy could probably be achieved in this effort by combining smaller arteries and passing traffic through the protection line in fewer locations. However, in most instances this would involve detailed traffic routing studies and designs that are beyond the scope of this effort. These studies would be included in the next phase of the development of these options, should such be warranted.

3.3.2.5.3.7 Railways

Because of the extreme gradient restrictions necessarily placed on railway construction, it is practically never acceptable to elevate a railway up and over a levee. Therefore, the available alternatives would include gated pass through structures. Because of the vertical clearance requirements of railroad traffic all railroad pass through structures for this study were configured having vertical walls on either side of the railway with double swing gates extending to the full height of the levee.

3.3.2.5.3.8 Levee and Roadway/Railway Intersections

With the installation of a ring levee around the Pearlington area to elevation 20, 18 roadway intersections would have to be accommodated. For this study it was estimated that all 18 would require swing gate structures.

3.3.2.5.4 HTRW

Due to the extent and large number of real estate parcels along with the potential for re-alignment of the structural aspects of this project, no preliminary assessment was performed to identify the possibility of hazardous waste on the sites. These studies will be conducted during the next phase of work after the final siting of the various structures. The real estate costs appearing in this report

therefore will not reflect any costs for remediation design and/or treatment and/or removal or disposal of these materials in the baseline cost estimate.

3.3.2.5.5 Construction Procedures and Water Control Plan

The construction procedures required for this option are similar to general construction in many respects in that the easement limits must be established and staked in the field, the work area cleared of all structures, pavements, utilities, trees, organics, etc. and the foundation prepared for the new work. Where the levee alignment crosses the existing streams or narrow bays, the alignment base shall be created by displacement with layers of crushed stone pushed ahead and compacted by the placement equipment and repeated until a stable platform is created. The required drainage culverts or other ancillary structures can then be constructed. The control of any surface water will be handled by temporary sheetpile cofferdams and pumping. The control of groundwater will be a series of wellpoints systems designed to keep the excavations dry to a depth and width sufficient to install the new work.

3.3.2.5.6 Project Security

The Protocol for security measures for this study has been performed in general accordance with the Risk Assessment Methodology for Dams (RAM-D) developed by the Interagency Forum for Infrastructure Protection (IFIP). This methodology has been used for physical security for the critical infrastructure throughout the Corps of Engineers. The determination of the level of physical security provided for each facility is based on the following critical elements: 1) threat assessment of the likelihood that an adversary will attack a critical asset, 2) consequence assessment should an adversary be successful in disrupting, disabling or destroying the asset and 3) effectiveness to prevent a successful attack against an operational component.

Three levels of physical security were selected for use in this study:

Level 1 Security provides no improved security for the selected asset. This security level would be applied to the barrier islands and the sand dunes. These features present a very low threat level of attack and basically no consequence if an attack occurred and is not applicable to this option.

Level 2 Security applies standard security measures such as road barricades, perimeter fencing, and intrusion detection systems for unoccupied buildings and vertical structures and security lighting. The intrusion detection systems will be connected to the local law enforcement office for response during an emergency. Facilities requiring this level of security would possess a higher threat level than those in Level 1 and would include assets such as levees, access roads and pumping stations.

Level 3 Security includes all of the features of Level 2 plus enhanced security measures such as the use of video cameras for real-time monitoring of the facility, monitors, motion detectors and alarm sound system in the occupied control buildings. Facilities requiring this level of security would possess the highest threat level of all the critical assets. Power plants would require this level of security.

3.3.2.5.7 Operation and Maintenance

Operation and maintenance activities for this project will be required on an annual basis. All pumps and gates will be operated to assure proper working order. Debris and shoaled sediment will be removed. Vegetation on the levees will be cut to facilitate inspection and to prevent roots from causing weak levee locations. Rills will be filled and damaged revetment will be repaired. Maintenance costs are included in this report.

3.3.2.5.8 Cost Estimate

The costs for the various options included in this measure are presented in Section 3.3.2.7, Cost Summary. Construction costs for the various options are included in Table 3.3.2-1 and costs for the annualized Operation and Maintenance of the options are included in Table 3.3.2-2. Estimates are comparative-Level "Parametric Type" and are based on Historical Data, Recent Pricing, and Estimator's Judgment. Quantities listed within the estimates represent Major Elements of the Project Scope and were furnished by the Project Delivery Team. Price Level of Estimate is April 07. Estimates excludes project Escalation and HTRW Cost. The construction costs include real estate, engineering design (E&D), construction management, and contingencies. The E&D cost for preparation of construction contract plans and specifications includes a detailed contract survey, preparation of contract specifications and plan drawings, estimating bid quantities, preparation of bid estimate, preparation of final submittal and contract advertisement package, project engineering and coordination, supervision technical review, computer costs and reproduction. Construction Contingency developed and assigned at 25% to cover the Cost Growth of the project.

3.3.2.5.9 Schedule for Design and Construction

After the authority for the design has been issued and funds have been provided, the design of these structures will require approximately 12 months including comprehensive plans and specifications, independent reviews and subsequent revisions. The construction of this option should require in excess of two years.

3.3.2.6 Option B – Elevation 30 ft NAVD88

This option consists of an earthen levee around the most populated areas of Pearlington. The alignment of the levee is the same as Option A, above, and is not reproduced here. The only difference between the description of this option and preceding description of Option A is the height of the levee, pumping facilities, number of roadway and railroad intersections, and the length of the levee culverts. Other features and methods of analysis are the same.

3.3.2.6.1 Interior Drainage

Interior drainage analysis and culverts are the same as those for Option A, above, except that the culvert lengths through the levees would be longer.

3.3.2.6.2 Geotechnical Data

The Geology and Geotechnical paragraphs for Option B are the same as for Option A, above.

3.3.2.6.3 Structural, Mechanical and Electrical

The only difference between the description of this option and preceding description of Option A is the height of the levee, pumping facilities, and the length of the levee culverts. Culvert length variations are not presented but are incorporated into the cost estimate. The other data for Option B is presented below.

3.3.2.6.3.1 Pumping Facilities. Flow and Pump Sizes. Option B.

Design hydraulic heads derived for the 6 pumping facilities included in the Pearlington Ring Levee system for the elevation 30 protection level were constant at approximately 25 feet and the corresponding flows required varied from 47,127 to 594,701 gallons per minute. The plants thus derived varied in size from a plant having one 42-inch diameter, 475 horsepower pumps, to one having eight 60-inch diameter pumps each running at 1000 horsepower.

3.3.2.6.4 HTRW

The HTRW paragraphs for Option B are the same as for Option A, above.

3.3.2.6.5 Construction and Water Control Plan

The Construction and Water Control Plan paragraphs for Option B are the same as for Option A, above.

3.3.2.6.6 Project Security

The Project Security paragraphs for Option B are the same as for Option A, above.

3.3.2.6.7 Operation and Maintenance

The Operation and Maintenance paragraphs for Option B are the same as for Option A, above.

3.3.2.6.8 Cost Estimate

The Cost Estimate paragraphs for Option B are the same as for Option A, above.

3.3.2.6.9 Schedule for Design and Construction

The Schedule for Design and Construction paragraphs for Option B are the same as for Option A, above.

3.3.2.7 Cost Estimate Summary

The costs for construction and for operations and maintenance of all options are shown in Tables 3.3.2-1 and 3.3.2-2 below. Estimates are comparative-Level "Parametric Type" and are based on Historical Data, Recent Pricing, and Estimator's Judgment. Quantities listed within the estimates represent Major Elements of the Project Scope and were furnished by the Project Delivery Team. Price Level of Estimate is April 07. Estimates excludes project Escalation and HTRW Cost.

Table 3.3.2-1.
Pearlington Ring Levee Construction Cost Summary

Option	Total project cost
Option A – Elevation 20 ft NAVD88	$104,800,000
Option B – Elevation 30 ft NAVD88	$120,200,000

Table 3.3.2-2.
Pearlington Ring Levee O & M Cost Summary

Option	O&M Cost
Option A – Elevation 20 ft NAVD88	$1,320,000
Option B – Elevation 30 ft NAVD88	$1,526,000

3.3.2.8 References

US Army Corps of Engineers (USACE) 1987. Hydrologic Analysis of Interior Areas. Engineer Manual EM 1110-2-1413. Department of the Army, US Army Corps of Engineers, Washington, D.C. 15 January 1987.

USACE 1993. Hydrologic Frequency Analysis. Engineer Manual EM 1110-2-1415. Department of the Army, US Army Corps of Engineers, Washington, D.C. 5 March 1993.

USACE 1995. Hydrologic Engineering Requirements for Flood Damage Reduction Studies. Engineer Manual EM 1110-2-1419. Department of the Army, US Army Corps of Engineers, Washington, D.C. 31 January 1995.

USACE 2006. Risk Analysis for Flood Damage Reduction Studies. Engineer Regulation ER 1105-2-101. Department of the Army, US Army Corps of Engineers, Washington, D.C. 3 January 2006.

National Resource Conservation Service (NRCS). 2003. WinTR5-55 User Guide (Draft). Agricultural Research Service. 7 May 2003.

Environmental Science Services Administration. 1968. "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.

Weather Bureau and USACE. 1956. 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.

3.3.3 Hancock County, Bay St. Louis Ring Levee

3.3.3.1 General

Bay St. Louis was an extremely hard hit area during the 2005 hurricane season. Water reached a depth of 10-20 ft over the coastal community. An earthen ring levee was evaluated for protection of this area. The levee was evaluated at elevations 20 ft NAVD88 and 30 ft NAVD88. The top width was assumed 15 ft with sideslopes of 1 vertical to 3 horizontal. Additional options not evaluated in detail are described elsewhere in this report.

Evaluation of this protection option was done by comparing benefits computed by Hydrologic Engineering Center's (HEC) Flood Damage Analysis (FDA) computer application HEC-FDA and costs computed. HEC-FDA modeling was done comparing the study reaches using variations in expected sea-level rise and development. Details regarding the methodology are presented elsewhere in this report.

3.3.3.2 Location

The location of the ring levee at Bay St. Louis is shown below in Figures 3.3.3-1 and in Figure 3.3.3-2.

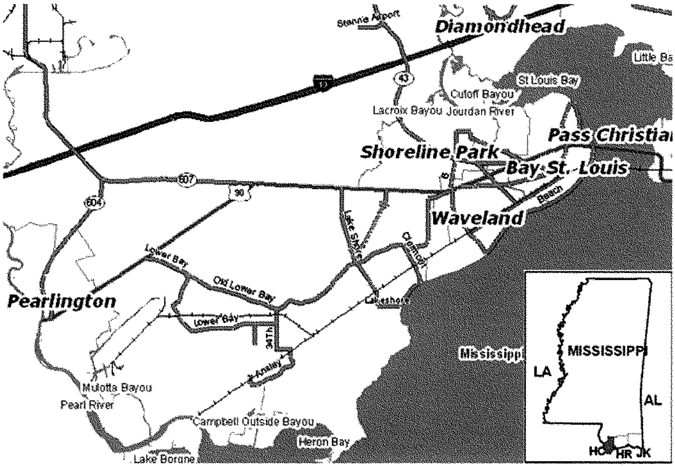


Figure 3.3.3-1. Vicinity Map, Bay St. Louis

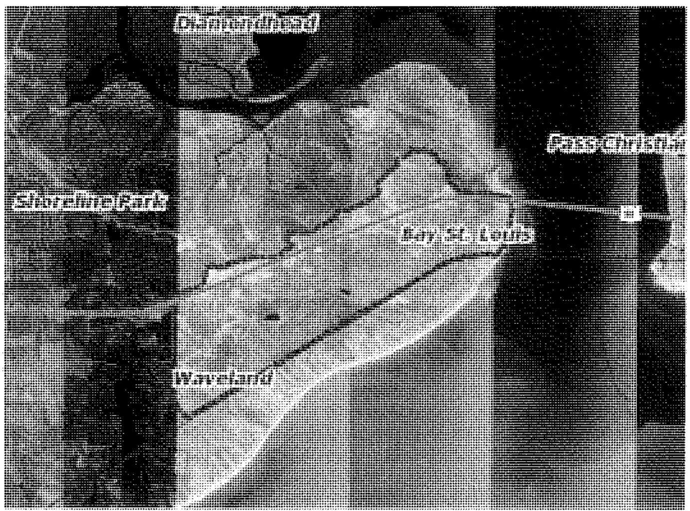


Figure 3.3.3-2. Bay St. Louis Ring Levee

3.3.3.3 Existing Conditions

Drainage at Bay St. Louis and Waveland is to the Mississippi Sound to the south and to tributaries of St. Louis Bay to the north. The Shoreline Park subdivision area to the north of Bay St. Louis is very low at elevations of 4-6 ft NAVD88 and subject to frequent flooding from storm surge. The 4-ft(blue), 8-ft(dark green), 12-ft(green), 16-ft(brown), 20-ft(peach), and 24-ft(dark pink) ground contour lines are shown below in Figure 3.3.3-3.

Impacts from hurricanes can be devastating. Damage from Hurricane Katrina in August, 2005 in the Bay St. Louis area are shown below in Figure 3.3.3-4 and 3.3.3-5.

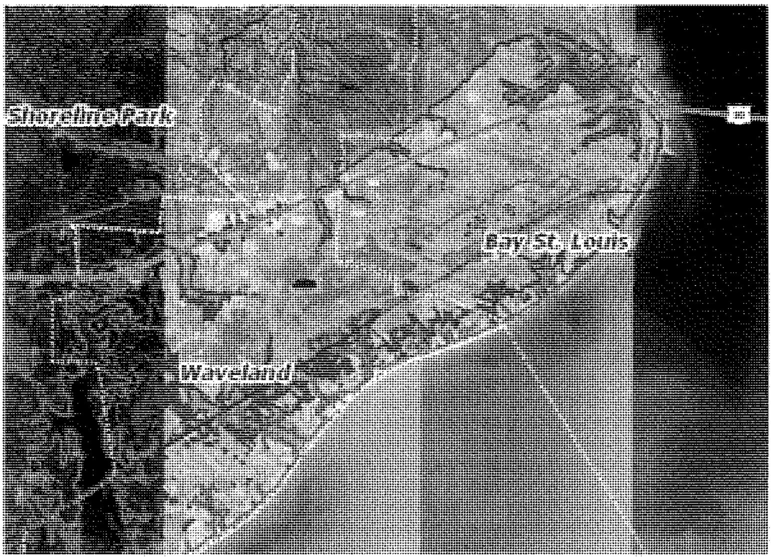


Figure 3.3.3-3. Bay St. Louis Ground Contours and City Limits

Source: http://ngs.woc.noaa.gov/storms/katrina/24614515.jpg

Figure 3.3.3-4. Hurricane Katrina Damage, Bay St. Louis, MS

Source: http://www.pbase.com/dbphotos/image/48766824

Figure 3.3.3-5. Hurricane Katrina Damage, Bay St. Louis, MS

3.3.3.4 Coastal and Hydraulic Data

Historic coastal data are shown in Paragraph 1.4, elsewhere in this report. High water marks taken by FEMA after Hurricane Katrina in 2005 as well as the 4-ft(blue), 8-ft(dark green), 12-ft(green), 16-ft(brown), 20-ft(peach), and 24-ft(dark pink) ground contour lines and Hurricane Katrina inundation limits are shown below in Figure 3.3.3-6. The data indicates the water was as high as 22-28 ft NAVD88 near the site, totally inundating most of the area.

Stage-Frequency data for a suite of severe storms using Joint Probability Method (JPM) and hydrodynamic modeling were developed by the Engineer Research and Development Center (ERDC) for 80 locations along the study area. These data were combined with historical gage frequencies for smaller storms to establish stage-frequency curves at 54 economic reaches in the study area which were entered into Hydrologic Engineering Center's (HEC) Flood Damage Analysis (HEC-FDA) application to evaluate benefits. An expanded description of the procedure is shown elsewhere in this report. Points near Bay St. Louis at which data from hydrodynamic modeling was saved are shown below in Figure 3.3.3-7.

Figure 3.3.3-6. Ground Contours and Katrina High Water, Bay St. Louis

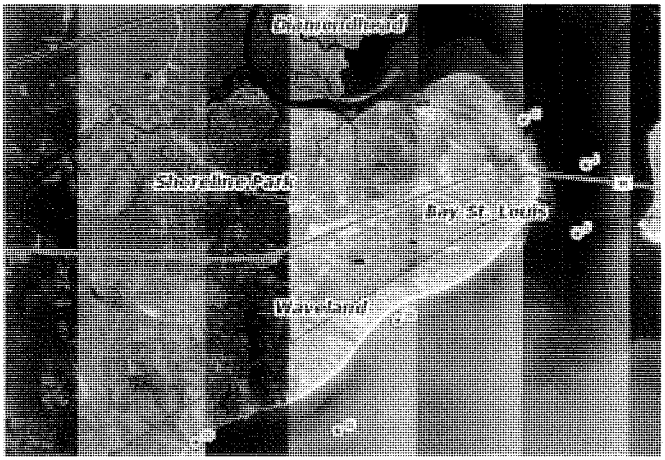


Figure 3.3.3-7. Hydrodynamic Modeling Save Point near Bay St. Louis

Existing Condition Stage –Frequency data for Save Point 62, at Highway 90 in Bay St. Louis, is shown below in Figure 3.3.3-8. The 95% confidence limits, approximately equally to plus and minus two standard deviations, are shown bounding the median curve. The elevations are presented at 100 ft higher than actual to facilitate HEC-FDA computations.

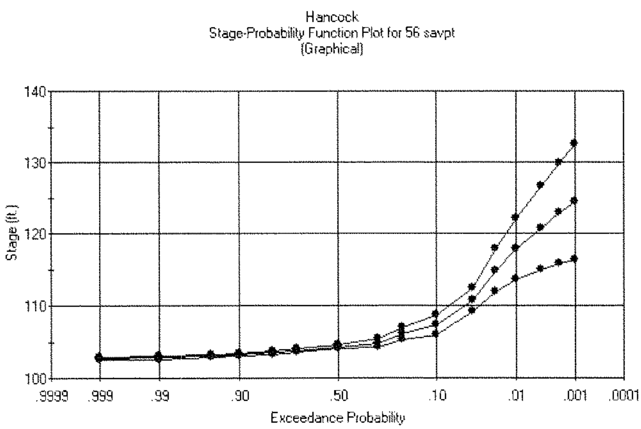


Figure 3.3.3-8. Existing Conditions at Save Point 56, near Bay St. Louis, MS

It should be noted that the frequency curve shown above reflects only that flooding resulting from storm surge in the gulf. Riverine flooding is not incorporated into this curve.

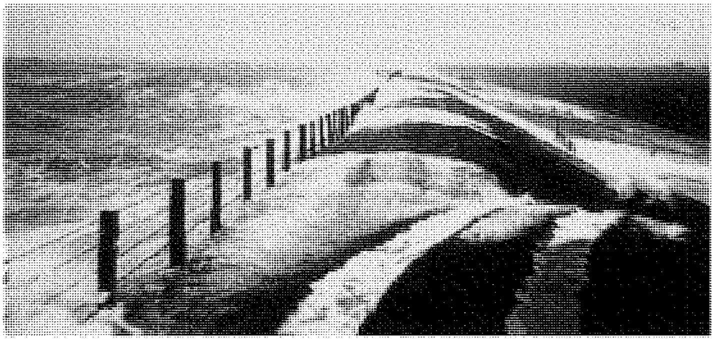
3.3.3.5 Option A – Elevation 20 ft NAVD88

This option consists of an earthen dike enclosing an area of 3591 acres around the most densely populated areas of Bay St. Louis as shown on the following Figure 3.3.3-9, along with the internal sub-basins and levee culvert/pump locations. The levee would have a top width of 15 ft and slopes of 1 vertical to 3 horizontal.

Figure 3.3.3-9. Pump/Culvert/Sub-basin Site Locations

Damage and failure by overtopping of levees could be caused by storms surges greater than the levee crest as shown in Figure 3.3.3-10.

Overtopping failures are caused by the high velocity of flow on the back side of the levee. Although significant wave attack on the seaward side of some of the New Orleans levees occurred during Hurricane Katrina, the duration of the wave attack was for such a short time that major damage did not occur from wave action. The erosion shown below in Figure 3.3.3-11 was caused by approximately 1-2 ft of overtopping crest depth.



Source: Wave Overtopping Flow on Seadikes, Experimental and Theoretical Investigations, Holger Schüttrumpf, (Photo:Leichtweiss-Institute) http://kfki.baw.de/fileadmin/projects/E_35_134_Lit.pdf

Figure 3.3.3-10. North Sea, Germany, March 1976

Source: ERDC, Steven Hughes

Figure 3.3.3-11. Crown Scour from Hurricane Katrina at Mississippi River Gulf Outlet (MRGO) Levee in St. Bernard Parish, New Orleans, LA

Revetment would be included in the levee design to prevent overtopping failure.

The levee would be protected by gabions on filter cloth as shown in Figure 3.3.3-12, extending across a drainage ditch which carries water to nearby culverts and which would also serve to dissipate some of the supercritical flow energy during overtopping conditions.

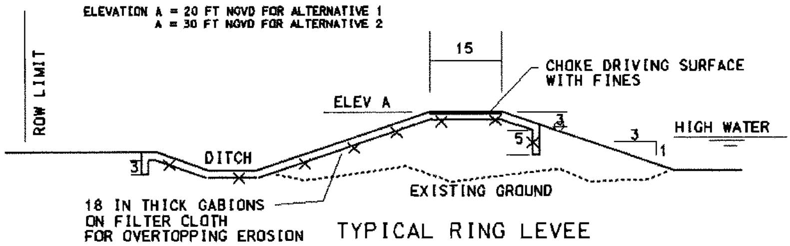


Figure 3.3.3-12. Typical Section at Ring Levee

3.3.3.5.1 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 3.3.3-13.

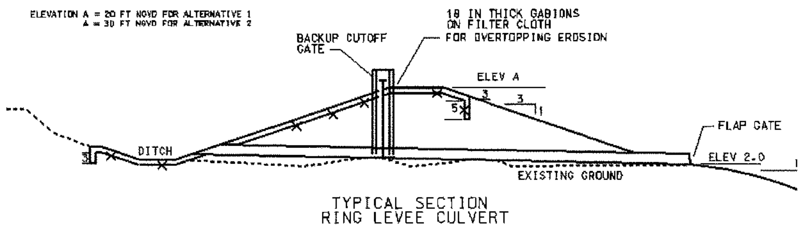


Figure 3.3.3-13. Typical Section at Culvert

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 ring levee into major sub-basins as shown in Figure 3.3.3-9 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 and their hydrologic soil grouping and sub-basins are shown in Figure 3.3.3-14.

Figure 3.3.3-14. Bay St. Louis Hydrologic Soil Groups

Hydrologic soil group A soils have low runoff potential and high infiltration rates, even with thoroughly wetted and a high rate of water transmission. Hydrologic soil group B soils have moderate infiltration rates when thoroughly wetted and a moderate rate of water transmission. Hydrologic soil group C soils have low infiltration rates when thoroughly wetted and have a low rate of water transmission. Hydrologic soil group C soils have high runoff potential and a very low rate of water transmission.

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. For the culvert design, headwater elevations at the culverts were maintained at an elevation no greater than 5 ft above the upstream invert with a tailwater elevation of 2.0 ft above the downstream invert assumed. Drainage ditches along the toe of the levee will be required to assure that smaller basins can be drained to a culvert/pump site. These ditches were sized using a normal depth flow computation. Curve numbers, pump, and culvert capacity tables are not included in the report beyond that necessary to obtain a cost estimate. The data are considered beyond the level of detail required for this report.

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. This decision was 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. However, in some of the areas, existing storage could be adequate to pond water without causing damage, even without pumps. In other areas that do have pumps, some rise in interior water during interior events greater than the 10-yr rain could occur, but may not cause damage. Designing the pumps for the peak 10-yr flow provides a significant pumping capacity. Further studies will detail the requirement for the appropriate ponding areas, pump sizes, or buyouts in the affected areas.

During non-hurricane periods of low water in the sound, when rainfall greater than the 25-yr event occurs, the pumps could also be used to augment the flow capacity of the levee culverts.

3.3.3.5.2 Geotechnical Data

Geology: Citronelle formation extends north of Interstate 10 and is a relatively thin unit of fluvial deposits of Plio-Pleistocene age consisting of gravelly sand and silty sand layers. Typically the formation is 30 to 80 feet thick, except where it has filled eroded channels in the underlying formations. The sand in the formation has a variety of colors, often associated with the presence of iron oxides in the form of hematite or goethite. Thin discontinuous clay layers are found in some areas. The iron oxide has occasionally cemented the sand into a somewhat friable sandstone, usually occurring only as a localized layer. Within the study area, this formation outcrops north of Interstate 10 and will not be encountered at project sites other than any levees that might extend northward to higher ground elevations.

The Prairie formation is found southward of the Citronelle formation and is of Pleistocene age. This formation consists of fluvial and floodplain sediments that extend southward from the outcrop of the Citronelle formation to or near the mainland coastline. Sand found within this formation has an economic value as beach fill due to its color and quality. Southward from its outcrop area, the formation extends under the overlying Holocene deposits out into the Mississippi Sound.

The Gulfport Formation is found along the coastline in most of Harrison County and western Jackson County at Belle Fontaine Beach. This formation of Pleistocene age overlies the Prairie formation and is present as well sorted sands that mark the edge of the coastline during the last high sea level stage of the Sangamonian Interglacial period. It does not extend under the Mississippi Sound.

Geotechnical: The inland barrier earthen levee section will have one vertical to three horizontal side slopes with a fifteen foot crest width. All work areas to receive the fill shall be cleared and grubbed of all trees and surface organics and all existing foundations, streets, utilities, etc. will be removed and the subsequent cavities backfilled and compacted. The levee will be constructed of sand clay materials obtained from off site commercial sources, trucked to the work area, placed in thin lifts and compacted to 95 percent of the maximum modified density. The final surface will be armored by the placement of 24 inch thick gabion mattress filled with small stone for erosion protection during an event that overtops the levee. The armoring will be anchored on the front face by trenching and extend across the downstream slope and the 25 foot easement area beyond the toe. The front side of the levee and all non critical surface areas will be subsequently covered by grassing. Road crossings will incorporate small gate structures or ramping over the embankment where the surface elevation is near that of the crest elevation. The elevation relationship of the crest and the adjacent railroad will be a governing factor. The surfaces will be paved with asphalt and the corresponding drainage will be accommodated. Those areas where the subgrade geology primarily consists of clean sands, seepage underneath the levee and the potential for erosion and instability must be considered. Final designs may require the installation of a bentonite concrete cutoff wall deep within the foundation. This condition will be investigated during any design phase and its requirement will be incorporated.

3.3.3.5.3 Structural, Mechanical and Electrical

Structural, Mechanical, and Electrical data are presented for culverts and pumping facilities. The sites are shown above.

3.3.3.5.3.1 Culverts

As any flood barrier is constructed the natural groundwater runoff would be inhibited. In order to maintain the natural runoff patterns culverts would be inserted through the protection line at appropriate locations. For this study these were configured as cast-in-place reinforced concrete box structures fitted with flap gates to minimize normal backflows and sluice gates to provide storm closure when needed. The shear number of these structures that would be required throughout the area covered by this study would dictate that an automated system be incorporated whereby the gates could be monitored and operated from some central location within defined districts. Detailed design of these monitoring and operating systems is beyond the scope of this study, however a parametric cost was developed for each site and included in the estimated construction cost for these facilities.

3.3.3.5.3.2 Pumping Facilities Structural

The layout of each pumping facility was made in conformance with Corp of Engineers Guidance document EM 1110-2-3105, Mechanical and Electrical Design of Pumping Stations. The basic plant dimensions for each site were set using approximate dimensions derived based on specific pump data (pump impeller diameter, pump bell bottom clearance, etc.). Each facility was roughly fitted to its site using existing ground elevations taken from available mapping and height of levee data. In every case the top of the pump floor was required to be above the 100 year flood elevation. Nominal sidewall and sump and pump floor thicknesses were assumed, along with wall and roof thicknesses for the pump room enclosure. Using these basic dimensions and the preliminary number and size of pumping units determined for each site, the overall plant footprint and elevations were set and quantities of basic construction materials computed. The pumping plants were configured, to the greatest extent possible with the data provided, to provide multiple pumps at each site.

Discharge piping for each plant was estimated using over the levee piping with one pipe per pumping unit. For estimating purposes the piping was sized to match the pump diameter. Each pipe was extended approximately 25 feet beyond the toe of the embankment on the discharge end to allow for energy dissipation features to be incorporated into the pipe discharge.

At the discharge end of the piping a heavy mat of grouted riprap was added as protection for the levee slope and immediately adjacent area. In each case the 4-foot deep stone mat was estimated as extending 30 feet up the levee slope and 50 feet out from the levee toe for a total width of 80 feet. The lateral extent was estimated at 10 feet per discharge pipe.

3.3.3.5.3.3 Pumping Stations Mechanical

Vertical shaft pumps were used for all of the pumping facilities. Preliminary mechanical design of the required pumping equipment was made by adaptation of manufacturer's stock pumping equipment to approximate hydraulic head and flow data developed for each pumping location. This data was coordinated with a pump manufacturer who supplied a cross check of the pump selections and cost data for use in preparation of project construction cost estimates. In consideration of the primary purpose which this equipment would serve, and in light of the widespread unavailability of electric power during and immediately after a major storm, it was determined that the pumps should be diesel engine driven.

3.3.3.5.3.4 Pumping Stations Electrical

The electrical design for these facilities would consist primarily of providing station power for the facilities. For each of the sites this would include installation of Power Poles, Cable, Power Pole Terminations, miscellaneous electrical appurtenances, and an Electrical 30 kW Diesel Generator Set for backup power.

Because of the number of pumping facilities involved and the need to closely control the pumping operations over a large area, a system of several operation and monitoring stations would be required from which the pumping facilities could be started and their operation monitored during and immediately following a storm event. The detailed design of this monitoring and operation system is beyond the scope of this study, however a parametric estimate of the cost involved in developing and installing such a system was made and included in the estimate of construction costs for these facilities.

3.3.3.5.3.5 Pumping Stations. Flow and Pump Sizes

Design hydraulic heads derived for the 12 pumping facilities included in the Bay St. Louis Ring Levee system for the elevation 20 protection level varied from approximately 10 feet to 15 feet and the corresponding flows required varied from 56,695 to 390,483 gallons per minute. The plants thus derived varied in size from a plant having two 36-inch diameter, 125 horsepower pumps, to one having eight 42-inch diameter pumps each running at 290 horsepower.

3.3.3.5.3.6 Roadways

At each point where a roadway crosses the protection line the decision must be made whether to maintain this artery and adapt the protection line to accommodate it, or to terminate the artery at the protection line and divert traffic to cross the protection line at another location. For this study it was assumed that all roadways and railways crossing the levee alignment would be retained except where it was very evident that traffic could be combined without undue congestion.

Once the decision has been made to retain a particular roadway, it must then be determined how best to configure the artery to conduct traffic across the protection line. The simplest means of passing roadway traffic is to ramp the roadway over the protection line. This alternative is not always viable because of severe right-of-way restraints caused by extreme levee height, urban congestion, etc. In such instances other methods can be used including partial ramping in combination with low profile roller gates. In more restricted areas full height gates which would leave the roadway virtually unaltered might be preferable, even though this alternative would usually be more costly than ramping. In some extreme circumstances where high levees are required to pass through very congested areas, installation of tunnels with closure gates may be required.

Some economy could probably be achieved in this effort by combining smaller arteries and passing traffic through the protection line in fewer locations. However, in most instances this would involve detailed traffic routing studies and designs that are beyond the scope of this effort. These studies would be included in the next phase of the development of these options, should such be warranted.

3.3.3.5.3.7 Levee and Roadway/Railway Intersections

With the installation of a ring levee around the Bay St. Louis area to elevation 20, 21 roadway intersections would have to be accommodated. For this study it was estimated that of this number, 4 would require swing gate structures, with the rest requiring roller gates of various heights.

3.3.3.5.4 HTRW

Due to the extent and large number of real estate parcels along with the potential for re-alignment of the structural aspects of this project, no preliminary assessment was performed to identify the possibility of hazardous waste on the sites. These studies will be conducted during the next phase of work after the final siting of the various structures. The real estate costs appearing in this report therefore will not reflect any costs for remediation design and/or treatment and/or removal or disposal of these materials in the baseline cost estimate.

3.3.3.5.5 Construction Procedures and Water Control Plan

The construction procedures required for this option are similar to general construction in many respects in that the easement limits must be established and staked in the field, the work area cleared of all structures, pavements, utilities, trees, organics, etc. and the foundation prepared for the new work. Where the levee alignment crosses the existing streams or narrow bays, the alignment base shall be created by displacement with layers of crushed stone pushed ahead and compacted by the placement equipment and repeated until a stable platform is created. The required drainage culverts or other ancillary structures can then be constructed. The control of any surface water will be handled by temporary sheetpile cofferdams and pumping. The control of groundwater will be a series of wellpoints systems designed to keep the excavations dry to a depth and width sufficient to install the new work.

3.3.3.5.6 Project Security

The Protocol for security measures for this study has been performed in general accordance with the Risk Assessment Methodology for Dams (RAM-D) developed by the Interagency Forum for Infrastructure Protection (IFIP). This methodology has been used for physical security for the critical infrastructure throughout the Corps of Engineers. The determination of the level of physical security provided for each facility is based on the following critical elements: 1) threat assessment of the likelihood that an adversary will attack a critical asset, 2) consequence assessment should an adversary be successful in disrupting, disabling or destroying the asset and 3) effectiveness to prevent a successful attack against an operational component.

Three levels of physical security were selected for use in this study:

Level 1 Security provides no improved security for the selected asset. This security level would be applied to the barrier islands and the sand dunes. These features present a very low threat level of attack and basically no consequence if an attack occurred and is not applicable to this option.

Level 2 Security applies standard security measures such as road barricades, perimeter fencing, and intrusion detection systems for unoccupied buildings and vertical structures and security lighting. The intrusion detection systems will be connected to the local law enforcement office for response during an emergency. Facilities requiring this level of security would possess a higher threat level than those in Level 1 and would include assets such as levees, access roads and pumping stations.

Level 3 Security includes all of the features of Level 2 plus enhanced security measures such as the use of video cameras for real-time monitoring of the facility, monitors, motion detectors and alarm sound system in the occupied control buildings. Facilities requiring this level of security would possess the highest threat level of all the critical assets. Power plants would require this level of security.

3.3.3.5.7 Operation and Maintenance

Operation and maintenance activities for this project will be required on an annual basis. All pumps and gates will be operated to assure proper working order. Debris and shoaled sediment will be removed. Vegetation on the levees will be cut to facilitate inspection and to prevent roots from causing weak levee locations. Rills will be filled and damaged revetment will be repaired. Scheduled maintenance should include periodic greasing of all gears and coupled joints, maintaining any battery backup systems, and replacement of standby fuel supplies.

3.3.3.5.8 Cost Estimate

The costs for the various options included in this measure are presented in Section 3.3.3.7.Cost Summary. Construction costs for the various options are included in Table 3.3.3-1 and costs for the annualized Operation and Maintenance of the options are included in Table 3.3.3-2. Estimates are comparative-Level "Parametric Type" and are based on Historical Data, Recent Pricing, and Estimator's Judgment. Quantities listed within the estimates represent Major Elements of the Project Scope and were furnished by the Project Delivery Team. Price Level of Estimate is April 07. Estimates excludes project Escalation and HTRW Cost. The construction costs include real estate, engineering design (E&D), construction management, and contingencies. The E&D cost for preparation of construction contract plans and specifications includes a detailed contract survey, preparation of contract specifications and plan drawings, estimating bid quantities, preparation of bid estimate, preparation of final submittal and contract advertisement package, project engineering and coordination, supervision technical review, computer costs and reproduction. Construction Contingency developed and assigned at 25% to cover the Cost Growth of the project.

3.3.3.5.9 Schedule for Design and Construction

After the authority for the design has been issued and funds have been provided, the design of these structures will require approximately 12 months including comprehensive plans and specifications, independent reviews and subsequent revisions. The construction of this option should require in excess of two years.

3.3.3.6 Option B – Elevation 30 ft NAVD88

This option consists of an earthen levee around the most populated areas of Bay St. Louis. The alignment of the levee is the same as Option A, above, and is not reproduced here. The only difference between the description of this option and preceding description of Option A is the height of the levee, pumping facilities, number of roadway and railroad intersections, and the length of the levee culverts. Other features and methods of analysis are the same.

3.3.3.6.1 Interior Drainage

Interior drainage analysis and culverts are the same as those for Option A, above, except that the culvert lengths through the levees would be longer.

3.3.3.6.2 Geotechnical Data

The Geology and Geotechnical paragraphs for Option B are the same as for Option A, above.

3.3.3.6.3 Structural, Mechanical and Electrical

The only difference between the description of this option and preceding description of Option A is the height of the levee, pumping facilities, and the length of the levee culverts. Culvert length variations are not presented but are incorporated into the cost estimate. The other data for Option B is presented below.

Pumping Facilities. Flow and Pump Sizes. Option B. Design hydraulic heads derived for the 12 pumping facilities included in the Bay St. Louis Ring Levee system for the elevation 30 protection level varied from approximately 20 feet to 30 feet, and the corresponding flows required varied from 56,695 to 390,483gallons per minute. The plants thus derived varied in size from a plant having 2 36-inch diameter, 250 horsepower pumps, to one having eight 42-inch diameter pumps, each running at 475 horsepower.

3.3.3.6.3.1 Levee and Roadway/Railway Intersections

With the installation of a ring levee around the Bay St. Louis area to elevation 30, 69 roadway intersections would have to be accommodated. For this study it was estimated that of this number, 62 would require swing gate structures, with the remaining 7 requiring roller gates of various heights.

3.3.3.6.4 HTRW

The HTRW paragraphs for Option B are the same as for Option A, above.

3.3.3.6.5 Construction and Water Control Plan

The Construction and Water Control Plan paragraphs for Option B are the same as for Option A, above.

3.3.3.6.6 Project Security

The Project Security paragraphs for Option B are the same as for Option A, above.

3.3.3.6.7 Operation and Maintenance

The Operation and Maintenance paragraphs for Option B are the same as for Option A, above.

3.3.3.6.8 Cost Estimate

The Cost Estimate paragraphs for Option B are the same as for Option A, above.

3.3.3.6.9 Schedule for Design and Construction

The Schedule for Design and Construction paragraphs for Option B are the same as for Option A, above.

3.3.3.7 Cost Estimate Summary

The costs for construction and for operations and maintenance of all options are shown in Tables 3.3.3-1 and 3.3.3-2 below. Estimates are comparative-Level "Parametric Type" and are based on Historical Data, Recent Pricing, and Estimator's Judgment. Quantities listed within the estimates represent Major Elements of the Project Scope and were furnished by the Project Delivery Team. Price Level of Estimate is April 07. Estimates excludes project Escalation and HTRW Cost.

Table 3.3.3-I.
Bay St Louis Ring Levee Construction Cost Summary

Option	Total project cost
Option A – Elevation 20 ft NAVD88	$283,000,000
Option B – Elevation 30 ft NAVD88	$382,900,000

Table 3.3.3-2.
Bay St Louis Ring Levee O & M Cost Summary

Option	O&M Costs
Option A – Elevation 20 ft NAVD88	$2,002,000
Option B – Elevation 30 ft NAVD88	$2,803,000

3.3.3.8 References

US Army Corps of Engineers (USACE) 1987. Hydrologic Analysis of Interior Areas. Engineer Manual EM 1110-2-1413. Department of the Army, US Army Corps of Engineers, Washington, D.C. 15 January 1987.

USACE 1993. Hydrologic Frequency Analysis. Engineer Manual EM 1110-2-1415. Department of the Army, US Army Corps of Engineers, Washington, D.C. 5 March 1993.

USACE 1995. Hydrologic Engineering Requirements for Flood Damage Reduction Studies. Engineer Manual EM 1110-2-1419. Department of the Army, US Army Corps of Engineers, Washington, D.C. 31 January 1995.

USACE 2006. Risk Analysis for Flood Damage Reduction Studies. Engineer Regulation ER 1105-2-101. Department of the Army, US Army Corps of Engineers, Washington, D.C. 3 January 2006.

National Resource Conservation Service (NRCS). 2003. WinTR5-55 User Guide (Draft). Agricultural Research Service. 7 May 2003.

Environmental Science Services Administration. 1968. "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.

Weather Bureau and USACE. 1956. 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.

3.3.4 Hancock County, Elevated Roadway

3.3.4.1 General

Residential and business areas along the coast in Hancock County are susceptible to storm surge damage. A damage reduction option is to raise the beach front road in Hancock County to elevation 11ft NAVD88 was evaluated. The levee alignment is shown in red below. Additional options not evaluated in detail are described elsewhere in this report. The option consists of more than one element and function. This option also contains a provision for a levee at elevation 16 ft NAVD88, shown in blue below. The elevation 16 ft NAVD88 levee functions in coordination with the Harrison County Elevated Hwy 90 Roadway also at elevation 16 ft NAVD and the St. Louis Bay closure structure.

Evaluation of this option was done by comparing benefits computed by Hydrologic Engineering Center's (HEC) Flood Damage Analysis (FDA) computer application HEC-FDA and costs computed. HEC-FDA modeling was done comparing the study reaches using variations in expected sea-level rise and development. Details regarding the methodology are presented in Section 2.13 of the Engineering Appendix and in the Economic Appendix.

3.3.4.2 Location

The location of project in Hancock County is shown below in Figure 3.3.4-1.

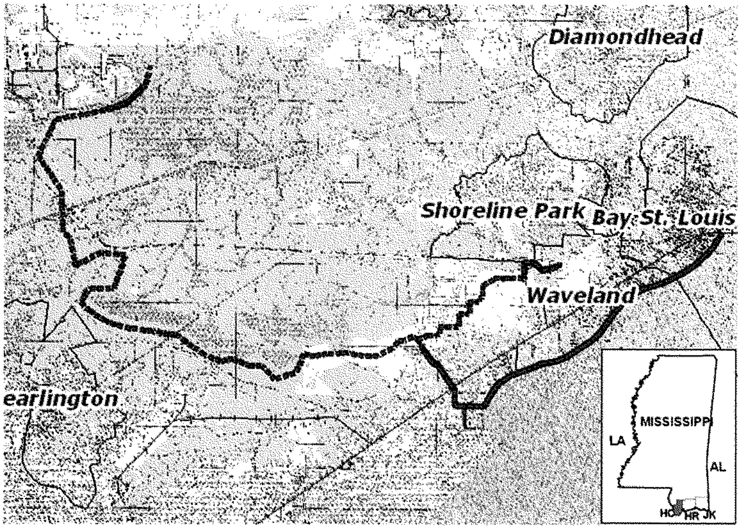


Figure 3.3.4-1. Vicinity Map near Waveland

3.3.4.3 Existing Conditions

The beach front road in Hancock County joins the communities of Bay St. Louis and Waveland at the mouth of St. Louis Bay. The 4-ft(blue), 8-ft(dark green), 12-ft(green), 16-ft(brown), and 20-ft(pink) ground contour lines are shown below in Figure 3.3.4-2.

Drainage at Bay St. Louis and Waveland is to the Mississippi Sound to the south and to tributaries of St. Louis Bay to the north. The Shoreline Park subdivision area to the north of Bay St. Louis is very low at elevations of 4-6 ft NAVD88 and subject to frequent flooding from storm surge.

Impacts from hurricanes can be devastating. Damage from Hurricane Katrina in August, 2005 in the Waveland area are shown below in Figures 3.3.4-3 and 3.3.4-4.

3.3.4.4 Coastal and Hydraulic Data

Typical coastal data are shown in Section 1.4 of this report. High water marks taken by FEMA after Hurricane Katrina in 2005 as well as the 4-ft(blue), 8-ft(dark green), 12-ft(green), 16-ft(brown), and 20-ft(pink) ground contour lines and Hurricane Katrina inundation limits are shown below in Figure 3.3.4-5. The data indicates the Katrina high water was as high as 28 ft NAVD88 near the Mississippi Sound, totally inundating the area.

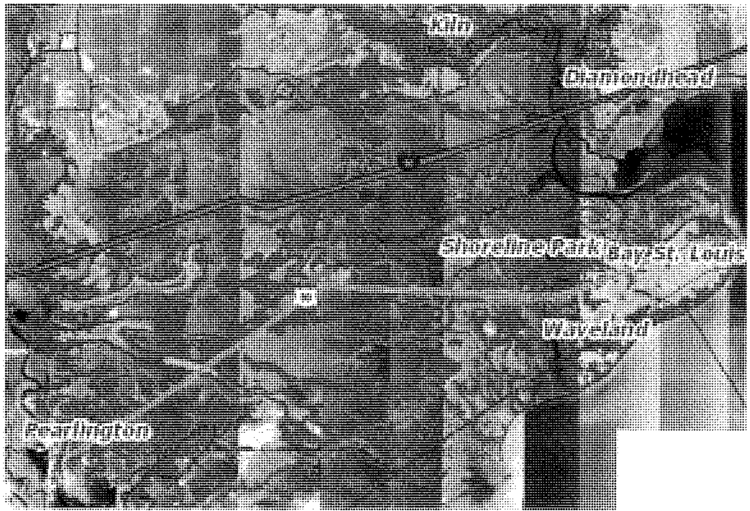


Figure 3.3.4-2. Existing Conditions near Waveland

Source: http://ngs.woc.noaa.gov/storms/katrina/24334552.jpg

Figure 3.3.4-3. Hurricane Katrina Damage near Waveland

Source:G.J. Charlet III, http://www.flickr.com/photo_zoom.gne?id=46937047&size=m

Figure 3.3.4-4. Hurricane Katrina Damage near Waveland

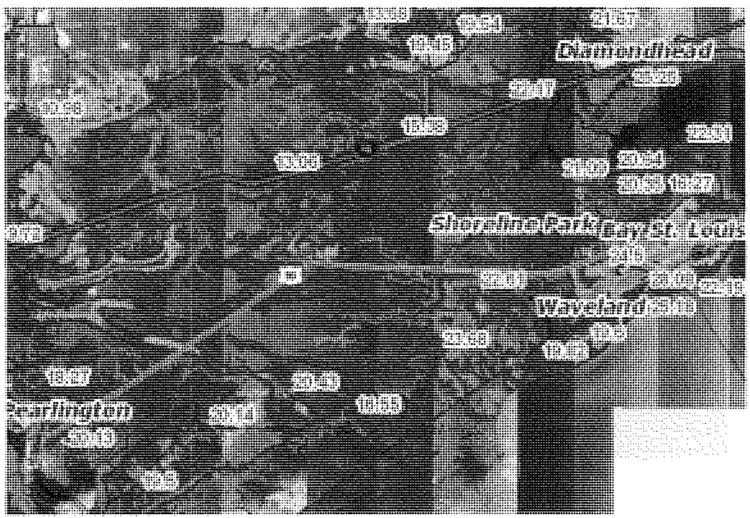


Figure 3.3.4-5. Ground Contours and Katrina High Water, Coastal Hancock Co.

Stage-Frequency data for a suite of severe storms using Joint Probability Method (JPM) and hydrodynamic modeling were developed by the Engineer Research and Development Center (ERDC) for 80 locations along the study area. These data were combined with historical gage frequencies for smaller storms to establish stage-frequency curves at 54 economic reaches in the study area which were entered into Hydrologic Engineering Center's (HEC) Flood Damage Analysis (HEC-FDA) application to evaluate benefits. An expanded description of the procedure is presented in Section 2.13 of the Engineering Appendix and in the Economic Appendix. Points near Ocean Springs at which data from hydrodynamic modeling was saved are shown below in Figure 3.3.4-6.

Existing Condition Stage –Frequency data for Save Point 56, just off the coast of Waveland, is shown below as an example in Figure 3.3.4-7. The 95% confidence limits, approximately equally to plus and minus two standard deviations, are shown bounding the median curve. The elevations are presented at 100 ft higher than actual to facilitate HEC-FDA computations.

3.3.4.5 Option – Elevate Roadway to 11 ft NAVD88

This option consists of raising the beach front road to elevation 11 ft NAVD88 in the Bay St. Louis/Waveland area as shown on the following Figures 3.3.4-8 and 3.3.4-9, along with the internal sub-basins and levee culvert/pump locations. There is one culvert but no pumps associated with the Elevation 16 ft NAVD88 levee. This levee runs mostly along the ridge line so the drainage is away from the levee. A small boat access structure is also shown at the mouth of one basin. Rising sector gates will be provided at this gate allowing shallow draft traffic most of the time. The gate will be closed prior to hurricane storm surge. A drawing of a typical boat access gate is shown in Figure 3.3.11-15.

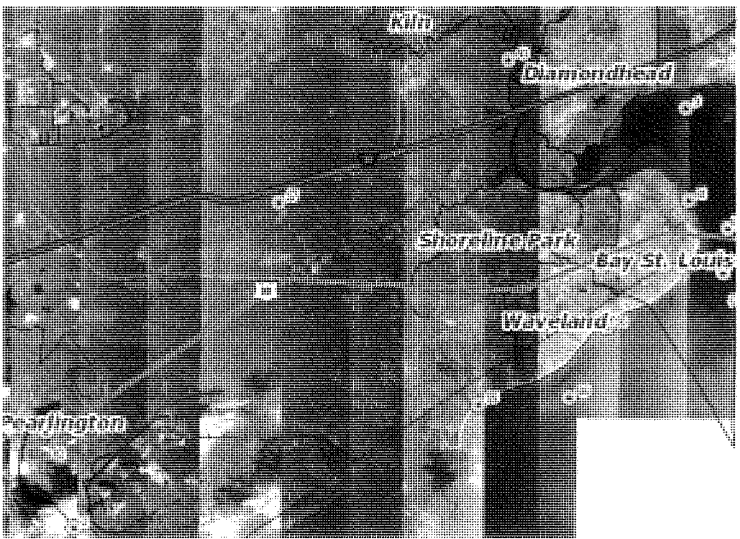


Figure 3.3.4-6. Hydrodynamic Modeling Save Points near Waveland

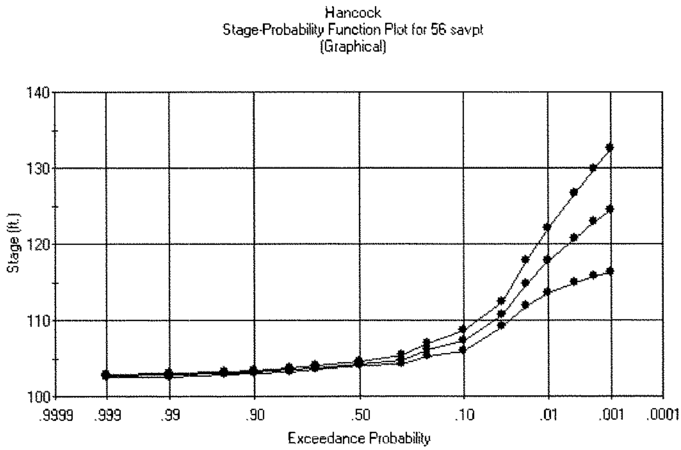


Figure 3.3.4-7. Existing Conditions at Save Point 56, near Waveland

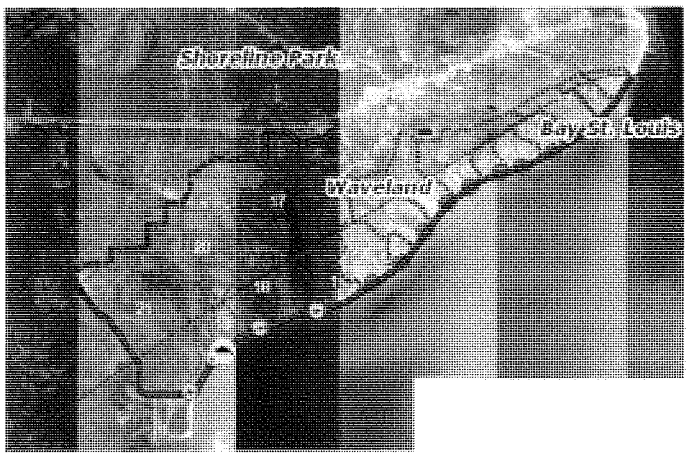


Figure 3.3.4-8. Pump/Culvert/Boat Access Site Locations and Sub-basins

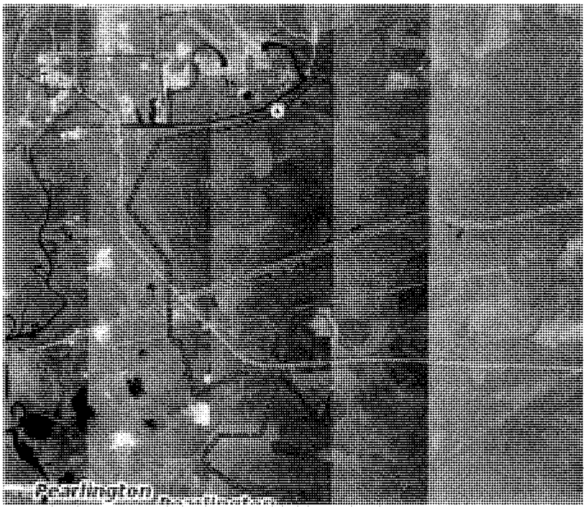


Figure 3.3.4-9. Culvert Site Location

Damage and failure by overtopping of levees could be caused by storms surges greater than the levee crest as shown on Figure 3.3.4-10.

Source: Wave Overtopping Flow on Seadikes, Experimental and Theoretical Investigations, Holger Schüttrumpf, (Photo:Leichtweiss-Institute) http://kfki.baw.de/fileadmin/projects/E_35_134_Lit.pdf

Figure 3.3.4-10. North Sea, Germany, March 1976

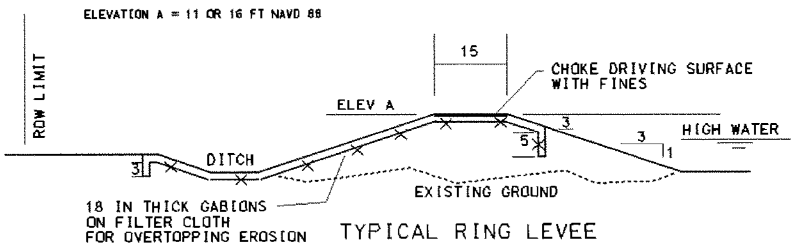
Overtopping failures are caused by the high velocity of flow on the top and back side of the levee. Although significant wave attack on the seaward side of some of the New Orleans levees occurred during Hurricane Katrina, the duration of the wave attack was for such a short time that major damage did not occur from wave action. The erosion shown below in Figure 3.3.4-11 was caused by approximately 1-2 ft of overtopping crest depth.

Source: ERDC, Steven Hughes

Figure 3.3.4-11. Crown Scour from Hurricane Katrina at Mississippi River Gulf Outlet (MRGO) Levee in St. Bernard Parish, New Orleans, LA

Revetment would be included in the levee design to prevent overtopping failure.

The levee would be protected by gabions on filter cloth as shown above on Figure 3.3.4-12, extending across a drainage ditch which carries water to nearby culverts and which would also serve to dissipate some of the supercritical flow energy during overtopping conditions.



Source: ERDC, Steven Hughes

Figure 3.3.4-12. Typical Section at Ring Levee

3.3.4.5.1 Interior Drainage

Drainage on the interior of the raised roadway would be collected at the highway and channeled to culverts placed at 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 for control in the event the flap gate malfunctions. A typical section is shown below in Figure 3.3.4-13.

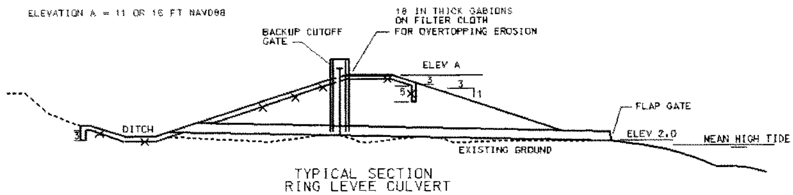


Figure 3.3.4-13. Typical Section at Culvert

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 drainage basin into major sub-basins as shown above 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.

Peak flows for the 1-yr to 100-yr storms were computed. 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. For the culvert design, headwater/tailwater elevation difference was maintained at 3.0 ft or less. Drainage ditches along the toe of the highway will be required to assure that smaller basins can be drained to a culvert/pump site. These ditches were sized using a normal depth flow computation. Curve numbers, pump, and culvert capacity tables are not included in the report beyond that necessary to obtain a cost estimate. The data is considered beyond the level of detail required for this report.

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. This decision was 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. However, in some of the areas, existing storage could be adequate to pond water without causing damage, even without pumps. In other areas that do have pumps, some rise in interior water during interior events greater than the 10-yr rain could occur, but may not cause damage. Designing the pumps for the peak 10-yr flow provides a significant pumping capacity. Further studies will detail the requirement for the appropriate ponding areas, pump sizes, or buyouts in the affected areas.

During non-hurricane periods of low water in the sound, when rainfall greater than the 25-yr event occurs, the pumps could also be used to augment the flow capacity of the levee culverts.

3.3.4.5.2 Geotechnical Data

Geology: The Prairie formation is found southward of the Citronelle formation and is of Pleistocene age. This formation consists of fluvial and floodplain sediments that extend southward from the outcrop of the Citronelle formation to or near the mainland coastline. Sand found within this formation has an economic value as beach fill due to its color and quality. Southward from its outcrop area, the formation extends under the overlying Holocene deposits out into the Mississippi Sound.

The Gulfport Formation is found along the coastline in Jackson County at Belle Fontaine Beach. This formation of Pleistocene age overlies the Prairie formation and is present as well sorted sands that mark the edge of the coastline during the last high sea level stage of the Sangamonian Interglacial period. It does not extend under the Mississippi Sound.

Geotechnical: The Line 3 defense elevates the roadway and accompanying seawall to elevation by extending the seaway at its present slope to grade, creating the roadway subgrade then sloping the backside to one vertical to three horizontal side slopes with a twenty five foot toe width for access and drainage. All work areas to receive the fill shall be cleared and grubbed of all trees and surface organics and all existing foundations, streets, utilities, etc. will be removed and the subsequent cavities backfilled and compacted. The embankment will be constructed of sand clay materials obtained from off site commercial sources, trucked to the work area, placed in thin lifts and compacted to 95 percent of the maximum modified density. The final surface on the back side will be armored by the placement of 12 inch thick gabion mattress filled with small stone for erosion protection during an event that overtops the road. The armoring will be anchored on the back face by trenching and extend across the toe easement. All non critical surface areas will be subsequently covered by grassing. Road crossings will incorporate ramping over the embankment where the surface elevation is near that of the crest elevation. The surfaces will be paved with asphalt and the corresponding drainage will be accommodated. Those areas where the subgrade geology primarily consists of clean sands, seepage underneath the roadway and the potential for erosion and instability must be considered. Final designs may require the installation of a cutoff wall within the foundation. This condition will be investigated during any design phase and its requirement will be incorporated.

3.3.4.5.3 Pumping Stations. Flow and Pump Sizes

Design hydraulic heads derived for the 12 pumping facilities included in the Hancock County Raised Roadway at the elevation 11 protection level was constant at 7 feet, and the corresponding flows required varied from 78,994 to 263,913 gallons per minute. The plants thus derived varied in size from a plant having two 42-inch diameter, 150 horsepower pumps, to one having four 60-inch diameter pumps each running at 750 horsepower.

3.3.4.5.4 HTRW

Due to the extent and large number of real estate parcels along with the potential for re-alignment of the structural aspects of this project, no preliminary assessment was performed to identify the possibility of hazardous waste on the sites. These studies will be conducted during the next phase of work after the final siting of the various structures. The real estate costs appearing in this report therefore will not reflect any costs for remediation design and/or treatment and/or removal or disposal of these materials in the baseline cost estimate.

3.3.4.5.5 Construction Procedures and Water Control Plan

Construction would be done by heavy construction equipment after removal of structures and relocation of utilities. Water control will be addressed by constructing drainage facilities prior to construction of the levee.

3.3.4.5.6 Project Security

The Protocol for security measures for this study has been performed in general accordance with the Risk Assessment Methodology for Dams (RAM-D) developed by the Interagency Forum for Infrastructure Protection (IFIP). This methodology has been used for physical security for the critical infrastructure throughout the Corps of Engineers. The determination of the level of physical security provided for each facility is based on the following critical elements: 1) threat assessment of the likelihood that an adversary will attack a critical asset, 2) consequence assessment should an adversary be successful in disrupting, disabling or destroying the asset and 3) effectiveness to prevent a successful attack against an operational component.

Three levels of physical security were selected for use in this study:

Level 1 Security provides no improved security for the selected asset. This security level would be applied to the barrier islands and the sand dunes. These features present a very low threat level of attack and basically no consequence if an attack occurred and is not applicable to this option.

Level 2 Security applies standard security measures such as road barricades, perimeter fencing, and intrusion detection systems for unoccupied buildings and vertical structures and security lighting. The intrusion detection systems will be connected to the local law enforcement office for response during an emergency. Facilities requiring this level of security would possess a higher threat level than those in Level 1 and would include assets such as levees, access roads and pumping stations.

Level 3 Security includes all of the features of Level 2 plus enhanced security measures such as the use of video cameras for real-time monitoring of the facility, monitors, motion detectors and alarm sound system in the occupied control buildings. Facilities requiring this level of security would possess the highest threat level of all the critical assets. Boat access gates and power plants would require this level of security.

3.3.4.5.7 Operation and Maintenance

Operation and maintenance activities for this project will be required on an annual basis. All pumps and gates will be operated to assure proper working order. Debris and shoaled sediment will be removed. Vegetation on the levees will be cut to facilitate inspection and to prevent roots from causing weak levee locations. Maintenance costs are included in this report.

3.3.4.5.8 Cost Estimate

The costs for the various options included in this measure are presented in Section 3.3.4.6, Cost Summary. Construction costs for the various options are included in Table 3.3.4-1 and costs for the annualized Operation and Maintenance of the options are included in Table 3.3.4-2. Estimates are comparative-Level "Parametric Type" and are based on Historical Data, Recent Pricing, and Estimator's Judgment. Quantities listed within the estimates represent Major Elements of the Project Scope and were furnished by the Project Delivery Team. Price Level of Estimate is April 07. Estimates excludes project Escalation and HTRW Cost. The construction costs include real estate, engineering design (E&D), construction management, and contingencies. The E&D cost for preparation of construction contract plans and specifications includes a detailed contract survey, preparation of contract specifications and plan drawings, estimating bid quantities, preparation of bid estimate, preparation of final submittal and contract advertisement package, project engineering and

coordination, supervision technical review, computer costs and reproduction. Construction Contingency developed and assigned at 25% to cover the Cost Growth of the project.

3.3.4.5.9 Schedule for Design and Construction

After the authority for the design has been issued and funds have been provided, the design of these structures will require approximately 12 months including comprehensive plans and specifications, independent reviews and subsequent revisions. The construction of this option should require in excess of two years.

3.3.4.6 Hancock County. Elevated Roadway. Cost Estimate Summary

The costs for construction and for operations and maintenance of all options are shown in Tables 3.3.4-1 and 3.3.4-2 below. Estimates are comparative-Level "Parametric Type" and are based on Historical Data, Recent Pricing, and Estimator's Judgment. Quantities listed within the estimates represent Major Elements of the Project Scope and were furnished by the Project Delivery Team. Price Level of Estimate is April 07. Estimates excludes project Escalation and HTRW Cost.

Table 3.3.4-1.
Hancock Co Elevated Roadway Construction Cost Summary

Option	Total project cost
Option - Elevated Roadway	$328,000,000

Table 3.3.4-2.
Hancock Co Elevated Roadway O & M Cost Summary

Option	O&M Cost
Option A – Elevated Roadway	$3,831,000

3.3.4.7 References

US Army Corps of Engineers (USACE) 1987. Hydrologic Analysis of Interior Areas. Engineer Manual EM 1110-2-1413. Department of the Army, US Army Corps of Engineers, Washington, D.C. 15 January 1987.

USACE 1993. Hydrologic Frequency Analysis. Engineer Manual EM 1110-2-1415. Department of the Army, US Army Corps of Engineers, Washington, D.C. 5 March 1993.

USACE 1995. Hydrologic Engineering Requirements for Flood Damage Reduction Studies. Engineer Manual EM 1110-2-1419. Department of the Army, US Army Corps of Engineers, Washington, D.C. 31 January 1995.

USACE 2006. Risk Analysis for Flood Damage Reduction Studies. Engineer Regulation ER 1105-2-101. Department of the Army, US Army Corps of Engineers, Washington, D.C. 3 January 2006.

National Resource Conservation Service (NRCS). 2003. WinTR5-55 User Guide (Draft). Agricultural Research Service. 7 May 2003.

Environmental Science Services Administration. 1968. "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.

Weather Bureau and USACE. 1956. 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.

3.3.5 Harrison County, Elevated Roadway

3.3.5.1 General

Residential and business areas along the coast in Harrison County are susceptible to storm surge damage. A damage reduction option is to raise Highway 90 to elevation 16ft NAVD88 was evaluated. Additional options not evaluated in detail are described elsewhere in this report.

Evaluation of this option was done by comparing benefits computed by Hydrologic Engineering Center's (HEC) Flood Damage Analysis (FDA) computer application HEC-FDA and costs computed. HEC-FDA modeling was done comparing the study reaches using variations in expected sea-level rise and development. Details regarding the methodology are presented in Section 2.13 of the Engineering Appendix and in the Economic Appendix.

3.3.5.2 Location

The location of Hwy 90 in Harrison County is shown below in Figure 3.3.5-1 extending from Biloxi Bay to Pass Christian.

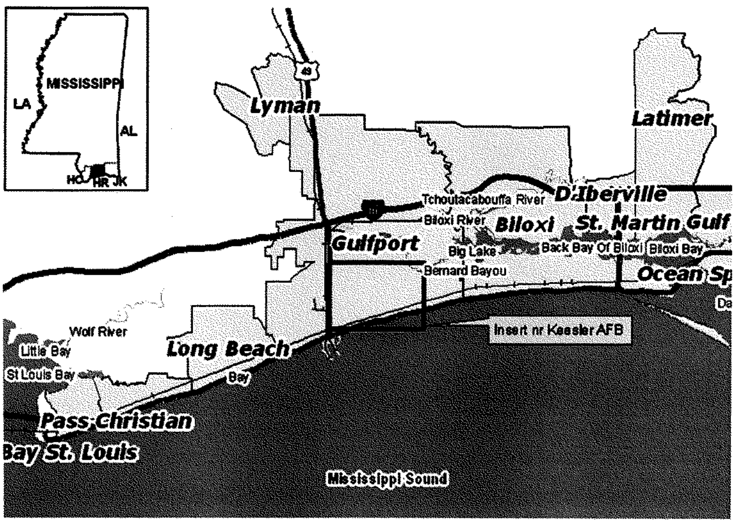


Figure 3.3.5-1. Vicinity Map, Harrison County

3.3.5.3 Existing Conditions

In Harrison County, ground elevations over most of the residential and business areas vary between elevation 8-12 ft NAVD88 on the coast and rising within 1000 ft to elevation 30-36 along a ridge parallel to the coast line, then decreasing to the north. The 4-ft (blue), 8-ft (green), 20-ft (pink), 30-ft (dark blue) and 34-ft (gold) ground contours shown the pattern at the coastline for the county below in Figure 3.3.5-2.

A close-up near Keesler Air Force Base is shown below. The 4-ft(blue), 8-ft(dark green), 12-ft(light green), 16-ft(brown), 20-ft(pink), 24-ft(light purple), 28-ft (teal), and 32-ft (gold) ground contour lines are shown below in Figure 3.3.5-3.

The area is drained by natural and some improved channels. Above the ridge water drains to the north, thence to either the Back Bay of Biloxi on the east side of the county, or to the west to the St Louis Bay. South of the ridge, the water drains to Mississippi Sound.

Drainage from ordinary rainfall is hindered on occasions when either of the rivers in the area or the gulf is high, but impacts from hurricanes are devastating.

Damage from Hurricane Katrina in August, 2005 in the Pascagoula area are shown below in Figures 3.3.5-4 and 3.3.5-5. Many homes are still un-repaired, pending settlement of insurance claims.

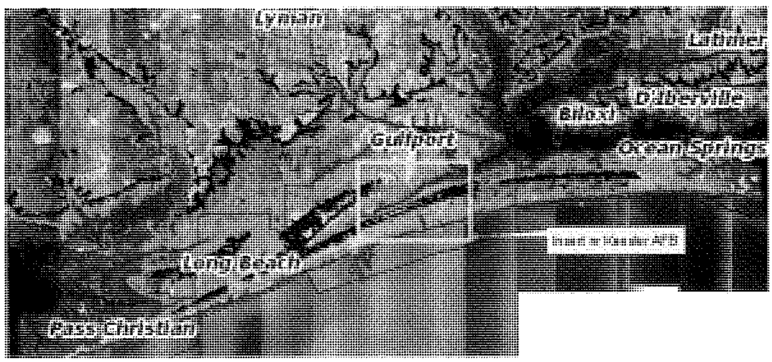


Figure 3.3.5-2. Existing Conditions, Harrison County

Figure 3.3.5-3. Existing Condition near Keesler AFB

Source : http://ngs.woc.noaa.gov/storms/katrina/24330924.jpg

Figure 3.3.5-4. Hurricane Katrina Damage, Harrison County

Source: danakay, http://www.flickr.com/photo_zoom.gne?id=45235550&size=m

Figure 3.3.5-5. Hurricane Katrina Damage, Harrison County

3.3.5.4 Coastal and Hydraulic Data

Typical coastal data are shown in Section 1.4 of this report. High water marks taken by FEMA after Hurricane Katrina in 2005 as well as the Katrina inundation limits are shown below in Figure 3.3.5-6 and 3.3.5-7. The data indicates the Katrina high water was as high as 21 ft NAVD88 Biloxi, and 28 ft NAVD88 at Pass Christian.

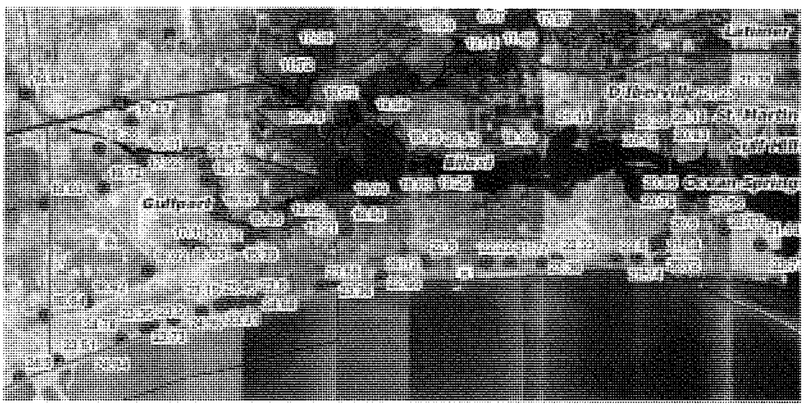


Figure 3.3.5-6. Katrina High Water Elevations, Harrison County

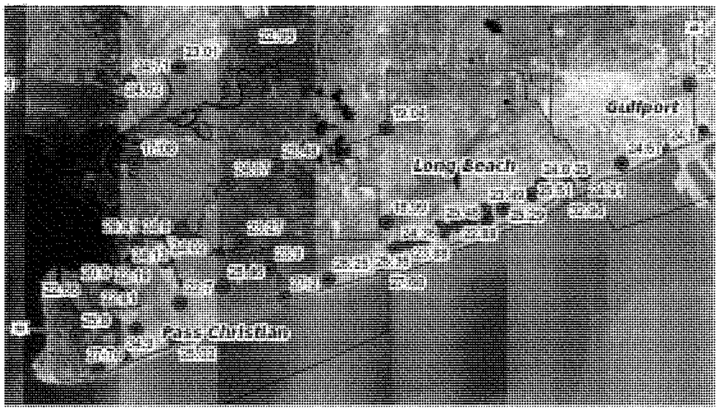


Figure 3.3.5-7. Katrina High Water Elevations, Harrison County

A closer view at the intersection of Hwy 90 and US Hwy 49 in Gulfport of existing flooding potential along Harrison County is shown below in Figure 3.3.5-8. Ground contours shown are 4-ft(blue), 8-ft(dark green), 12-ft(light green), 16-ft(brown), 20-ft(pink), 24-ft(light purple), 28-ft (teal), and 32-ft (gold).

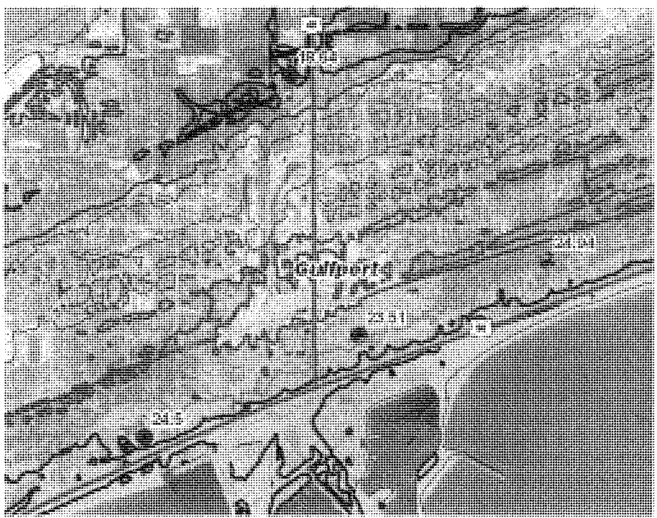


Figure 3.3.5-8. Ground Contours and Katrina High Water Elevations at Hwy 49

Stage-Frequency data for a suite of severe storms using Joint Probability Method (JPM) and hydrodynamic modeling were developed by the Engineer Research and Development Center (ERDC) for 80 locations along the study area. These data were combined with historical gage frequencies for smaller storms to establish stage-frequency curves at 54 economic reaches in the study area which were entered into Hydrologic Engineering Center's (HEC) Flood Damage Analysis (HEC-FDA) application to evaluate benefits. An expanded description of the procedure is presented in Section 2.13 of the Engineering Appendix and in the Economic Appendix. Points near the coast in Harrison County at which data from hydrodynamic modeling was saved are shown below in Figures 3.3.5-9 and 3.3.5-10.

Existing Condition Stage –Frequency data for Save Point 50, just off the coast of Harrison County, is shown below as an example in Figure 3.3.5-11. The 95% confidence limits, approximately equal to plus and minus two standard deviations, are shown bounding the median curve. The elevations are presented at 100 ft higher than actual to facilitate HEC-FDA computations.

3.3.5.5 Option – Elevate US Highway 90 to Elevation 16.0 ft NAVD88

This option consists of raising US Hwy 90 to elevation 16 ft NAVD88 along the coast of Harrison County as shown on the following Figures 3.3.5.12 through 3.3.5.15, along with the internal sub-basins and levee culvert/pump locations.

Damage and failure by overtopping of levees could be caused by storms surges greater than the levee crest as shown below on Figure 3.3.5-16.

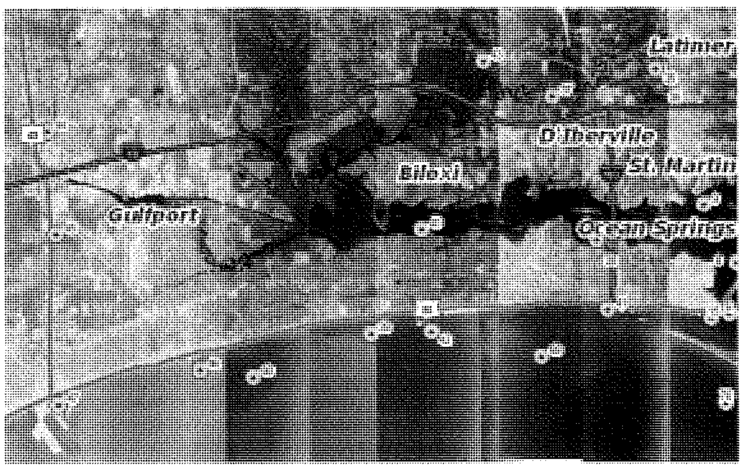


Figure 3.3.5-9. Hydrodynamic Modeling Save Points in Harrison County

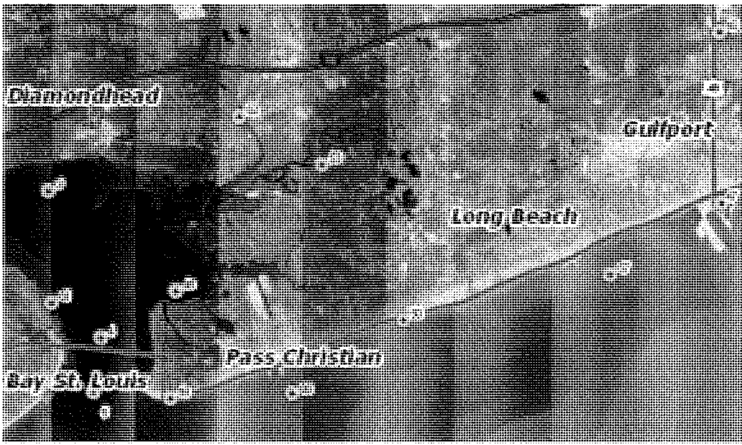


Figure 3.3.5-10. Hydrodynamic Modeling Save Points in Harrison County

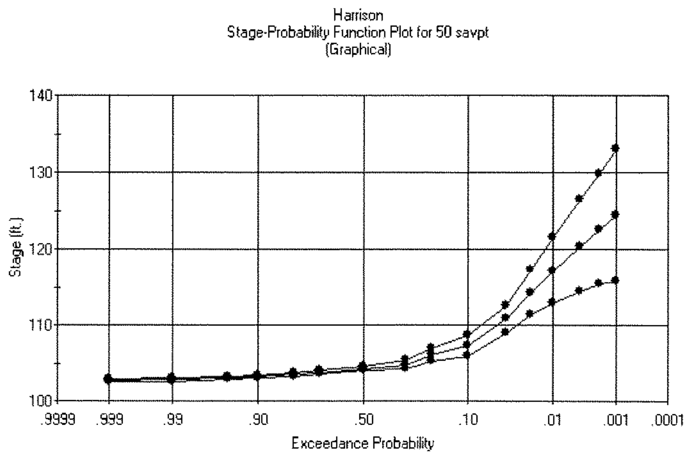


Figure 3.3.5-11. Existing Conditions at Save Point 50, near Pass Christian, MS

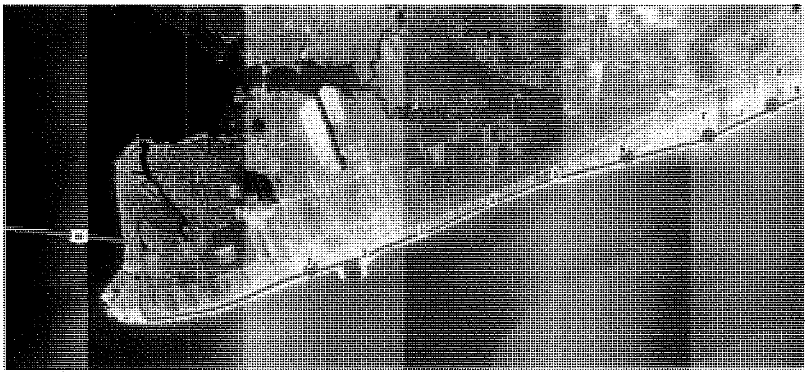


Figure 3.3.5-12. Pump/Culvert/Sub-basin Site Locations, Harrison County

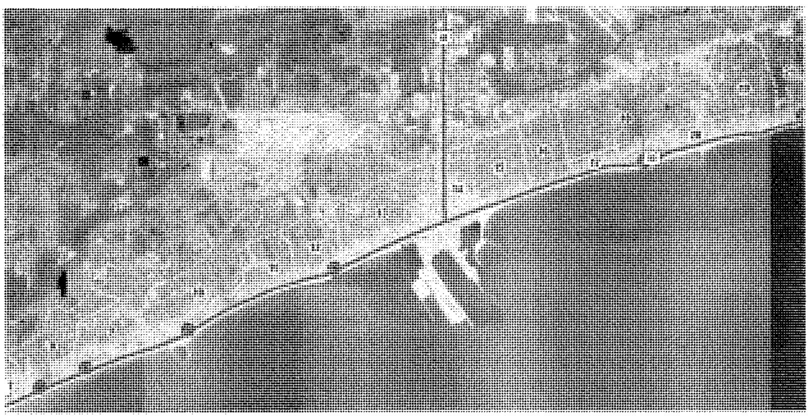


Figure 3.3.5-13. Pump/Culvert/Sub-basin Site Locations, Harrison County

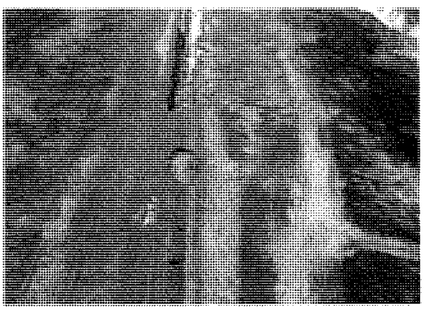
Figure 3.3.5-14. Pump/Culvert/Sub-basin Site Locations, Harrison County

Figure 3.3.5-15. Pump/Culvert/Sub-basin Site Locations, Harrison County

Source: Wave Overtopping Flow on Seadikes, Experimental and Theoretical Investigations, Holger Schüttrumpf, (Photo:Leichtweiss-Institute) http://kfki.baw.de/fileadmin/projects/E_35_134_Lit.pdf

Figure 3.3.5-16. North Sea, Germany, March 1976

Overtopping failures are caused by the high velocity of flow on the top and back side of the levee. Although significant wave attack on the seaward side of some of the New Orleans levees occurred during Hurricane Katrina, the duration of the wave attack was for such a short time that major damage did not occur from wave action. The erosion shown on Figure 3.3.5-17, below was caused by approximately 1-2 ft of overtopping crest depth.



Source: ERDC, Steven Hughes

Figure 3.3.5-17. Crown Scour from Hurricane Katrina at Mississippi River Gulf Outlet (MRGO) Levee in St. Bernard Parish, New Orleans, LA

Revetment would be included in the levee design to prevent overtopping failure.

The levee would be protected by gabions on filter cloth as shown above in Figure 3.3.5-18, extending across a drainage ditch which carries water to nearby culverts and which would also serve to dissipate some of the supercritical flow energy during overtopping conditions.

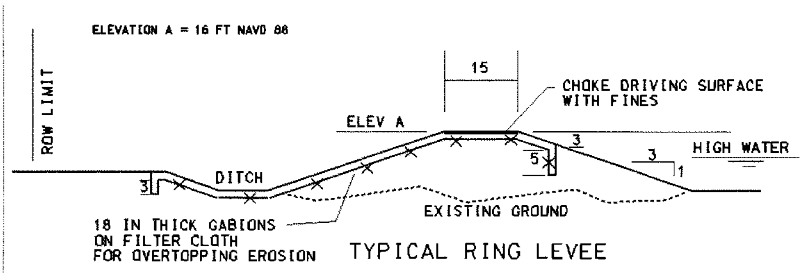


Figure 3.3.5-18. Typical Section at Ring Levee

3.3.5.5.1 Interior Drainage

Drainage on the interior of the raised highway would be collected at the highway and channeled to culverts placed at 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 for control in the event the flap gate malfunctions. A typical section is shown below in Figure 3.3.5-19.

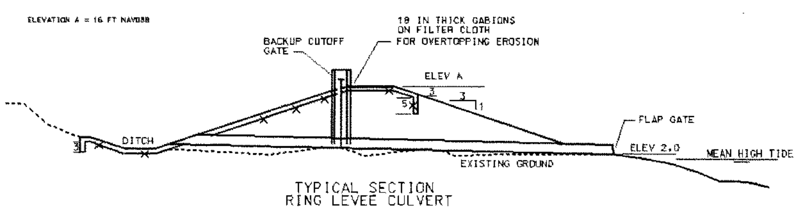


Figure 3.3.5-19. Typical Section at Culvert

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 drainage basin into major sub-basins as shown above 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.

Peak flows for the 1-yr to 100-yr storms were computed. 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. For the culvert design, headwater/tailwater elevation difference was maintained at 3.0 ft or less. Drainage ditches along the toe of the highway will be required to assure that smaller basins can be drained to a culvert/pump site. These ditches were sized using a normal depth flow computation. Curve numbers, pump, and culvert capacity tables are not included in the report beyond that necessary to obtain a cost estimate. The data is considered beyond the level of detail required for this report.

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. This decision was 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. However, in some of the areas, existing storage could be adequate to pond water without causing damage, even without pumps. In other areas that do have pumps, some rise in interior water during interior events greater than the 10-yr rain could occur, but may not cause damage. Designing the pumps for the peak 10-yr flow provides a significant pumping capacity. Further studies will detail the requirement for the appropriate ponding areas, pump sizes, or buyouts in the affected areas.

During non-hurricane periods of low water in the sound, when rainfall greater than the 25-yr event occurs, the pumps could also be used to augment the flow capacity of the levee culverts.

3.3.5.5.2 Geotechnical Data

Geology. The Prairie formation is found southward of the Citronelle formation and is of Pleistocene age. This formation consists of fluvial and floodplain sediments that extend southward from the outcrop of the Citronelle formation to or near the mainland coastline. Sand found within this formation has an economic value as beach fill due to its color and quality. Southward from its outcrop area, the formation extends under the overlying Holocene deposits out into the Mississippi Sound.

The Gulfport Formation is found along the coastline in Jackson County at Belle Fontaine Beach. This formation of Pleistocene age overlies the Prairie formation and is present as well sorted sands that mark the edge of the coastline during the last high sea level stage of the Sangamonian Interglacial period. It does not extend under the Mississippi Sound.

Geotechnical: The Line 3 defense elevates the roadway and accompanying seawall to elevation by extending the seaway at its present slope to grade, creating the roadway subgrade then sloping the backside to one vertical to three horizontal side slopes with a twenty five foot toe width for access and drainage. All work areas to receive the fill shall be cleared and grubbed of all trees and surface organics and all existing foundations, streets, utilities, etc. will be removed and the subsequent cavities backfilled and compacted. The embankment will be constructed of sand clay materials obtained from off site commercial sources, trucked to the work area, placed in thin lifts and compacted to 95 percent of the maximum modified density. The final surface on the back side will be armored by the placement of 12 inch thick gabion mattress filled with small stone for erosion protection during an event that overtops the road. The armoring will be anchored on the back face by trenching and extend across the toe easement. All non critical surface areas will be subsequently covered by grassing. Road crossings will incorporate ramping over the embankment where the surface elevation is near that of the crest elevation. The surfaces will be paved with asphalt and the corresponding drainage will be accommodated. Those areas where the subgrade geology primarily consists of clean sands, seepage underneath the roadway and the potential for erosion and instability must be considered. Final designs may require the installation of a cutoff wall within the foundation. This condition will be investigated during any design phase and its requirement will be incorporated.

3.3.5.5.3 Pumping Stations. Flow and Pump Sizes

Design hydraulic heads derived for the 15 pumping facilities included in the Harrison County Raised Roadway at the elevation 16 protection level was constant at 7 feet, and the corresponding flows required varied from 39,945 to 515,258 gallons per minute. The plants thus derived varied in size from a plant having two 42-inch diameter, 475 horsepower pumps, to one having six 60-inch diameter pumps each running at 1000 horsepower.

3.3.5.5.4 HTRW

Due to the extent and large number of real estate parcels along with the potential for re-alignment of the structural aspects of this project, no preliminary assessment was performed to identify the possibility of hazardous waste on the sites. These studies will be conducted during the next phase of work after the final siting of the various structures. The real estate costs appearing in this report therefore will not reflect any costs for remediation design and/or treatment and/or removal or disposal of these materials in the baseline cost estimate.

3.3.5.5.5 Construction Procedures and Water Control Plan

Construction would be done by heavy construction equipment after removal of structures and relocation of utilities. Water control will be addressed by constructing drainage facilities prior to construction of the levee.

3.3.5.5.6 Project Security

The Protocol for security measures for this study has been performed in general accordance with the Risk Assessment Methodology for Dams (RAM-D) developed by the Interagency Forum for Infrastructure Protection (IFIP). This methodology has been used for physical security for the critical infrastructure throughout the Corps of Engineers. The determination of the level of physical security provided for each facility is based on the following critical elements: 1) threat assessment of the likelihood that an adversary will attack a critical asset, 2) consequence assessment should an adversary be successful in disrupting, disabling or destroying the asset and 3) effectiveness to prevent a successful attack against an operational component.

Three levels of physical security were selected for use in this study:

Level 1 Security provides no improved security for the selected asset. This security level would be applied to the barrier islands and the sand dunes. These features present a very low threat level of attack and basically no consequence if an attack occurred and is not applicable to this option.

Level 2 Security applies standard security measures such as road barricades, perimeter fencing, and intrusion detection systems for unoccupied buildings and vertical structures and security lighting. The intrusion detection systems will be connected to the local law enforcement office for response during an emergency. Facilities requiring this level of security would possess a higher threat level than those in Level 1 and would include assets such as levees, access roads and pumping stations.

Level 3 Security includes all of the features of Level 2 plus enhanced security measures such as the use of video cameras for real-time monitoring of the facility, monitors, motion detectors and alarm sound system in the occupied control buildings. Facilities requiring this level of security would

possess the highest threat level of all the critical assets. Boat access gates and power plants would require this level of security.

3.3.5.5.7 Operation and Maintenance

Operation and maintenance activities for this project will be required on an annual basis. All pumps and gates will be operated to assure proper working order. Debris and shoaled sediment will be removed. Vegetation on the levees will be cut to facilitate inspection and to prevent roots from causing weak levee locations. Maintenance costs are included in this report.

3.3.5.5.8 Cost Estimate

The costs for the various options included in this measure are presented in Section 3.3.5.6, Cost Summary. Construction costs for the various options are included in Table 3.3.5-1 and costs for the annualized Operation and Maintenance of the options are included in Table 3.3.5-2. Estimates are comparative-Level "Parametric Type" and are based on Historical Data, Recent Pricing, and Estimator's Judgment. Quantities listed within the estimates represent Major Elements of the Project Scope and were furnished by the Project Delivery Team. Price Level of Estimate is April 07. Estimates excludes project Escalation and HTRW Cost. The construction costs include real estate, engineering design (E&D), construction management, and contingencies. The E&D cost for preparation of construction contract plans and specifications includes a detailed contract survey, preparation of contract specifications and plan drawings, estimating bid quantities, preparation of bid estimate, preparation of final submittal and contract advertisement package, project engineering and coordination, supervision technical review, computer costs and reproduction. Construction Contingency developed and assigned at 25% to cover the Cost Growth of the project.

3.3.5.5.9 Schedule for Design and Construction

After the authority for the design has been issued and funds have been provided, the design of these structures will require approximately 12 months including comprehensive plans and specifications, independent reviews and subsequent revisions. The construction of this option should require in excess of two years.

3.3.5.6 Cost Estimate Summary

The costs for construction and for operations and maintenance of all options are shown in Tables 3.3.5-1 and 3.3.5-2 below. Estimates are comparative-Level "Parametric Type" and are based on Historical Data, Recent Pricing, and Estimator's Judgment. Quantities listed within the estimates represent Major Elements of the Project Scope and were furnished by the Project Delivery Team. Price Level of Estimate is April 07. Estimates excludes project Escalation and HTRW Cost.

Table 3.3.5-1.
Harrison Co Elevated Roadway Construction Cost Summary

Option	Total project cost
Option - Elevated Roadway	$1,989,200,000

Table 3.3.5-2.
Harrison Co Elevated Roadway O & M Cost Summary

Option	O&M Cost
Option A – Elevated Roadway	$19,586,000

3.3.5.7 References

US Army Corps of Engineers (USACE) 1987. Hydrologic Analysis of Interior Areas. Engineer Manual EM 1110-2-1413. Department of the Army, US Army Corps of Engineers, Washington, D.C. 15 January 1987.

USACE 1993. Hydrologic Frequency Analysis. Engineer Manual EM 1110-2-1415. Department of the Army, US Army Corps of Engineers, Washington, D.C. 5 March 1993.

USACE 1995. Hydrologic Engineering Requirements for Flood Damage Reduction Studies. Engineer Manual EM 1110-2-1419. Department of the Army, US Army Corps of Engineers, Washington, D.C. 31 January 1995.

USACE 2006. Risk Analysis for Flood Damage Reduction Studies. Engineer Regulation ER 1105-2-101. Department of the Army, US Army Corps of Engineers, Washington, D.C. 3 January 2006.

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Environmental Science Services Administration. 1968. "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.

Weather Bureau and USACE. 1956. 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.

3.3.6 Forrest Heights Levee, City of Gulfport, Harrison County

3.3.6.1 General

The culturally historical Forest Heights residential community in the City of Gulfport, Harrison County, Mississippi, has frequently been inundated by flood waters due to storm surges from the Mississippi Sound and from inland flooding along the lower Turkey Creek. Water reached a depth of 2-8 ft over the entire community during Hurricane Katrina inundation. The Forest Heights levee is proposed to be constructed as a pilot project for the MsCIP comprehensive plan. The levee will address the combination of storm surge protection, inland flooding protection, and evacuation. The levee is intended to be constructed to a height such that the levee might be certified under the National Flood Insurance Program. A preliminary engineering analysis suggests a levee built to approximately elevation 21 feet NAVD '88 would satisfy or exceed certification elevation criteria.

Engineering performance and economic evaluations of protection options were done using the Hydrologic Engineering Center's (HEC) Flood Damage Analysis (FDA) computer application HEC-FDA. HEC-FDA modeling was done using variations in with-project conditions compared to the future without-project conditions for the Turkey Creek study. Details regarding the methodology are presented in the Economic Appendix. Additional evaluation to determine the precise levee height will be performed during final engineering and design based upon analyzing the risk and uncertainty associated with the coincident occurrence of inland flooding and storm surge impacts.

3.3.6.2 Location

The Forrest Heights community is located in an area known as North Gulfport within the City of Gulfport on the Mississippi Gulf Coast. The location of the levee at Forrest Heights is shown below in Figures 3.3.6-1 and 3.3.6-2. The community lies along the lower Turkey Creek floodplain, which has a tendency to frequently exceed its stream channel capacity and flood adjacent low-lying areas.

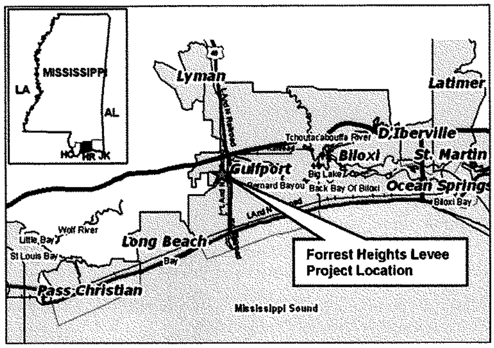


Figure 3.3.6-1. Vicinity Map

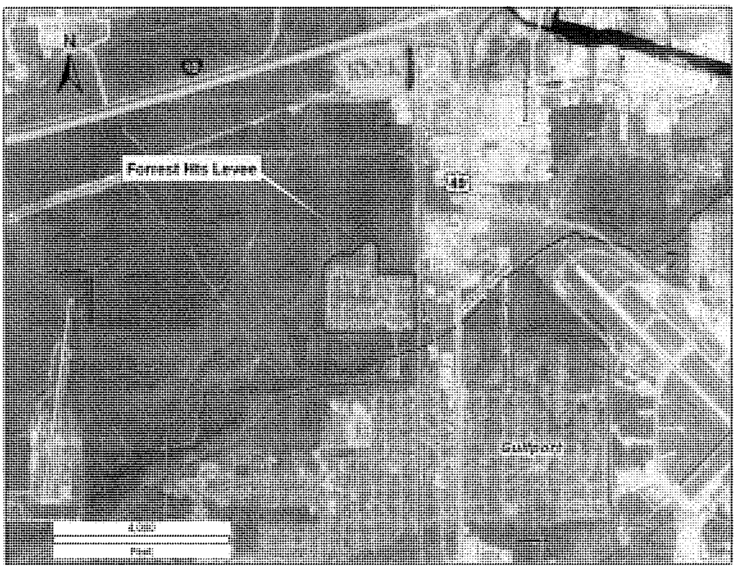


Figure 3.3.6-2. Forrest Heights Ring Levee Location

3.3.2.3 Existing Conditions

The community of Forrest Heights lies on the bank of Turkey Creek about 2.6 miles from the mouth at Bernard Bayou. Ground elevations over most of the residential area are between elevations 10-14 ft NAVD88. Drainage is mostly along streets and through natural drainage ways to the Turkey Creek. Impacts from flooding and hurricanes have been devastating. Hurricane Katrina in August, 2005 resulted in significant flood damages to residences in the Forrest Heights community. A levee with top width of 6 ft was constructed around the community to elevation 16.5 ft NGVD with sideslopes of 1 vertical to 1.5 horizontal in 1969, prior to Hurricane Camile. It has not had adequate maintenance and is a state of disrepair. It is scheduled to be restored to as-built condition by January of 2009. However, the restored levee will not be sufficient to meet the present day standard for certification according to the existing FEMA flood profiles in the vicinity. It is assumed that the as-built condition of this restored levee will be the existing condition for this report.

3.3.6.4 Coastal and Hydraulic Data

Typical coastal data are shown in Section 1.4 of this report. High water marks taken by FEMA after Hurricane Katrina in 2005 as well as the 4-ft(blue), 8-ft(dark green), 12-ft(green), 16-ft(brown), 20-ft(orange), and 20-ft(pink) ground contour lines and Hurricane Katrina inundation limits are shown below in Figure 3.3.6-3. The data indicates the water was as high as 18-20 ft NAVD88 near the site, totally inundating the entire area.

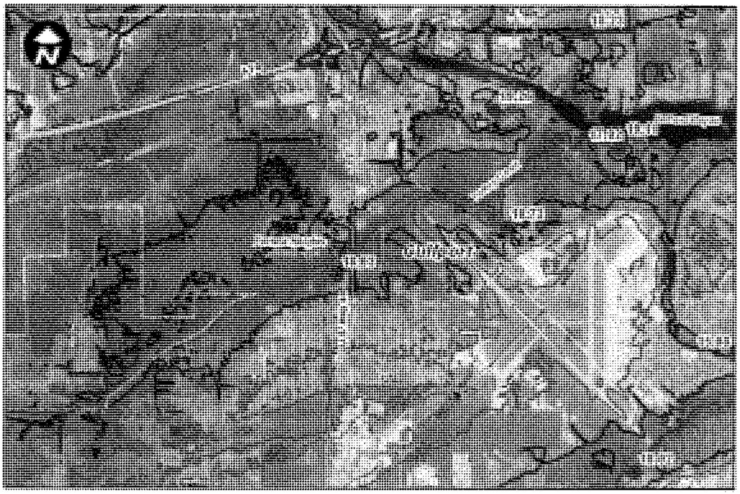


Figure 3.3.6-3. Hurricane Katrina Inundation and High Water, Forrest Heights

Stage-Frequency data for a suite of severe storms using Joint Probability Method (JPM) and hydrodynamic modeling were developed by the Engineer Research and Development Center (ERDC) for 80 locations along the study area. These data were combined with historical coastal tide gage frequencies for smaller storms to establish stage-frequency curves at 54 economic reaches in the study area. An expanded description of the procedure is presented in Section 2.13 of the

Engineering Appendix and in the Economic Appendix. Points near Forrest Heights at which data from hydrodynamic modeling was saved are shown below in Figure 3.3.6-4, and the stage frequency curve for that location is shown in Figure 3.3.6-5. Hydrodynamic output stage-frequency pairs, with uncertainty, are displayed in Table 3.3.6-1.

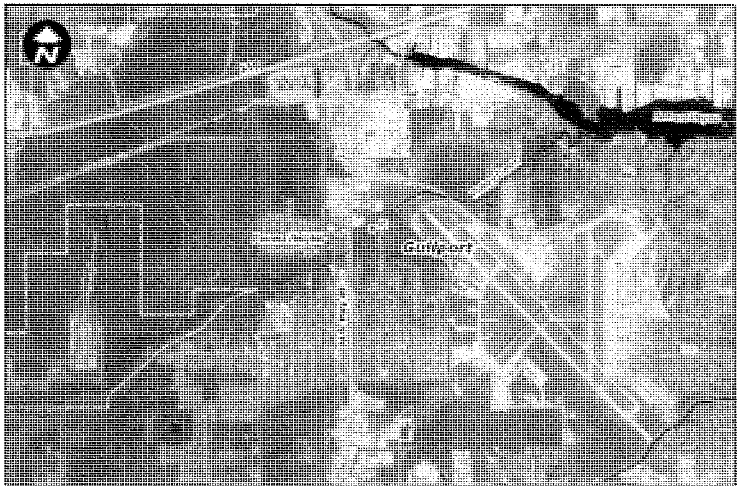


Figure 3.3.6-4. Hydrodynamic Modeling Save Point near Forrest Heights

It should be noted that the frequency curve reflects only that flooding resulting from storm surge in the gulf. The Forrest Heights community is also subject to riverine flooding by Turkey Creek. The preliminary FEMA Harrison County Flood Insurance Study (FIS) dated November 2007 provides computed Turkey Creek flood profiles which appear to have been adjusted for the effects of coincident surge in Back Bay of Biloxi. Table 3.3.6-2 shows relevant discharge and stage information from the FIS for Turkey Creek at Ohio Avenue, the southern entrance to the Forrest Heights community. In comparison to the preliminary FEMA Flood Insurance Study dated November 2007, which is based on contemporary (post-Katrina) FEMA contractor hydrodynamic modeling, the ERDC frequency curve, which is based on surge alone, suggests a lower stage associated with the annual one in one hundred chance (0.01 exceedance probability) event.

Figure 3.3.6-6 shows a portion of the preliminary Harrison County Flood Insurance Rate Map in the vicinity of Forrest Heights. Low-lying peripheral areas of the neighborhood are shown in a shaded blue field as being in the 1% annual chance ('100-yr') regulatory floodplain, with the remainder of the community occupying a shaded Zone X field, being areas subject to shallow flooding at annual probabilities of occurrence between 0.02 (2%) and 0.01 (1%).

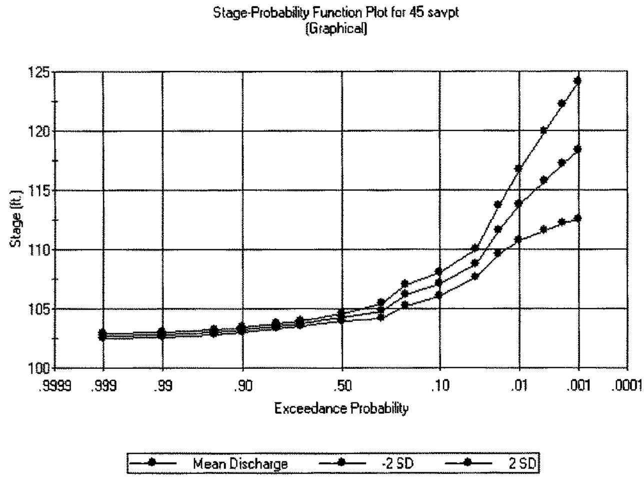


Figure 3.3.6-5. Surge-only Stage Frequency Curve, Vicinity of Forrest Heights

Table 3.3.6-1.
Surge Stage-Probability and Uncertainty

Annual Probability	Stage (Ft. NAVD88)	Standard Deviation (Feet)
0.04	8.8	0.6
0.02	11.6	1
0.01	13.7	1.5
0.002	17.2	2.5
0.001	18.3	2.9

Table 3.3.6-2.
Turkey Creek Flood Stages at Ohio Avenue, Harrison County FIS

Exceedance Probability	Discharge (cfs)	Stage (ft. NAVD '88)
0.1	2600	12
0.02	3650	14.2
0.01	5500	15.5
0.002	7950	18.3

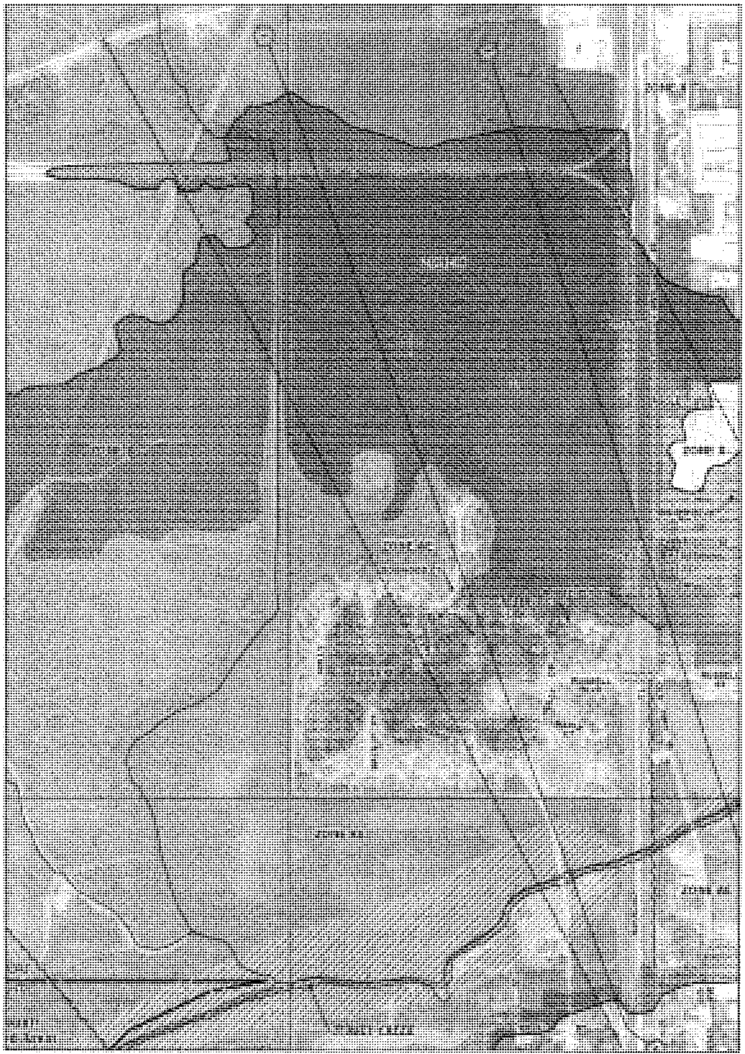


Figure 3.3.6-6. Preliminary FEMA Flood Insurance Rate Map, Vicinity of Forrest Heights

Hydraulic data was developed for use in the Hydrologic Engineering Center's Flood Damage Analysis (HEC-FDA) program. The HEC-FDA program uses risk-based 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 annual damages. Version 1.2.3b dated August 2007 was used. As described in chapter 2 of this appendix, this is a customized version of the current official release version 1.2 dated March 2000. This section describes the model's hydrologic and hydraulic input as applied to the Forrest Heights community. The Economic appendix describes the economic input and results. The Main Report describes how the model output was examined and used in the plan formulation process.

Forrest Heights is subject to both riverine and surge flooding. For this reason, a discharge-frequency curve and a stage-discharge relationship (also known as a 'rating curve') were developed for input into the HEC-FDA model. The discharge-frequency curve was computed in FDA using synthetic statistics using the 0.5-, 0.1-, and 0.01 annual exceedance probability discharges from the preliminary Harrison County FIS (see Table 3.3.6-2). The version of FDA used extends the stage frequency curve to the 0.999 and 0.0001 annual exceedance values. Uncertainty about the discharge-frequency curve was computed by the FDA program assuming an equivalent period of record. Sensitivity analysis of discharge uncertainty with respect to the equivalent period of record was conducted. Interpretation of the standard error and apparent period of record of the underlying hydrologic information used to develop the FIS discharge values versus discharge uncertainty computed by the FDA program suggested that an equivalent period of record of 20 years provided a reasonable preliminary estimate of uncertainty of discharge in the un-gaged stream. The resultant discharge-frequency curve and curves at the 5% and 95% confidence limits are shown below in Figure 3.3.6-7 and the values are shown in Table 3.3.6-3. These relationships are representative in the vicinity of Ohio Avenue.

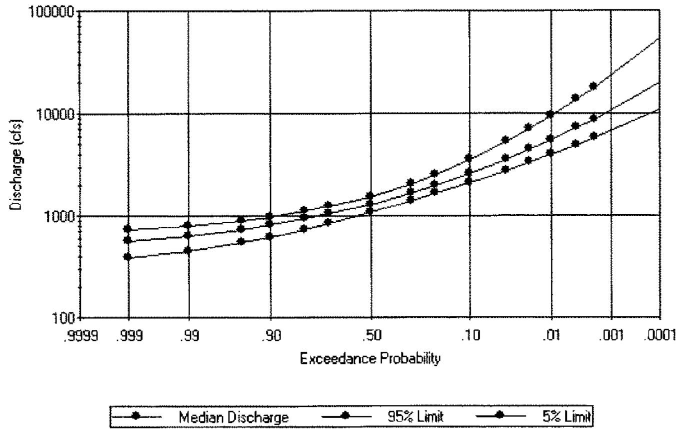


Figure 3.3.6-7. Computed Discharge-Frequency Curve, Turkey Creek at Ohio Avenue.

Table 3.3.6-3.
Discharge-Frequency, Turkey Creek at Ohio Avenue

Exceedance Probability	Discharge (cfs)	Confidence Limit Curves Discharge (cfs)			
		95%	75%	25%	5%
0.9990	563	383	458	660	720
0.9900	634	447	525	733	795
0.9500	735	542	622	839	904
0.9000	811	614	696	918	986
0.8000	932	731	814	1,044	1,118
0.7000	1,045	840	924	1,165	1,245
0.5000	1,300	1,081	1,167	1,443	1,548
0.3000	1,678	1,412	1,511	1,882	2,051
0.2000	1,995	1,669	1,785	2,274	2,522
0.1000	2,601	2,118	2,281	3,066	3,515
0.0400	3,563	2,770	3,027	4,411	5,296
0.0200	4,449	3,330	3,684	5,716	7,104
0.0100	5,500	3,961	4,439	7,334	9,428
0.0040	7,211	4,935	5,625	10,093	13,561
0.0020	8,771	5,778	6,671	12,723	17,655
0.0001	19,704	11,042	13,464	33,224	52,792

The stage-discharge curve was developed by fitting an equation of the form $H = CQ^a$ (H = water surface elevation; Q is discharge; C and a determined by regression) through the Turkey Creek stage at cross section F as shown on the Turkey Creek Flood Profile, Plate 83P, of the preliminary FIS. The profile plate shows this location to have been adjusted for coincident probability of surge. The equation thus developed was used to extend the rating curve through a broader range of discharges than represented on the flood profiles. Uncertainty about the rating curve was assumed to be 1.5 feet at the 10-year and higher discharges based on FIS hydraulic modeling techniques and assuming a poor historic hydrologic data record (Turkey Creek is ungaged). The rating curve is shown in Figure 3.3.6-8.

3.3.6.4.1 Engineering Performance

Project engineering performance was computed using HEC-FDA. Engineering performance was computed for the existing and future without project conditions; and a variety of existing and future with-project conditions. Performance was computed with risk and uncertainty. The base year was assumed to be 2012, and the future year was assumed to be 2061 (50 year period of analysis). Scenarios were also evaluated assuming (a) existing sea level, (b) expected sea level rise, and (c) high sea level rise.

The existing condition assumes that the NRCS has reconstituted their levee around the Forest Heights community to a crest elevation of 16.5 feet. The existing and future hydrologic and hydraulic conditions are presumed to be as represented by the FIS hydrology and flood profiles with uncertainty. Typically, one would consider increasing future flood discharges to account for possible increases in runoff due to development and urbanization. However, in this case, the underlying FIS hydrologic information is dated, being circa 1976, and subsequent studies have suggested that the effective tributary drainage area in this relatively flat and undifferentiated portion of the Turkey Creek watershed is less than the 25 or so square miles attributed to the creek at the location of Forest Heights. The existing hydrology is most likely conservative, and revisions downward for an un-gaged stream seem ill-advised. Additionally, the area in question benefits from an updated and contemporary FIS, where the Turkey Creek profiles have been adjusted for coincident surge elevations, and the floodplain has been re-mapped accordingly. In the end, it seems advisable to rely on the existing FIS profiles and hydrology for conservative results.

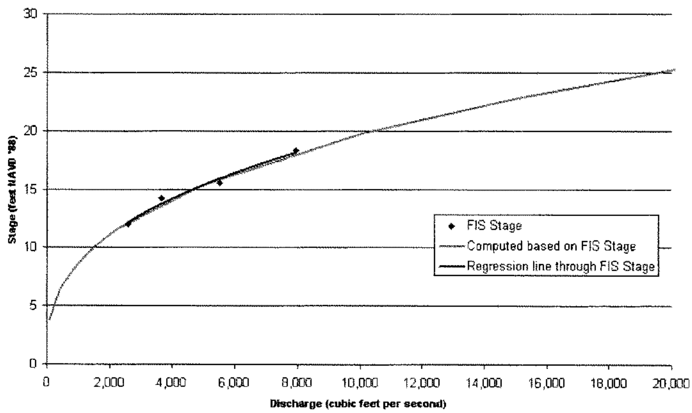
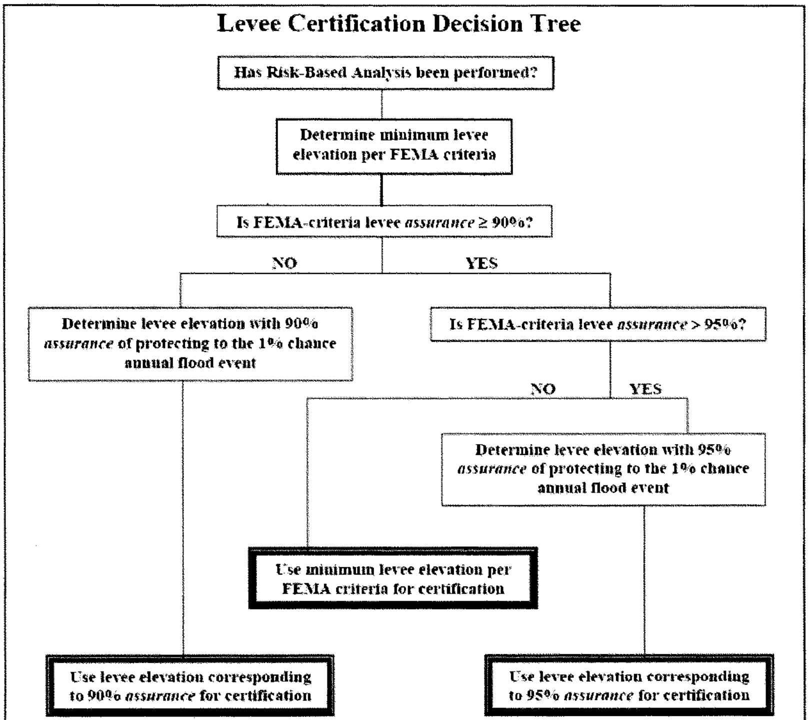


Figure 3.3.6-8. Computed Rating Curve, Turkey Creek at Ohio Avenue.

With-project conditions were evaluated for levees with crest elevations of 17 and 21 feet. The existing with-project condition assumes clearing and snagging of debris in Turkey Creek will counteract any local water surface profile impact due to flow obstruction by the levee. Future with-project conditions assume that the channel maintenance has been neglected, and thus the rating curve at Ohio Avenue is shifted upwards by 0.3 feet,

Performance was also evaluated assuming a levee built to the local Base Flood Elevation (BFE, the regulatory one in one hundred annual chance ('100-year') water surface elevation plus three feet. Historically, FEMA required levees to be built to the BFE plus three feet for certification. This condition no longer in and of itself satisfies certification criteria, which now requires that risk and uncertainty also be considered, as illustrated in Figure 3.3.6-9. This condition was evaluated for the purposes of levee certification. Assuming the BFE is defined by the FIS water surface elevation at Ohio Avenue as described on the FIS Turkey Creek Flood Profile, this elevation is 15.5 feet plus 3 feet, or elevation 18.5 feet.

Forest Heights occupies a small fringe of the floodplain, and the FDA simulations assume that when the levee is overtopped, the interior floods to the exterior flood elevation.



FEMA Criteria = 1% chance median annual flood event plus three feet of freeboard
ASSURANCE = percent chance non-exceedance given the 1% annual chance event occurs.

Figure 3.3.6-9. USACE Levee Certification Decision Tree, circa 2007

3.3.6.4.2 Performance Results

Engineering performance results as computed by HEC-FDA are shown in Figure 3.3.6-10. Base year 2012 results are the same regardless of the sea level scenario and are thus only reported once. Note that 'without project' implies that an NRCS levee built to elevation 16.5 feet (NGVD).

In this, and similar tables, the median target stage describes the probability each year of the water surface elevation exceeding the levee crest elevation according to the best estimates of the discharge frequency curve and rating curve (i.e. uncertainty is not accounted for). The expected annual exceedance probability takes discharge-frequency and stage-frequency into account when estimated the annual probability of exceeding the levee crest.

Long term risk describes the probability that the water surface would exceed the levee crest elevation in the specified time period. For example, according to these calculations, there is a 32.3 percent change that the NRCS levee (aka 'without project) elevation would be equaled or exceeded in a 30 year period. The expected probability is used in estimating long term risk.

The conditional non-exceedance probability describes the probability, given the occurrence of some event, that the levee crest elevation would not be exceeded. For example, given the occurrence of the 1% annual water surface elevation, there is about a 55% chance that the levee would not be overtopped. Discharge and stage uncertainty is accounted for in this computation.

Figure 3.3.6-10 shows that the FEMA criteria levee at elevation 18.5 feet provides an assurance at 78.9%, which is less than 90%. With respect to the levee certification decision tree shown in Figure 3.3.6-9, and according to these analyses, the minimum certifiable levee elevation is that elevation corresponding to 90% assurance (i.e. conditional non-exceedance probability). The el. 21 feet levee is the only levee evaluated that exceeds the required assurance (92.9% base year, 91.9% future year). Sensitivity analysis shows that the 90% assurance levee crest elevation is approximately 20.2 feet NAVD '88.

Note that crest elevation is not the sole determinant for levee certification; amongst other things, the levee must be properly constructed of sound material; the levee must be properly maintained by the owner; and interior flooding must be properly accounted for. Levee certification may be reconsidered over time as physical conditions change. For example, Figure 3.3.6-10 shows that, all else remaining the same, if sea level rises one foot in 50 years, a levee built to elevation 21 feet would provide an assurance of 87.4 percent, and the probability that it would be overtopped in a 50 year time frame would change from 11.6% to 16.9%. The point here is that, as the environment changes, the benefits of investments change.

Engineering analyses for sufficiently demonstrating a certifiable levee will be carried forward in the planning, engineering, and design phase of this project.

3.3.6.5 Option A - Elevation 17 ft NAVD88

This option consists of an earthen dike around the Forrest Heights community as shown on the following Figure 3.3.6-11, along with the levee culvert/interior pump/detention location. The earth dike will be trapezoidal in shape with a 12-foot top width with one foot vertical to three foot horizontal slopes on both sides (1H:3V). For this option the two existing roadway entrances will be ramped over the restored levee. The total length of the levee will be approximately 7900 feet.

Levees reduce the storage capacity and overbank flow conveyance of the adjacent floodplain. The reductions in overbank flow area could induce higher water levels upstream. An HECRAS model was used to evaluate the potential for induced damages and solutions. The modeling indicates that selective clearing and snagging would prevent increases in water surface elevations upstream that would occur due the placement of the levees in the floodplain.

The selective clearing and snagging would extend for approximately 4.5 miles from the mouth of Turkey Creek at Bernard Bayou to the upstream limits as shown in Figure 3.3.6-12. Selective clearing and snagging would remove obstructions such as debris dams and excessive sedimentation that hinders the flow through the Turkey Creek channel. While the selective clearing and snagging component of the plan does not eliminate flooding along Turkey Creek, the plan does reduce flood damages along the creek and at the upper end of the canals at 28th Street. The main purpose of the selective clearing and snagging is to make sure that induced damages do not occur due to the construction of the levee.

Note: FEMA Base Flood Elevation at FIS x-section F, Turkey Ck. at Ohio Avenue, is 15.5 feet. Levee height then for "FEMA plus 3 ft" plan is 15.5 ft. + 3 ft. = 18.5 feet NAVD '88. FIS: Harrison County FIS, Preliminary, dated 15 November 2007.

Forest Heights Project Performance
by Plans and Damage Reaches by Analysis Year 2012
(Stages in ft.)

Without Project Base Year Performance Target Criteria:
Event Exceedance Probability = 0.01
Residual Damage = 5.00 %

Plan Name	Stream Name	Damage Reach Name	Damage Reach Description	Target Stage	Target Stage Annual Exceedance Probability: Median	Expected	Long-Term Risk (years): 10	30	50	Conditional Non-Exceedance Probability by Events: 10%	4%	2%	1%	.4%	.2%
Without	Harrison Stream	12	Forest Heights Reach	levee	0.0064	0.0155	0.1447	0.3235	0.5424	0.9901	0.8957	0.7398	0.5493	0.3239	0.199
17-FT Levee	Harrison Stream	12	Forest Heights Reach	levee	0.0047	0.0123	0.1160	0.2654	0.4603	0.9950	0.9281	0.7978	0.6227	0.3994	0.251
21-FT Levee	Harrison Stream	12	Forest Heights Reach	levee	0.0006	0.0022	0.0218	0.0536	0.1043	1.0000	0.9976	0.9792	0.9250	0.8024	0.671
FEMA plus 3 ft	Harrison Stream	12	Forest Heights Reach	levee	0.0022	0.0063	0.0610	0.1456	0.2699	0.9995	0.9784	0.9114	0.7690	0.5725	0.411

Forest Heights Project Performance
by Plans and Damage Reaches by Analysis Year 2061
(Stages in ft.)

Without Project Base Year Performance Target Criteria:
Event Exceedance Probability = 0.01
Residual Damage = 5.00 %

Plan Name	Stream Name	Damage Reach Name	Damage Reach Description	Target Stage	Target Stage Annual Exceedance Probability: Median	Expected	Long-Term Risk (years): 10	30	50	Conditional Non-Exceedance Probability by Events: 10%	4%	2%	1%	.4%	.2%
Without	Harrison Stream	12	Forest Heights Reach	levee	0.0064	0.0155	0.1447	0.3235	0.5424	0.9901	0.8957	0.7398	0.5493	0.3239	0.1996
17-FT Levee	Harrison Stream	12	Forest Heights Reach	levee	0.0057	0.0139	0.1305	0.2951	0.5030	0.9934	0.9127	0.7661	0.5819	0.3503	0.2202
21-FT Levee	Harrison Stream	12	Forest Heights Reach	levee	0.0007	0.0025	0.0244	0.0599	0.1163	1.0000	0.9968	0.9752	0.9191	0.7827	0.6454
FEMA plus 3 ft	Harrison Stream	12	Forest Heights Reach	levee	0.0025	0.0071	0.0699	0.1636	0.3004	0.9992	0.9724	0.8954	0.7611	0.5396	0.378

Forest Heights Project Performance
by Plans and Damage Reaches by Analysis Year 2061
(Stages in ft.)

Without Project Base Year Performance Target Criteria:
Event Exceedance Probability = 0.01
Residual Damage = 5.00 %

Expected Sea Level Rise, 1.0 feet

Plan Name	Stream Name	Damage Reach Name	Damage Reach Description	Target Stage	Target Stage Annual Exceedance Probability: Median	Expected	Long-Term Risk (years): 10	30	50	Conditional Non-Exceedance Probability by Events: 10%	4%	2%	1%	.4%	.2%
Without	Harrison Stream	12	Forest Heights Reach	levee	0.0126	0.0257	0.2289	0.4779	0.7274	0.9640	0.7926	0.5888	0.3905	0.1996	0.1118
17-FT Levee	Harrison Stream	12	Forest Heights Reach	levee	0.0110	0.0223	0.2019	0.4309	0.6762	0.9763	0.8255	0.6260	0.4266	0.2236	0.1278
21-FT Levee	Harrison Stream	12	Forest Heights Reach	levee	0.0012	0.0037	0.0365	0.0897	0.1694	0.9999	0.9922	0.9558	0.8744	0.7025	0.5488

Forest Heights Project Performance
by Plans and Damage Reaches by Analysis Year 2061
(Stages in ft.)

Without Project Base Year Performance Target Criteria:
Event Exceedance Probability = 0.01
Residual Damage = 5.00 %

High Sea Level Rise, 1.5 feet

Plan Name	Stream Name	Damage Reach Name	Damage Reach Description	Target Stage	Target Stage Annual Exceedance Probability: Median	Expected	Long-Term Risk (years): 10	30	50	Conditional Non-Exceedance Probability by Events: 10%	4%	2%	1%	.4%	.2%
Without	Harrison Stream	12	Forest Heights Reach	levee	0.0167	0.0331	0.2857	0.5688	0.8141	0.9378	0.7225	0.5042	0.3139	0.1482	0.0791
17-FT Levee	Harrison Stream	12	Forest Heights Reach	levee	0.0150	0.0282	0.2489	0.5110	0.7609	0.9584	0.7646	0.5460	0.3490	0.1698	0.0919
21-FT Levee	Harrison Stream	12	Forest Heights Reach	levee	0.0016	0.0046	0.0449	0.1084	0.2051	0.9998	0.9882	0.9411	0.8449	0.6540	0.4961

Figure 3.3.6-10. Engineering Performance

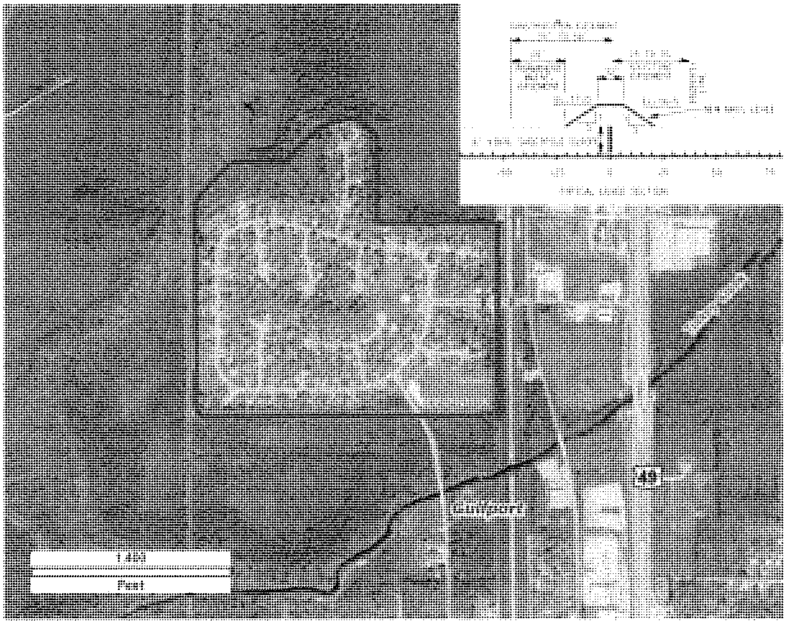


Figure 3.3.6-11. 17-ft Elevation Levee Alignment with Culvert and Pump/Detention Basin Locations

The selective clearing and snagging work will follow Stream Obstruction Removal Guidelines established by the American Fisheries Society. Only debris, snags and sediment that obstruct the flow will be removed. Material to be removed includes: 1) fine sediment accumulations that obstruct flows and alter flow patterns; 2) Debris blockages that currently or in the near future cause obstructed flow and altered flow patterns; and 3) Rooted trees that obstruct flow or need to be cleared for equipment access. Access areas that are cleared will be reestablished at the conclusion of the selective clearing and snagging activities. Some access points, however, may remain for the non-Federal sponsor to use for maintenance activity of the completed project. The existing bank alignment along the entire reach will not be changed, including the downstream reaches of Turkey Creek along the meander bends. Specific reaches to be cleared and snagged will be identified by an interdisciplinary team prior to construction.

Damage and failure by overtopping of levees could be caused by storm surges greater than the levee crest. Overtopping failures are caused by the high velocity of flow on the top and back side of the levee. Although significant wave attack on the seaward side of some of the New Orleans levees occurred during Hurricane Katrina, the duration of the wave attack was for such a short time that major damage did not occur from wave action. The erosion shown below in Figure 3.3.6-13 was caused by approximately 1-2 ft of overtopping crest depth.

An overtopping reach of the levee with a revetment at the detention/culvert location would be included in the levee design to prevent overtopping failure. The levee would be protected by gabions on filter cloth as shown in Figure 3.3.6-14, extending across a drainage ditch which carries water to nearby culverts and which would also serve to dissipate some of the supercritical flow energy during overtopping conditions.

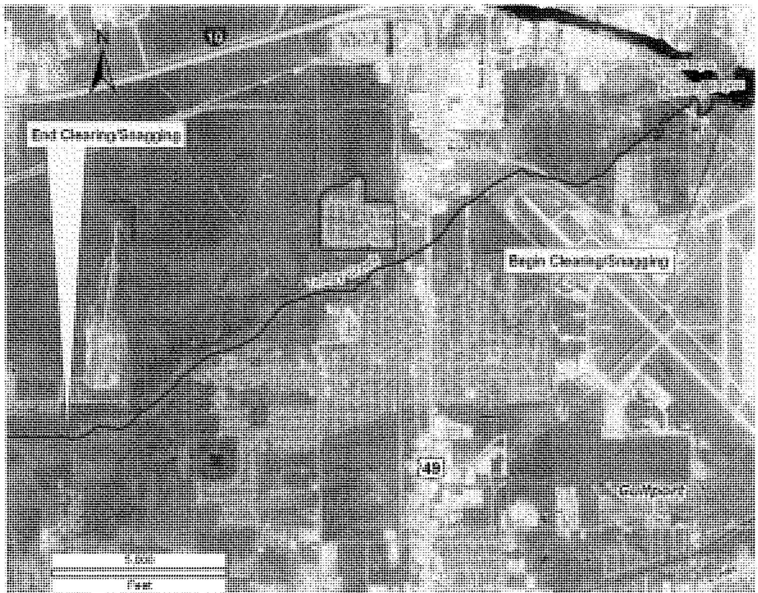
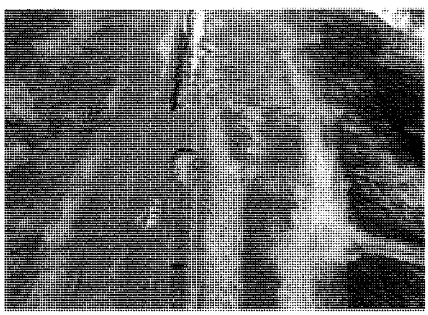


Figure 3.3.6-12. Channel Clearing and Snagging Limits



Source: ERDC, Steven Hughes

Figure 3.3.6-13. Crown Scour from Hurricane Katrina at Mississippi River Gulf Outlet (MRGO) Levee in St. Bernard Parish, New Orleans, LA

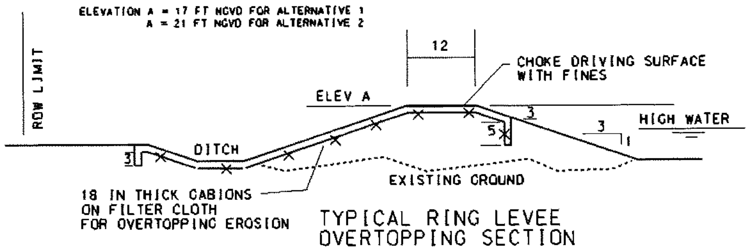


Figure 3.3.6-14. Typical Levee Overtopping Section

3.3.6.5.1 Interior Drainage

Drainage at the site is impacted by hurricanes in the gulf and by adjacent flooding from Turkey Creek. Backwater from each of these sources prevents water from running off. The existing NRCS levee at elevation 16.5 NAVD88 protects the neighborhood to some degree from these sources, but does not eliminate the flooding during times when the water outside the levee is up and there is rainfall inside the levee. This is the present condition at the site. Construction of the Corps levee will follow the footprint of the NRCS levee and provide additional protection from flooding from hurricanes and Turkey Creek. The interior flooding will be improved by adding a detention basin and pumping facility.

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 in Figure 3.3.6-9. The culverts would have flap gates on the outside ends to prevent backflow when the water in Mississippi Sound is high. An additional closure gate would also be provided in the levee for control in the event the flap gate malfunctions. A typical section is shown below in Figure 3.3.6-15.

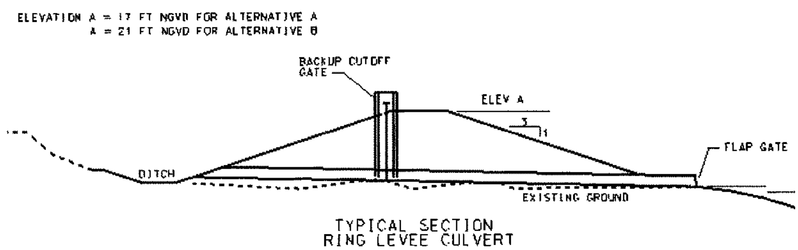


Figure 3.3.6-15. Typical Section at Culvert

Flow within the levee interior was determined by subdividing the interior of the ring levee into major sub-basins shown below in Figure 3.3.6-16 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 curve number was determined from previous studies done for Turkey Creek.

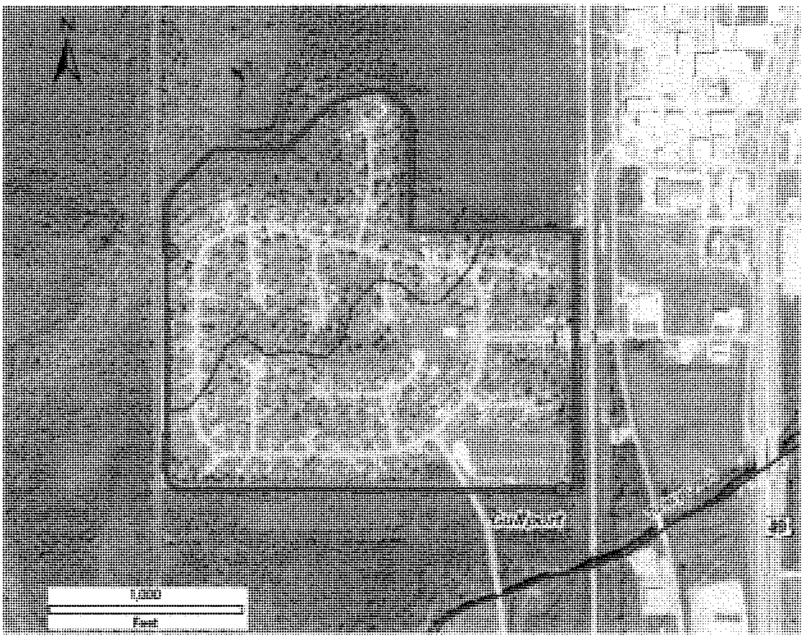


Figure 3.3.6-16 17-ft Elevation Levee Sub-basins

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. For the culvert design, headwater elevations at the culverts were maintained at an elevation no greater than 10 ft NAVD88 with a tailwater elevation of 6 ft NAVD88 assumed. Drainage ditches along the toe of the levee will be required to assure that smaller basins can be drained to a culvert/pump site. These ditches were sized using a normal depth flow computation. Curve numbers and culvert capacity tables are not included in the report beyond that necessary to obtain a cost estimate. The data are considered beyond the level of detail required for this report.

During periods of high water in Turkey Creek or Mississippi Sound, pumping would be required to evacuate rainfall. Pump size was determined for the peak flow resulting from a 10-yr rainfall. This decision was 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 or high water in Turkey Creek, when the culvert gates are shut, and rainfall exceeds the average 10-yr intensity over the basin, some ponding from rainfall will occur. A detention basin was added to help reduce the size of required pumps. The detention basin would have an area of approximately 3 acres but would not be excavated. The area is the lowest site in the subdivision and is presently is used for recreation facilities such as baseball and tennis. Detailed modeling of the area was not possible for this report, therefore the exact extent of the detention basin is not precisely defined. Designing the pumps for the peak 10-yr flow provides a significant pumping capacity. Further design during construction will refine the requirement for the appropriate detention area and pump sizes to provide protection from 100-yr rainfall.

During non-hurricane periods of low water in the sound, when rainfall greater than the 25-yr event occurs, the pump could also be used to augment the flow capacity of the levee culverts.

3.3.6.5.2 Geotechnical Data

Geology: Citronelle formation extends north of Interstate 10 and is a relatively thin unit of fluvial deposits of Plio-Pleistocene age consisting of gravelly sand and silty sand layers. Typically the formation is 30 to 80 feet thick, except where it has filled eroded channels in the underlying formations. The sand in the formation has a variety of colors, often associated with the presence of iron oxides in the form of hematite or goethite. Thin discontinuous clay layers are found in some areas. The iron oxide has occasionally cemented the sand into a somewhat friable sandstone, usually occurring only as a localized layer. Within the study area, this formation outcrops north of Interstate 10 and will not be encountered at project sites other than any levees that might extend northward to higher ground elevations.

The Prairie formation is found southward of the Citronelle formation and is of Pleistocene age. This formation consists of fluvial and floodplain sediments that extend southward from the outcrop of the Citronelle formation to or near the mainland coastline. Sand found within this formation has an economic value as beach fill due to its color and quality. Southward from its outcrop area, the formation extends under the overlying Holocene deposits out into the Mississippi Sound.

The Gulfport Formation is found along the coastline in most of Harrison County and western Jackson County at Belle Fontaine Beach. This formation of Pleistocene age overlies the Prairie formation and is present as well sorted sands that mark the edge of the coastline during the last high sea level stage of the Sangamonian Interglacial period. It does not extend under the Mississippi Sound.

Geotechnical: The inland barrier earthen levee section will have one vertical to three horizontal side slopes with a fifteen foot crest width. All work areas to receive the fill shall be cleared and grubbed of all trees and surface organics and all existing foundations, streets, utilities, etc. will be removed and the subsequent cavities backfilled and compacted. The levee will be constructed of sand clay materials obtained from off site commercial sources, trucked to the work area, placed in thin lifts and compacted to 95 percent of the maximum modified density. The final surface will be armored by the placement of 24 inch thick gabion mattress filled with small stone for erosion protection during an event that overtops the levee. The armoring will be anchored on the front face by trenching and extend across the downstream slope and the 25 foot easement area beyond the toe. The front side of the levee and all non critical surface areas will be subsequently covered by grassing. Road crossings will incorporate small gate structures or ramping over the embankment where the surface elevation is near that of the crest elevation. The elevation relationship of the crest and the adjacent railroad will be a governing factor. The surfaces will be paved with asphalt and the corresponding drainage will be accommodated. Those areas where the subgrade geology primarily consists of clean sands, seepage underneath the levee and the potential for erosion and instability must be considered. Final designs may require the installation of a bentonite concrete cutoff wall deep within the foundation. This condition will be investigated during any design phase and its requirement will be incorporated.

3.3.6.5.3 Structural, Mechanical and Electrical

3.3.6.5.3.1 Culverts

Culverts for the project were assumed to be reinforced concrete box structures fitted with flap gates and sluice gates to provide protection from high water outside the levee. An automated system could be incorporated whereby the gates could be monitored and operated from some central location. Detailed design of these monitoring and operating systems is beyond the scope of this study.

3.3.6.5.3.2 Levee and Roadway/Railway Intersections

With the installation of a ring levee around the Forrest Heights community 2 roadway intersections would have to be accommodated. For this study it was estimated that for option 1 both roadway entrances could use ramps for crossing the restored levee. For option 2 both roadway entrances would use sliding flood gates.

3.3.6.5.4 HTRW

Due to the extent and large number of real estate parcels along with the potential for re-alignment of the structural aspects of this project, no preliminary assessment was performed to identify the possibility of hazardous waste on the sites. These studies will be conducted during the next phase of work after the final siting of the various structures. The real estate costs appearing in this report therefore will not reflect any costs for remediation design and/or treatment and/or removal or disposal of these materials in the baseline cost estimate.

3.3.6.5.5 Construction Procedures and Water Control Plan

The construction procedures required for this option are similar to general construction in many respects in that the easement limits must be established and staked in the field, the work area cleared of all structures, pavements, utilities, trees, organics, etc. and the foundation prepared for the new work. Where the levee alignment crosses the existing streams or narrow bays, the alignment base shall be created by displacement with layers of crushed stone pushed ahead and compacted by the placement equipment and repeated until a stable platform is created. The required drainage culverts or other ancillary structures can then be constructed. The control of any surface water will be handled by temporary sheetpile cofferdams and pumping. The control of groundwater will be a series of wellpoints systems designed to keep the excavations dry to a depth and width sufficient to install the new work.

3.3.6.5.6 Project Security

The Protocol for security measures for this study has been performed in general accordance with the Risk Assessment Methodology for Dams (RAM-D) developed by the Interagency Forum for Infrastructure Protection (IFIP). This methodology has been used for physical security for the critical infrastructure throughout the Corps of Engineers. The determination of the level of physical security provided for each facility is based on the following critical elements: 1) threat assessment of the likelihood that an adversary will attack a critical asset, 2) consequence assessment should an adversary be successful in disrupting, disabling or destroying the asset and 3) effectiveness to prevent a successful attack against an operational component.

Three levels of physical security were selected for use in this study:

Level 1 Security provides no improved security for the selected asset. This security level would be applied to the barrier islands and the sand dunes. These features present a very low threat level of attack and basically no consequence if an attack occurred and is not applicable to this option.

Level 2 Security applies standard security measures such as road barricades, perimeter fencing, and intrusion detection systems for unoccupied buildings and vertical structures and security lighting. The intrusion detection systems will be connected to the local law enforcement office for response during an emergency. Facilities requiring this level of security would possess a higher threat level than those in Level 1 and would include assets such as levees, access roads and pumping stations.

Level 3 Security includes all of the features of Level 2 plus enhanced security measures such as the use of video cameras for real-time monitoring of the facility, monitors, motion detectors and alarm sound system in the occupied control buildings. Facilities requiring this level of security would possess the highest threat level of all the critical assets. Power plants would require this level of security.

3.3.6.5.7 Operation and Maintenance

Operation and maintenance activities for this project will be required on an annual basis. All gates will be operated to assure proper working order. Debris and shoaled sediment will be removed from the interior ponding area. Vegetation on the levees will be cut to facilitate inspection and to prevent roots from causing weak levee locations. Rills will be filled and damaged revetment will be repaired. An operation and maintenance (O&M) manual for the levee will be developed for the non-Federal sponsor. The O&M manual will include guidelines for maintaining the integrity of the levee over the 50-year life of the project. Regular inspections and maintenance of the levees would be performed by the non-federal sponsor and USACE personnel. Maintenance costs are included in this report.

3.3.6.5.8 Cost Estimate

The costs for the various options included in this measure are presented in Section 3.3.6.7., Cost Summary. Construction costs for the various options are included in Table 3.3.6-4 and costs for the annualized Operation and Maintenance of the options are included in Table 3.3.6-5. Estimates are comparative-Level "Parametric Type" and are based on Historical Data, Recent Pricing, and Estimator's Judgment. Quantities listed within the estimates represent Major Elements of the Project Scope and were furnished by the Project Delivery Team. Price Level of Estimate is April 07. Estimates excludes project Escalation and HTRW Cost. The construction costs include real estate, engineering design (E&D), construction management, and contingencies. The E&D cost for preparation of construction contract plans and specifications includes a detailed contract survey, preparation of contract specifications and plan drawings, estimating bid quantities, preparation of bid estimate, preparation of final submittal and contract advertisement package, project engineering and coordination, supervision technical review, computer costs and reproduction. Construction Contingency developed and assigned at 25% to cover the Cost Growth of the project.

3.3.6.5.9 Schedule for Design and Construction

After the authority for the design has been issued and funds have been provided, the design of these structures will require approximately 12 months including comprehensive plans and specifications, independent reviews and subsequent revisions. The construction of this option should require in excess of two years.

3.3.6.6 Option B - Elevation 21 ft NAVD88

This option consists of an earthen levee around northern, western, and southern sides of the Forrest Heights community. Because of the height of the levee, the eastern side will be constructed with a concrete "T"-wall structure. The "T" wall will take less space than an earthen levee and encroach less into property along the alignment. The alignment of the levee is generally the same as Option A, but is shown below in Figure 3.3.6-17. Closure gates across the two access roads to the subdivision will be required. The lengths of the levee culverts will be slightly longer than those used in Option A. Other features and methods of analysis are the same.

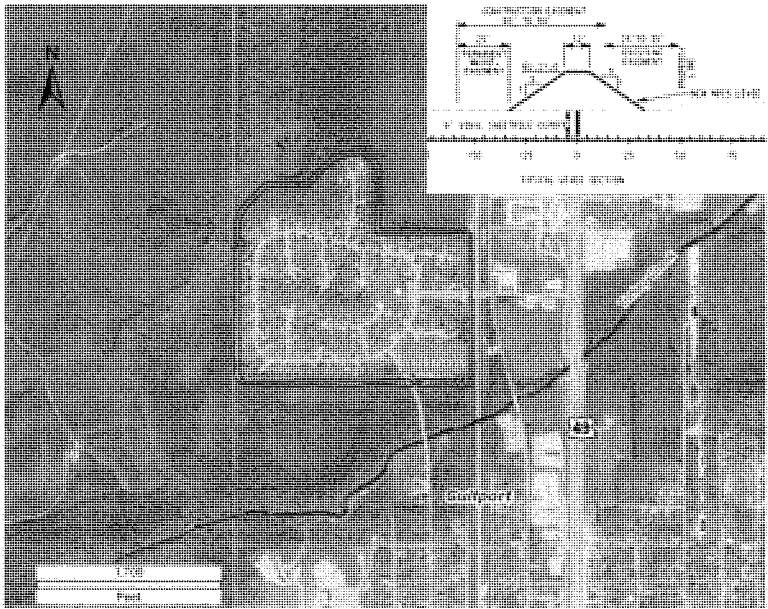


Figure 3.3.6-17. 21-ft Elevation Levee Alignment with Culvert and Detention Basin/Pump Locations

3.3.6.6.1 Interior Drainage

Interior drainage analysis and culverts are the same as those for Option A, above, except that the culvert lengths through the levees would be longer.

3.3.6.6.2 Geotechnical Data

The Geology and Geotechnical paragraphs for Option B are the same as for Option A, above.

3.3.6.6.3 Structural, Mechanical and Electrical

Culvert lengths are not presented but are incorporated into the cost estimate. The "T" wall is shown below in Figures 3.3.6-18.

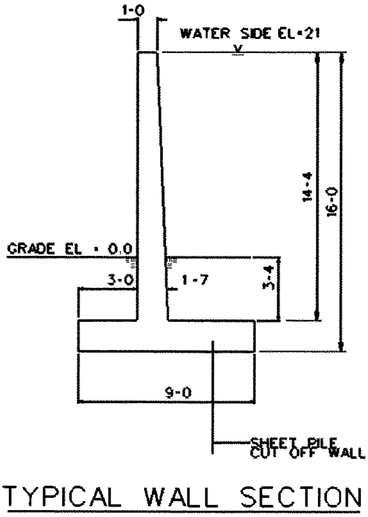


Figure 3.3.6-18. 21-ft Elevation Flood Wall Section

3.3.6.6.4 HTRW

The HTRW paragraphs for Option B are the same as for Option A, above.

3.3.6.6.5 Construction and Water Control Plan

The Construction and Water Control Plan paragraphs for Option B are the same as for Option A, above.

3.3.6.6.6 Project Security

The Project Security paragraphs for Option B are the same as for Option A, above.

3.3.6.6.7 Operation and Maintenance

The Operation and Maintenance paragraphs for Option B are the same as for Option A, above, with additional requirements for periodic inspection and operation of the flood gates.

3.3.6.6.8 Cost Estimate

The Cost Estimate paragraphs for Option B are the same as for Option A, above.

3.3.6.6.9 Schedule for Design and Construction

The Schedule for Design and Construction paragraphs for Option B are the same as for Option A, above.

3.3.6.7 Cost Estimate Summary

The costs for construction and for operations and maintenance of all options are shown in Tables 3.3.6-4 and 3.3.6-5 below. Estimates are comparative-Level "Parametric Type" and are based on Historical Data, Recent Pricing, and Estimator's Judgment. Quantities listed within the estimates represent Major Elements of the Project Scope and were furnished by the Project Delivery Team. Price Level of Estimate is April 07. Estimates excludes project Escalation and HTRW Cost.

Table 3.3.6-4.
Construction Cost Summary

Option	Total project cost
Option A – Elevation 17 ft NAVD88	$6,100,000
Option B – Elevation 21 ft NAVD88	$11,400,000

Table 3.3.6-5.
O & M Cost Summary

Option	O&M Cost
Option A – Elevation 17 ft NAVD88	$42,000
Option B – Elevation 21 ft NAVD88	$114,000

3.3.6.8 References

US Army Corps of Engineers (USACE) 1987. Hydrologic Analysis of Interior Areas. Engineer Regulation ER 1105-2-1413. Department of the Army, US Army Corps of Engineers, Washington, D.C. 15 January 1987.

USACE 1993. Hydrologic Frequency Analysis. Engineer Regulation ER 1105-2-1415. Department of the Army, US Army Corps of Engineers, Washington, D.C. 5 March 1993.

USACE 1995. Hydrologic Engineering Requirements for Flood Damage Reduction Studies. Engineer Regulation ER 1105-2-1419. Department of the Army, US Army Corps of Engineers, Washington, D.C. 31 January 1995.

USACE 2006. Risk Analysis for Flood Damage Reduction Studies. Engineer Regulation ER 1105-2-101. Department of the Army, US Army Corps of Engineers, Washington, D.C. 3 January 2006.

3.3.7 Jackson County, Ocean Springs Elevated Roadway

3.3.7.1 General

Residential and business areas along the coast in Jackson County are susceptible to storm surge damage. A damage reduction option is to raise the beach front road in Ocean Springs to elevation 11ft NAVD88 was evaluated. This option entails the raising of the Beach Road and the adjoining seawall to Elevation 11.00 from Highway 90 eastward to the Jackson County Marina. The project also provides for all utility infrastructure such as water, sewer, storm drain, gas and electric lines to be removed and reinstalled to meet the new grades. Several options of this measure were considered before selecting the final one for cost and economic comparisons. Additional options not evaluated in detail are described elsewhere in this report.

Evaluation of this option was done by comparing benefits computed by Hydrologic Engineering Center's (HEC) Flood Damage Analysis (FDA) computer application HEC-FDA and costs computed. HEC-FDA modeling was done comparing the study reaches using variations in expected sea-level rise and development. Details regarding the methodology are presented elsewhere in this report.

3.3.7.2 Location

The location of project in Ocean Springs is shown below in Figure 3.3.7.1.

3.3.7.3 Existing Conditions

The city of Ocean Springs lies at the eastern side of the Back Bay of Biloxi. Ground elevations over most of the residential and business areas vary between elevation 16-24 ft NAVD88, with houses along the coast at between 8-16 ft NAVD88. The 4-ft(blue), 8-ft(dark green), 12-ft(green), 16-ft(brown), and 20-ft(pink) ground contour lines are shown below in Figure 3.3.6-2.

Drainage is mostly through natural drainage ways, drowned at the mouth by Mississippi Sound.

Impacts from hurricanes can be devastating. Damage from Hurricane Katrina in August, 2005 in the Ocean Springs area are shown below in Figure 3.3.7-3 and 3.3.7-4.

3.3.7.4 Coastal and Hydraulic Data

Typical coastal data is shown in Paragraph 1.4, elsewhere in this report. High water marks taken by FEMA after Hurricane Katrina in 2005 as well as the 4-ft(blue), 8-ft(dark green), 12-ft(green), 16-ft(brown), and 20-ft(pink) ground contour lines and Hurricane Katrina inundation limits are shown below in Figure 3.3.7-5. The data indicates the Katrina high water was as high as 22.5 ft NAVD88 near the Mississippi Sound.

Stage-Frequency data for a suite of severe storms using Joint Probability Method (JPM) and hydrodynamic modeling were developed by the Engineer Research and Development Center (ERDC) for 80 locations along the study area. These data were combined with historical gage frequencies for smaller storms to establish stage-frequency curves at 54 economic reaches in the study area which were entered into Hydrologic Engineering Center's (HEC) Flood Damage Analysis (HEC-FDA) application to evaluate benefits. An expanded description of the procedure is shown in Section 2.13 of the Engineering Appendix and in the Economic Appendix. Points near Ocean Springs at which data from hydrodynamic modeling was saved are shown below in Figure 3.3.7-6.

Existing Condition Stage–Frequency data for Save Point 33, just off the coast of Ocean Springs, is shown below in Figure 3.3.7-7. The 95% confidence limits, approximately equally to plus and minus two standard deviations, are shown bounding the median curve. The elevations are presented at 100 ft higher than actual to facilitate HEC-FDA computations.

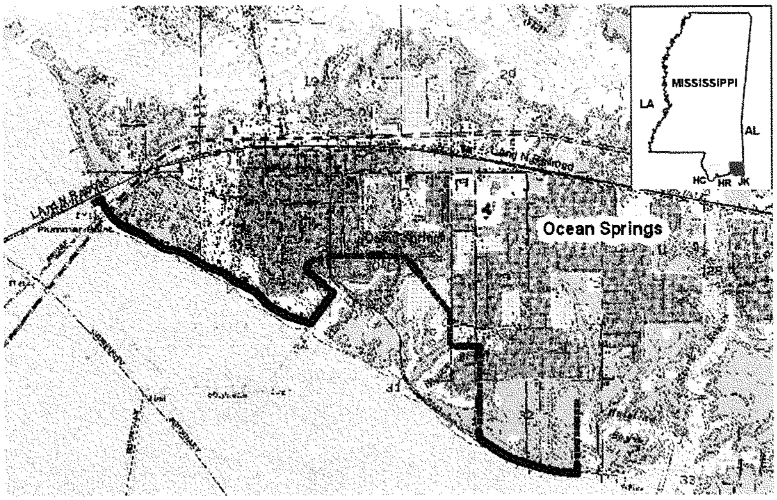


Figure 3.3.7-1. Vicinity Map, Ocean Springs

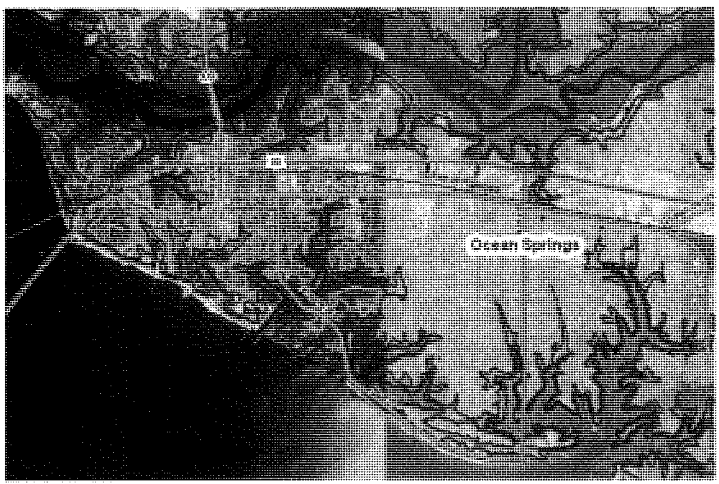


Figure 3.3.7-2. Existing Conditions

Source: http://ngs.woc.noaa.gov/storms/katrina/24834173.jpg

Figure 3.3.7-3. Hurricane Katrina Damage, Jackson County

Source:B&B Sanders, http://www.flickr.com/photo_zoom.gne?id=355219026

Figure 3.3.7-4. Hurricane Katrina Damage, Jackson County

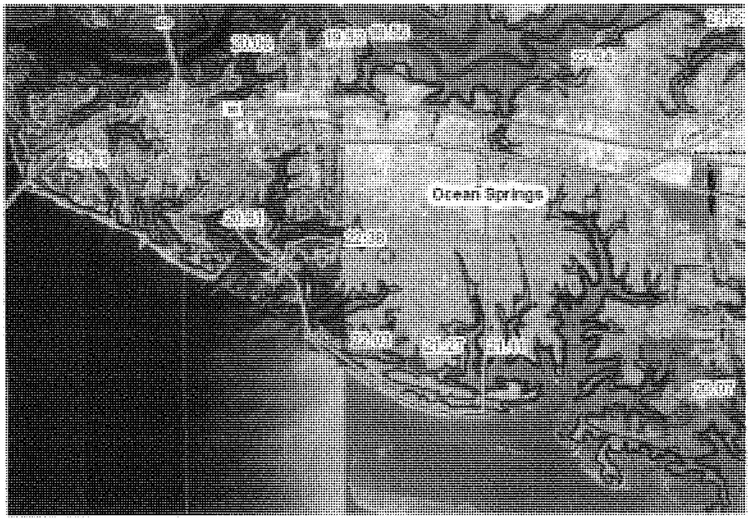


Figure 3.3.7-5. Ground Contours and Katrina High Water, Ocean Springs

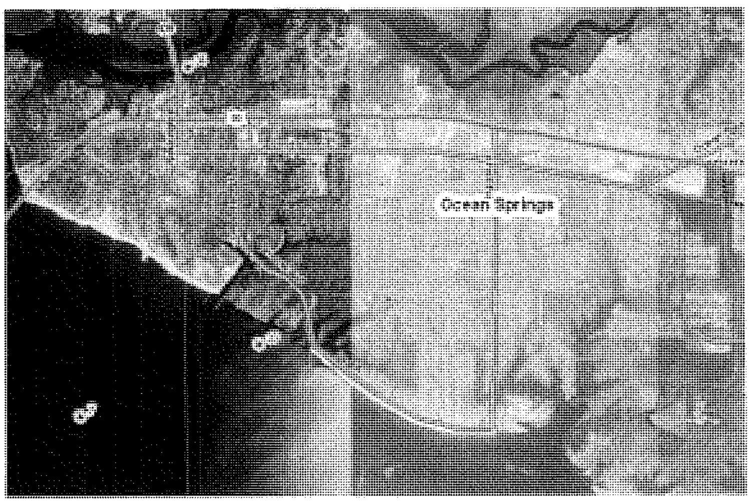


Figure 3.3.7-6. Hydrodynamic Modeling Save Points near Ocean Springs

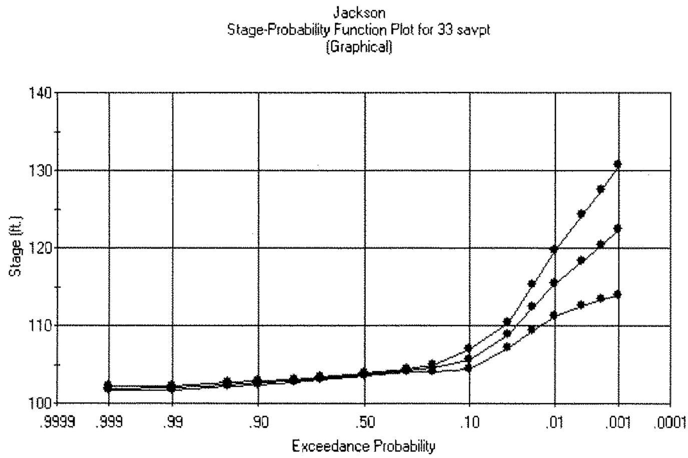


Figure 3.3.7-7. Existing Conditions at Save Point 33, near Ocean Springs

3.3.7.5 Option – Elevate Roadway to 11 ft NAVD88

This option consists of raising the beach front road to elevation 11 ft NAVD88 in Ocean Springs as shown on the following Figure 3.3.7-8, along with the internal sub-basins and levee culvert/pump locations.

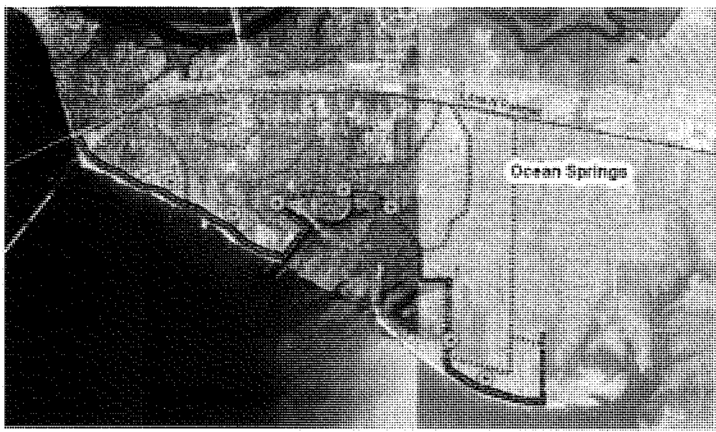
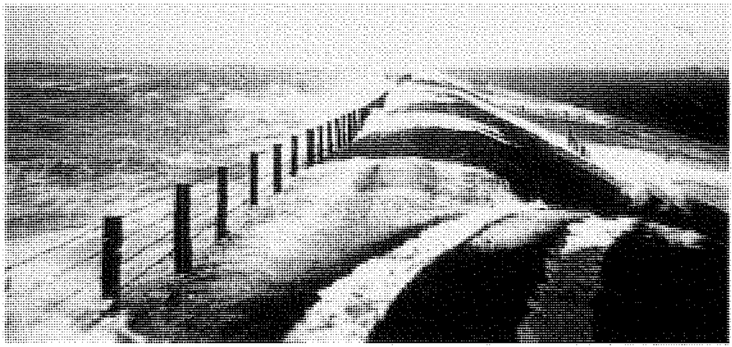


Figure 3.3.7-8. Pump/Culvert/Sub-basin Site Location

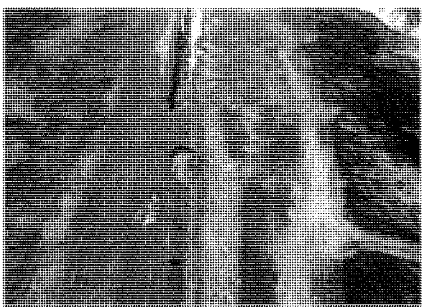
Damage and failure by overtopping of levees could be caused by storms surges greater than the levee crest as shown in Figure 3.3.7-9.



Source: Wave Overtopping Flow on Seadikes, Experimental and Theoretical Investigations, Holger Schüttrumpf, (Photo:Leichtweiss-Institute) http://kfki.baw.de/fileadmin/projects/E_35_134_Lit.pdf

Figure 3.3.7-9. North Sea, Germany, March 1976

Overtopping failures are caused by the high velocity of flow on the top and back side of the levee. Although significant wave attack on the seaward side of some of the New Orleans levees occurred during Hurricane Katrina, the duration of the wave attack was for such a short time that major damage did not occur from wave action. The erosion shown below in Figure 3.3.7-10 was caused by approximately 1-2 ft of overtopping crest depth.



Source: ERDC, Steven Hughes

Figure 3.3.7-10. Crown Scour from Hurricane Katrina at Mississippi River Gulf Outlet (MRGO) Levee in St. Bernard Parish, New Orleans, LA

Revetment would be included in the levee design to prevent overtopping failure.

The levee would be protected by gabions on filter cloth as shown above in Figure 3.3.7-11, extending across a drainage ditch which carries water to nearby culverts and which would also serve to dissipate some of the supercritical flow energy during overtopping conditions.

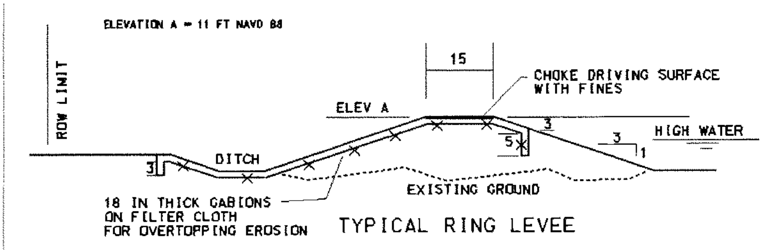


Figure 3.3.7-11. Typical Section at Ring Levee

3.3.7.5.1 Interior Drainage

Drainage on the interior of the raised highway would be collected at the highway and channeled to culverts placed at 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 for control in the event the flap gate malfunctions. A typical section is shown below in Figure 3.3.7-12.

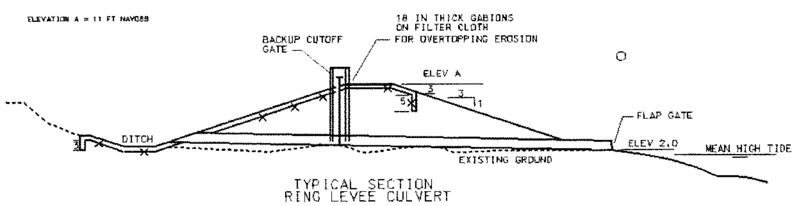


Figure 3.3.7-12. Typical Section at Culvert

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 drainage basin into major sub-basins as shown above 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.

Peak flows for the 1-yr to 100-yr storms were computed. 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. For the culvert design, headwater/tailwater elevation difference was maintained at 3.0 ft or less. Drainage ditches along the toe of the highway will be required to assure that smaller basins can be drained to a culvert/pump site. These ditches were sized using a normal depth flow computation. Curve numbers, pump, and culvert capacity tables are not included in the report beyond that necessary to obtain a cost estimate. The data is considered beyond the level of detail required for this report.

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. This decision was 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. However, in some of the areas, existing storage could be adequate to pond water without causing damage, even without pumps. In other areas that do have pumps, some rise in interior water during interior events greater than the 10-yr rain could occur, but may not cause damage. Designing the pumps for the peak 10-yr flow provides a significant pumping capacity. Further studies will detail the requirement for the appropriate ponding areas, pump sizes, or buyouts in the affected areas.

During non-hurricane periods of low water in the sound, when rainfall greater than the 25-yr event occurs, the pumps could also be used to augment the flow capacity of the levee culverts.

3.3.7.5.2 Geotechnical

Geology: The Prairie formation is found southward of the Citronelle formation and is of Pleistocene age. This formation consists of fluvial and floodplain sediments that extend southward from the outcrop of the Citronelle formation to or near the mainland coastline. Sand found within this formation has an economic value as beach fill due to its color and quality. Southward from its outcrop area, the formation extends under the overlying Holocene deposits out into the Mississippi Sound.

The Gulfport Formation is found along the coastline in Jackson County at Belle Fontaine Beach. This formation of Pleistocene age overlies the Prairie formation and is present as well sorted sands that mark the edge of the coastline during the last high sea level stage of the Sangamonian Interglacial period. It does not extend under the Mississippi Sound.

Geotechnical: The Line 3 defense elevates the roadway and accompanying seawall to elevation by extending the seaway at its present slope to grade, creating the roadway subgrade then sloping the backside to one vertical to three horizontal side slopes with a twenty five foot toe width for access and drainage. All work areas to receive the fill shall be cleared and grubbed of all trees and surface organics and all existing foundations, streets, utilities, etc. will be removed and the subsequent cavities backfilled and compacted. The embankment will be constructed of sand clay materials obtained from off site commercial sources, trucked to the work area, placed in thin lifts and compacted to 95 percent of the maximum modified density. The final surface on the back side will be armored by the placement of 12 inch thick gabion mattress filled with small stone for erosion protection during an event that overtops the road. The armoring will be anchored on the back face by trenching and extend across the toe easement. All non critical surface areas will be subsequently covered by grassing. Road crossings will incorporate ramping over the embankment where the surface elevation is near that of the crest elevation. The surfaces will be paved with asphalt and the corresponding drainage will be accommodated. Those areas where the subgrade geology primarily consists of clean sands, seepage underneath the roadway and the potential for erosion and instability must be considered. Final designs may require the installation of a cutoff wall within the foundation. This condition will be investigated during any design phase and its requirement will be incorporated.

3.3.7.5.3 Pumping Stations. Flow and Pump Sizes

Design hydraulic heads derived for the 7 pumping facilities included in the Jackson County Raised Roadway at the elevation 11 protection level were approximately constant at 7 feet, and the corresponding flows required varied from 83,926 to 237,864 gallons per minute. The plants thus derived varied in size from a plant having two 42-inch diameter, 150 horsepower pumps, to one having six 60-inch diameter pumps each running at 150 horsepower.

3.3.7.5.4 HTRW

Due to the extent and large number of real estate parcels along with the potential for re-alignment of the structural aspects of this project, no preliminary assessment was performed to identify the possibility of hazardous waste on the sites. These studies will be conducted during the next phase of work after the final siting of the various structures. The real estate costs appearing in this report therefore will not reflect any costs for remediation design and/or treatment and/or removal or disposal of these materials in the baseline cost estimate.

3.3.7.5.5 Construction Procedures and Water Control Plan

Construction would be done by heavy construction equipment after removal of structures and relocation of utilities. Water control will be addressed by constructing drainage facilities prior to construction of the levee.

3.3.7.5.6 Project Security

The Protocol for security measures for this study has been performed in general accordance with the Risk Assessment Methodology for Dams (RAM-D) developed by the Interagency Forum for Infrastructure Protection (IFIP). This methodology has been used for physical security for the critical infrastructure throughout the Corps of Engineers. The determination of the level of physical security provided for each facility is based on the following critical elements: 1) threat assessment of the likelihood that an adversary will attack a critical asset, 2) consequence assessment should an adversary be successful in disrupting, disabling or destroying the asset and 3) effectiveness to prevent a successful attack against an operational component.

Three levels of physical security were selected for use in this study:

Level 1 Security provides no improved security for the selected asset. This security level would be applied to the barrier islands and the sand dunes. These features present a very low threat level of attack and basically no consequence if an attack occurred and is not applicable to this option.

Level 2 Security applies standard security measures such as road barricades, perimeter fencing, and intrusion detection systems for unoccupied buildings and vertical structures and security lighting. The intrusion detection systems will be connected to the local law enforcement office for response during an emergency. Facilities requiring this level of security would possess a higher threat level than those in Level 1 and would include assets such as levees, access roads and pumping stations.

Level 3 Security includes all of the features of Level 2 plus enhanced security measures such as the use of video cameras for real-time monitoring of the facility, monitors, motion detectors and alarm sound system in the occupied control buildings. Facilities requiring this level of security would possess the highest threat level of all the critical assets. Boat access gates and power plants would require this level of security.

3.3.7.5.7 Operation and Maintenance

Operation and maintenance activities for this project will be required on an annual basis. All pumps and gates will be operated to assure proper working order. Debris and shoaled sediment will be removed. Vegetation on the levees will be cut to facilitate inspection and to prevent roots from causing weak levee locations. Maintenance costs are included in this report.

3.3.7.5.8 Cost Estimate

The costs for the various options included in this measure are presented in Section 3.3.7.6 Cost Summary. Construction costs for the various options are included in Table 3.3.7-1 and costs for the annualized Operation and Maintenance of the options are included in Table 3.3.7-2. Estimates are comparative-Level "Parametric Type" and are based on Historical Data, Recent Pricing, and Estimator's Judgment. Quantities listed within the estimates represent Major Elements of the Project Scope and were furnished by the Project Delivery Team. Price Level of Estimate is April 07. Estimates excludes project Escalation and HTRW Cost. The construction costs include real estate, engineering design (E&D), construction management, and contingencies. The E&D cost for preparation of construction contract plans and specifications includes a detailed contract survey, preparation of contract specifications and plan drawings, estimating bid quantities, preparation of bid estimate, preparation of final submittal and contract advertisement package, project engineering and coordination, supervision technical review, computer costs and reproduction. Construction Contingency developed and assigned at 25% to cover the Cost Growth of the project.

3.3.7.5.9 Schedule for Design and Construction

After the authority for the design has been issued and funds have been provided, the design of these structures will require approximately 12 months including comprehensive plans and specifications, independent reviews and subsequent revisions. The construction of this option should require in excess of two years

3.3.7.6 Cost Estimate Summary

The costs for construction and for operations and maintenance of all options are shown in Tables 3.3.7-1 and 3.3.7-2 below. Estimates are comparative-Level "Parametric Type" and are based on Historical Data, Recent Pricing, and Estimator's Judgment. Quantities listed within the estimates represent Major Elements of the Project Scope and were furnished by the Project Delivery Team. Price Level of Estimate is April 07. Estimates excludes project Escalation and HTRW Cost.

Table 3.3.7-1.
Jackson Co Ocean Springs Elevated Roadway
Construction Cost Summary

Option	Total project cost
Option - Elevated Roadway	$67,500,000

Table 3.3.7-2.
Jackson Co Ocean Springs Elevated Roadway O & M Cost Summary

Option	O&M Cost
Option A – Elevated Roadway	$287,000

3.3.7.7 References

US Army Corps of Engineers (USACE) 1987. Hydrologic Analysis of Interior Areas. Engineer Manual EM 1110-2-1413. Department of the Army, US Army Corps of Engineers, Washington, D.C. 15 January 1987.

USACE 1993. Hydrologic Frequency Analysis. Engineer Manual EM 1110-2-1415. Department of the Army, US Army Corps of Engineers, Washington, D.C. 5 March 1993.

USACE 1995. Hydrologic Engineering Requirements for Flood Damage Reduction Studies. Engineer Manual EM 1110-2-1419. Department of the Army, US Army Corps of Engineers, Washington, D.C. 31 January 1995.

USACE 2006. Risk Analysis for Flood Damage Reduction Studies. Engineer Regulation ER 1105-2-101. Department of the Army, US Army Corps of Engineers, Washington, D.C. 3 January 2006.

National Resource Conservation Service (NRCS). 2003. WinTR5-55 User Guide (Draft). Agricultural Research Service. 7 May 2003.

Environmental Science Services Administration. 1968. "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.

Weather Bureau and USACE. 1956. 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.

3.3.8 Jackson County, Ocean Springs Ring Levee

3.3.8.1 General

Several high density residential and business areas in Jackson County were identified. They are: Pascagoula/Mosspoint, Gautier, Belle Fontaine, Gulf Park Estates, and Ocean Springs. These are subject to damage from storm surges associated with hurricanes. Earthen ring levees were evaluated for protection of these areas. The levees were evaluated at elevations 20 ft NAVD88 and 30 ft NAVD88. The top width was assumed 15 ft with sideslopes of 1 vertical to 3 horizontal. Each of the levees is presented separately in this report. Additional options not evaluated in detail are described elsewhere in this report.

Evaluation of this option was done by comparing benefits computed by Hydrologic Engineering Center's (HEC) Flood Damage Analysis (FDA) computer application HEC-FDA and costs computed. HEC-FDA modeling was done comparing the study reaches using variations in expected sea-level rise and development. Details regarding the methodology are presented in Section 2.13 of the Engineering Appendix and in the Economic Appendix.

3.3.8.2 Location

The location of the Ocean Springs ring levee in Jackson County is shown below in Figures 3.3.8-1 and 3.3.8-2.

3.3.8.3 Existing Conditions

The city of Ocean Springs lies at the eastern side of the Back Bay of Biloxi. Ground elevations over most of the residential and business areas vary between elevation 16-24 ft NAVD88, with houses along the coast at between 8-16 ft NAVD88. The 4-ft(blue), 8-ft(dark green), 12-ft(green), 16-ft(brown), and 20-ft(pink) ground contour lines are shown below in Figure 3.3.8-3.

Drainage is mostly through natural drainage ways, drowned at the mouth by Mississippi Sound.

Impacts from hurricanes can be devastating. Damage from Hurricane Katrina in August, 2005 in the Ocean Springs area are shown below in Figure 3.3.8-4 and 3.3.8-5.

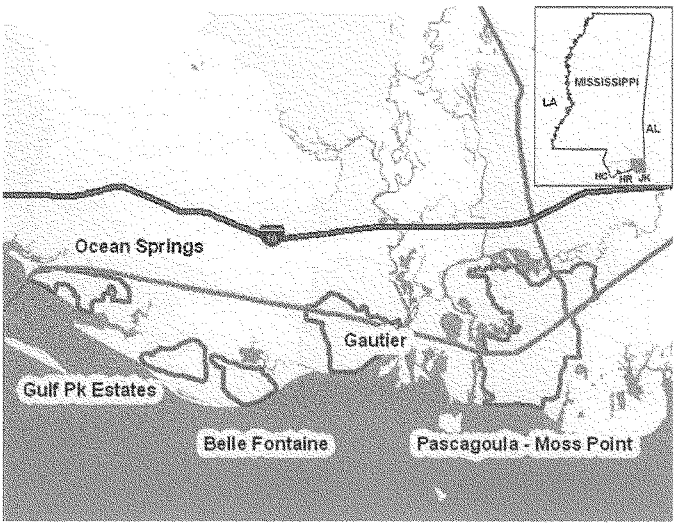


Figure 3.3.8-1. Vicinity Map Ocean Springs, MS

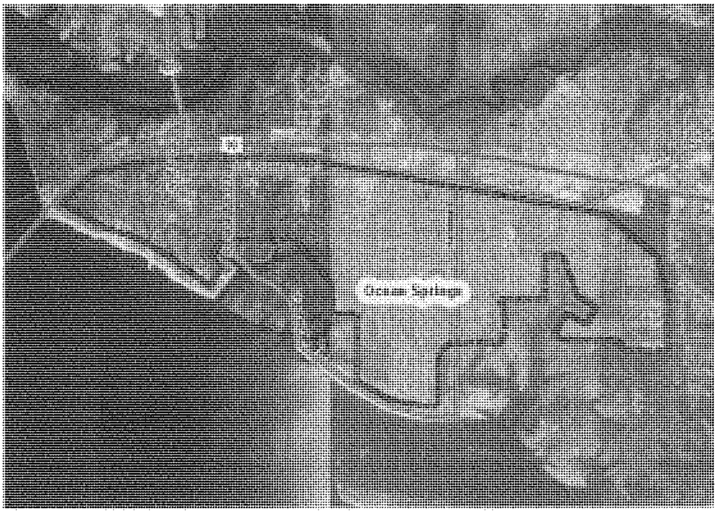


Figure 3.3.8-2. Ocean Springs Ring Levee

Figure 3.3.8-3. Existing Conditions Ocean Springs, MS

Source: http://ngs.woc.noaa.gov/storms/katrina/24834173.jpg

Figure 3.3.8-4. Hurricane Katrina Damage Ocean Springs, MS

Source: B&B Sanders, http://www.flickr.com/photo_zoom.gne?id=355219026

Figure 3.3.8-5. Hurricane Katrina Damage Ocean Springs, MS

3.3.8.4 Coastal and Hydraulic Data

Typical coastal data are shown in Section 1.4 of this report. High water marks taken by FEMA after Hurricane Katrina in 2005 as well as the 4-ft(blue), 8-ft(dark green), 12-ft(green), 16-ft(brown), and 20-ft(pink) ground contour lines and Hurricane Katrina inundation limits are shown below in Figure 3.3.8-6. The data indicates the Katrina high water was as high as 22.5 ft NAVD88 near the Mississippi Sound.

Stage-Frequency data for a suite of severe storms using Joint Probability Method (JPM) and hydrodynamic modeling were developed by the Engineer Research and Development Center (ERDC) for 80 locations along the study area. These data were combined with historical gage frequencies for smaller storms to establish stage-frequency curves at 54 economic reaches in the study area which were entered into Hydrologic Engineering Center's (HEC) Flood Damage Analysis (HEC-FDA) application to evaluate benefits. An expanded description of the procedure is shown in Section 2.13 of the Engineering Appendix and in the Economic Appendix. Points near Ocean Springs at which data from hydrodynamic modeling was saved are shown below in Figure 3.3.8-7.

Existing Condition Stage –Frequency data for Save Point 33, just off the coast of Ocean Springs, is shown below in Figure 3.3.8-8. The 95% confidence limits, approximately equal to plus and minus two standard deviations, are shown bounding the median curve. The elevations are presented at 100 ft higher than actual to facilitate HEC-FDA computations.

3.3.8.5 Option A – Elevation 20 ft NAVD88

This option consists of an earthen dike enclosing an area of 1752 acres around the most densely populated areas of Ocean Springs as shown on the following Figure 3.3.8-9, along with the internal sub-basins and levee culvert/pump locations. The levee would have a top width of 15 ft and slopes of 1 vertical to 3 horizontal.

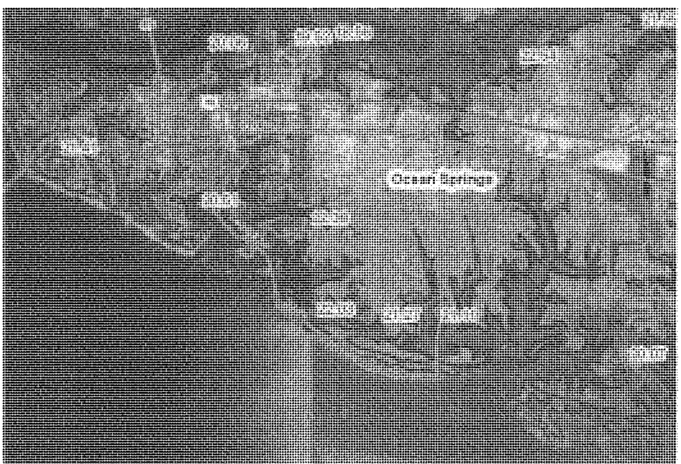


Figure 3.3.8-6. Ground Contours and Katrina High Water

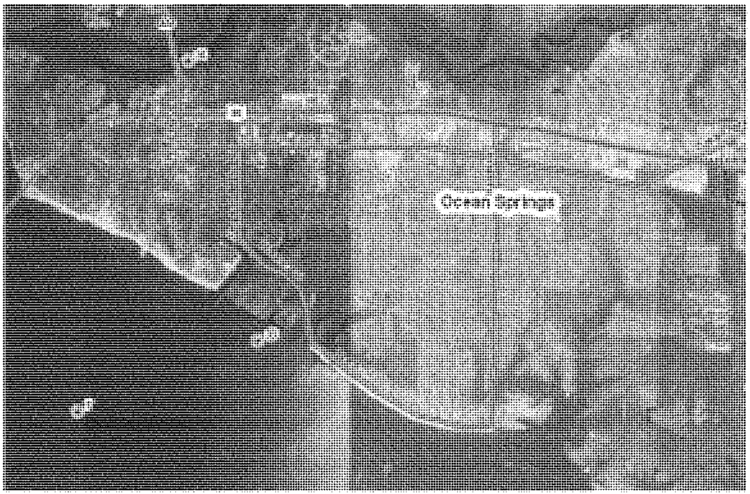


Figure 3.3.8-7. Hydrodynamic Modeling Save Points near Ocean Springs

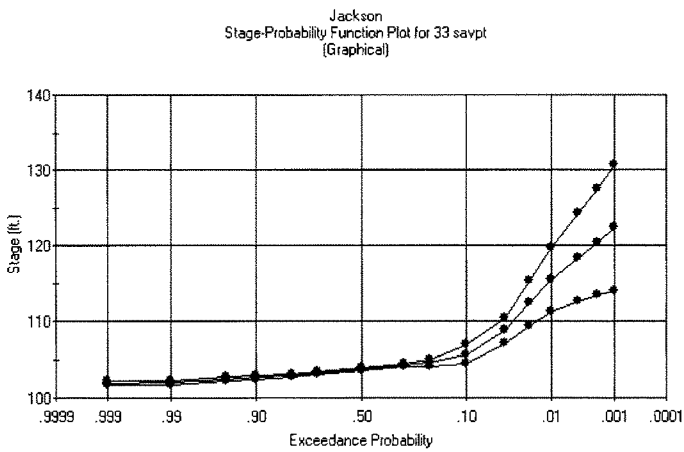
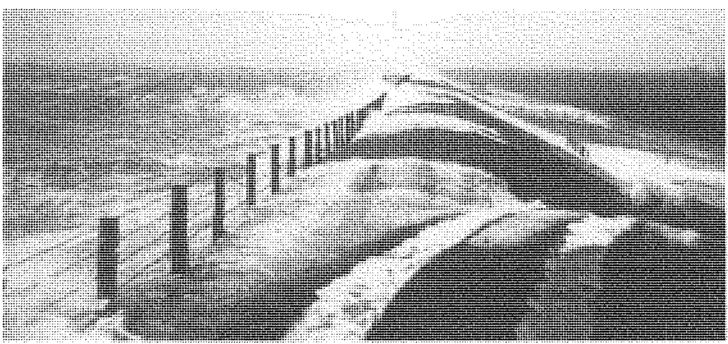


Figure 3.3.8-8. Existing Conditions at Save Point 33, near Ocean Springs

Figure 3.3.8-9. Pump/Culvert/Sub-basin Locations

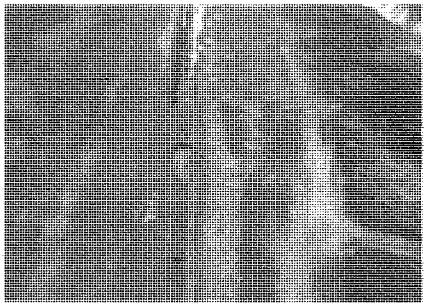
Damage and failure by overtopping of levees could be caused by storms surges greater than the levee crest as shown in Figure 3.3.8-10.



Source: Wave Overtopping Flow on Seadikes, Experimental and Theoretical Investigations, Holger Schüttrumpf, (Photo:Leichtweiss-Institute) http://kfki.baw.de/fileadmin/projects/E_35_134_Lit.pdf

Figure 3.3.8-10. North Sea, Germany, March 1976

Overtopping failures are caused by the high velocity of flow on the top and back side of the levee. Although significant wave attack on the seaward side of some of the New Orleans levees occurred during Hurricane Katrina, the duration of the wave attack was for such a short time that major damage did not occur from wave action. The erosion shown below in Figure 3.3.8-11 was caused by approximately 1-2 ft of overtopping crest depth.



Source: ERDC, Steven Hughes

Figure 3.3.8-11. Crown Scour from Hurricane Katrina at Mississippi River Gulf Outlet (MRGO) Levee in St. Bernard Parish, New Orleans, LA

Revetment would be included in the levee design to prevent overtopping failure.

The levee would be protected by gabions on filter cloth as shown in Figure 3.3.8-12, extending across a drainage ditch which carries water to nearby culverts and which would also serve to dissipate some of the supercritical flow energy during overtopping conditions.

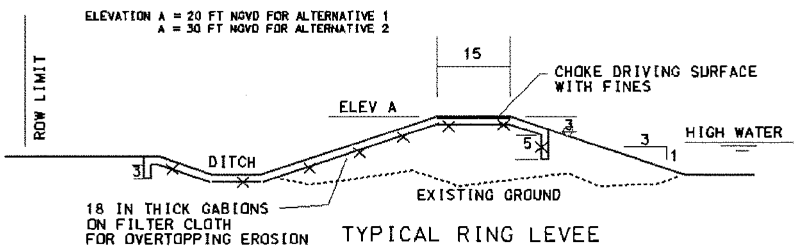


Figure 3.3.8-12. Typical Section at Ring Levee

3.3.8.5.1 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 in Figure 3.3.8-9. 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 3.3.8-13.

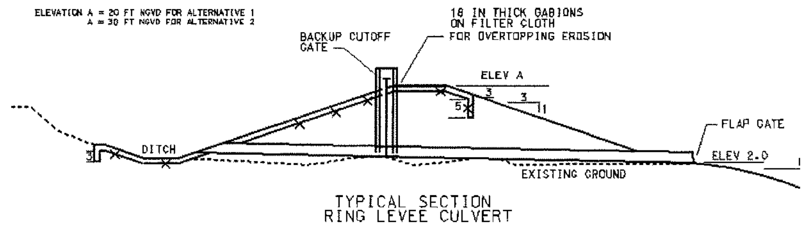


Figure 3.3.8-13. Typical Section at Culvert

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 ring levee into major sub-basins as shown above in Figure 3.3.8-9 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 sub-basins is shown below in Figure 3.3.8-14.

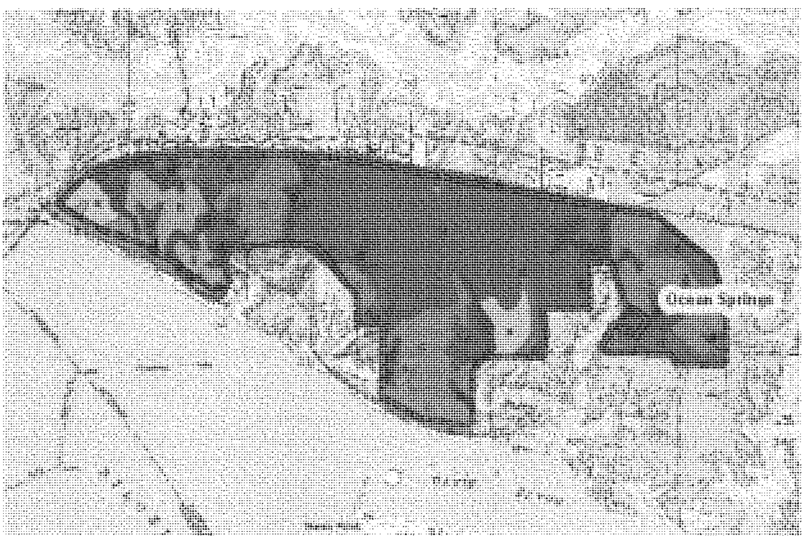


Figure 3.3.8-14. Ocean Springs Hydrologic Soil Groups

Hydrologic soil group A soils have low runoff potential and high infiltration rates, even with thoroughly wetted and a high rate of water transmission. Hydrologic soil group B soils have moderate infiltration rates when thoroughly wetted and a moderate rate of water transmission. Hydrologic soil group C soils have low infiltration rates when thoroughly wetted and have a low rate of water transmission. Hydrologic soil group C soils have high runoff potential and a very low rate of water transmission.

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. For the culvert design, headwater elevations at the culverts were maintained at an elevation no greater than 5 ft NAVD88 with a tailwater elevation of 2.0 ft NAVD88 assumed. Drainage ditches along the toe of the levee will be required to assure that smaller basins can be drained to a culvert/pump site. These ditches were sized using a normal depth flow computation. Curve numbers, pump, and culvert capacity tables are not included in the report beyond that necessary to obtain a cost estimate. The data are considered beyond the level of detail required for this report.

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. This decision was 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. However, in some of the areas, existing storage could be adequate to pond water without causing damage, even without pumps. In other areas that do have pumps, some rise in interior water during interior events greater than the 10-yr rain could occur, but may not cause damage. Designing the pumps for the peak 10-yr flow provides a significant pumping capacity. Further studies will detail the requirement for the appropriate ponding areas, pump sizes, or buyouts in the affected areas.

During non-hurricane periods of low water in the sound, when rainfall greater than the 25-yr event occurs, the pumps could also be used to augment the flow capacity of the levee culverts.

3.3.8.5.2 Geotechnical Data

Geology: Citronelle formation is found above the Interstate 10 alignment and is a relatively thin unit of fluvial deposits of Plio-Pleistocene age consisting of gravelly sand and silty sand layers. Typically the formation is 30 to 80 feet thick, except where it has filled eroded channels in the underlying formations. The sand in the formation has a variety of colors, often associated with the presence of iron oxides in the form of hematite or goethite. Thin discontinuous clay layers are found in some areas. The iron oxide has occasionally cemented the sand into a friable sandstone, usually occurring only as a localized layer. Within the study area, this formation outcrops north of Interstate 10 and will not be encountered at project sites other than any levees that might extend northward to higher ground elevations.

Prairie formation is found along the rest of the Line 4 alignment within Jackson County. The Prairie formation is found southward of the Citronelle formation and is of Pleistocene age. This formation consists of fluvial and floodplain sediments that extend southward from the outcrop of the Citronelle formation to or near the mainland coastline. Sand found within this formation has an economic value as beach fill due to its color and quality. Southward from its outcrop area, the formation extends under the overlying Holocene deposits out into the Mississippi Sound.

Gulfport Formation is found along the coastline in most of western Jackson County at Belle Fontaine Beach. This formation of Pleistocene age overlies the Prairie formation and is present as well sorted sands that mark the edge of the coastline during the last high sea level stage of the Sangamonian Interglacial period. It does not extend under the Mississippi Sound.

Geotechnical: The inland barrier earthen levee section will have one vertical to three horizontal side slopes with a fifteen foot crest width. All work areas to receive the fill shall be cleared and grubbed of all trees and surface organics and all existing foundations, streets, utilities, etc. will be removed and the subsequent cavities backfilled and compacted. The levee will be constructed of sand clay materials obtained from off site commercial sources, trucked to the work area, placed in thin lifts and compacted to 95 percent of the maximum modified density. The final surface will be armored by the placement of 24 inch thick gabion mattress filled with small stone for erosion protection during an event that overtops the levee. The armoring will be anchored on the front face by trenching and extend across the downstream slope and the 25 foot easement area beyond the toe. The front side of the levee and all non critical surface areas will be subsequently covered by grassing. Road crossings will incorporate small gate structures or ramping over the embankment where the surface elevation is near that of the crest elevation. The elevation relationship of the crest and the adjacent railroad will be a governing factor. The surfaces will be paved with asphalt and the corresponding drainage will be accommodated. Those areas where the subgrade geology primarily consists of clean sands, seepage underneath the levee and the potential for erosion and instability must be considered. Final designs may require the installation of a bentonite concrete cutoff wall deep within the foundation. This condition will be investigated during any design phase and its requirement will be incorporated.

3.3.8.5.3 Jackson County Ring Levee. Ocean Springs. Option A - Elevation 20 ft NAVD88. Structural, Mechanical and Electrical

3.3.8.5.3.1 Culverts

As any flood barrier is constructed the natural groundwater runoff would be inhibited. In order to maintain the natural runoff patterns culverts would be inserted through the protection line at appropriate locations. For this study these were configured as cast-in-place reinforced concrete box structures fitted with flap gates to minimize normal backflows and sluice gates to provide storm closure when needed. The shear number of these structures that would be required throughout the area covered by this study would dictate that an automated system be incorporated whereby the gates could be monitored and operated from some central location within defined districts. Detailed design of these monitoring and operating systems is beyond the scope of this study, however a parametric cost was developed for each site and included in the estimated construction cost for these facilities.

3.3.8.5.3.2 Pumping Facilities Structural

The layout of each pumping facility was made in conformance with Corp of Engineers Guidance document EM 1110-2-3105, Mechanical and Electrical Design of Pumping Stations. The basic plant dimensions for each site were set using approximate dimensions derived based on specific pump data (pump impeller diameter, pump bell bottom clearance, etc.). Each facility was roughly fitted to its site using existing ground elevations taken from available mapping and height of levee data. In every case the top of the pump floor was required to be above the 100 year flood elevation. Nominal sidewall and sump and pump floor thicknesses were assumed, along with wall and roof thicknesses for the pump room enclosure. Using these basic dimensions and the preliminary number and size of pumping units determined for each site, the overall plant footprint and elevations were set and quantities of basic construction materials computed. The pumping plants were configured, to the greatest extent possible with the data provided, to provide multiple pumps at each site.

Discharge piping for each plant was estimated using over the levee piping with one pipe per pumping unit. For estimating purposes the piping was sized to match the pump diameter. Each pipe was extended approximately 25 feet beyond the toe of the embankment on the discharge end to allow for energy dissipation features to be incorporated into the pipe discharge.

At the discharge end of the piping a heavy mat of grouted riprap was added as protection for the levee slope and immediately adjacent area. In each case the 4-foot deep stone mat was estimated as extending 30 feet up the levee slope and 50 feet out from the levee toe for a total width of 80 feet. The lateral extent was estimated at 10 feet per discharge pipe.

3.3.8.5.3.3 Pumping Stations Mechanical

Vertical shaft pumps were used for all of the pumping facilities. Preliminary mechanical design of the required pumping equipment was made by adaptation of manufacturer's stock pumping equipment to approximate hydraulic head and flow data developed for each pumping location. This data was coordinated with a pump manufacturer who supplied a cross check of the pump selections and cost data for use in preparation of project construction cost estimates. In consideration of the primary purpose which this equipment would serve, and in light of the widespread unavailability of electric power during and immediately after a major storm, it was determined that the pumps should be diesel engine driven.

3.3.8.5.3.4 Pumping Stations Electrical

The electrical design for these facilities would consist primarily of providing station power for the facilities. For each of the sites this would include installation of Power Poles, Cable, Power Pole Terminations, miscellaneous electrical appurtenances, and an Electrical 30 kW Diesel Generator Set for backup power.

Because of the number of pumping facilities involved and the need to closely control the pumping operations over a large area, a system of several operation and monitoring stations would be required from which the pumping facilities could be started and their operation monitored during and immediately following a storm event. The detailed design of this monitoring and operation system is beyond the scope of this study, however a parametric estimate of the cost involved in developing and installing such a system was made and included in the estimate of construction costs for these facilities.

3.3.8.5.3.5 Pumping Stations. Flow and Pump Sizes

Design hydraulic heads derived for the 14 pumping facilities included in the Ocean Springs Ring Levee system for the elevation 20 protection level varied from approximately 10 to 15 feet and the corresponding flows required varied from 70,915 to 401,703 gallons per minute. The plants thus derived varied in size from a plant having two 42-inch diameter, 150 horsepower pumps, to one having four 60-inch diameter pumps each running at 560 horsepower.

3.3.8.5.3.6 Roadways

At each point where a roadway crosses the protection line the decision must be made whether to maintain this artery and adapt the protection line to accommodate it, or to terminate the artery at the protection line and divert traffic to cross the protection line at another location. For this study it was assumed that all roadways and railways crossing the levee alignment would be retained except where it was very evident that traffic could be combined without undue congestion.

Once the decision has been made to retain a particular roadway, it must then be determined how best to configure the artery to conduct traffic across the protection line. The simplest means of passing roadway traffic is to ramp the roadway over the protection line. This alternative is not always viable because of severe right-of-way restraints caused by extreme levee height, urban congestion, etc. In such instances other methods can be used including partial ramping in combination with low profile roller gates. In more restricted areas full height gates which would leave the roadway virtually unaltered might be preferable, even though this alternative would usually be more costly than ramping. In some extreme circumstances where high levees are required to pass through very congested areas, installation of tunnels with closure gates may be required.

Some economy could probably be achieved in this effort by combining smaller arteries and passing traffic through the protection line in fewer locations. However, in most instances this would involve detailed traffic routing studies and designs that are beyond the scope of this effort. These studies would be included in the next phase of the development of these options, should such be warranted.

3.3.8.5.3.7 Railways

Because of the extreme gradient restrictions necessarily placed on railway construction, it is practically never acceptable to elevate a railway up and over a levee. Therefore, the available alternatives would include gated pass through structures. Because of the vertical clearance requirements of railroad traffic all railroad pass through structures for this study were configured having vertical walls on either side of the railway with double swing gates extending to the full height of the levee.

3.3.8.5.3.8 Levee and Roadway/Railway Intersections

With the installation of a ring levee around the Ocean Springs area to elevation 20, 24 roadway intersections would have to be accommodated. For this study it was estimated that 6 roller gate structures and 18 swing gate structures would be required.

3.3.8.5.4 Jackson County Ring Levee. Ocean Springs. Option A - Elevation 20 ft NAVD88. HTRW

Due to the extent and large number of real estate parcels along with the potential for re-alignment of the structural aspects of this project, no preliminary assessment was performed to identify the possibility of hazardous waste on the sites. These studies will be conducted during the next phase of work after the final siting of the various structures. The real estate costs appearing in this report therefore will not reflect any costs for remediation design and/or treatment and/or removal or disposal of these materials in the baseline cost estimate.

3.3.8.5.5 Construction Procedures and Water Control Plan

The construction procedures required for this option are similar to general construction in many respects in that the easement limits must be established and staked in the field, the work area cleared of all structures, pavements, utilities, trees, organics, etc. and the foundation prepared for the new work. Where the levee alignment crosses the existing streams or narrow bays, the alignment base shall be created by displacement with layers of crushed stone pushed ahead and compacted by the placement equipment and repeated until a stable platform is created. The required drainage culverts or other ancillary structures can then be constructed. The control of any surface water will be handled by temporary sheetpile cofferdams and pumping. The control of groundwater will be a series of wellpoints systems designed to keep the excavations dry to a depth and width sufficient to install the new work.

3.3.8.5.6 Project Security

The Protocol for security measures for this study has been performed in general accordance with the Risk Assessment Methodology for Dams (RAM-D) developed by the Interagency Forum for Infrastructure Protection (IFIP). This methodology has been used for physical security for the critical infrastructure throughout the Corps of Engineers. The determination of the level of physical security provided for each facility is based on the following critical elements: 1) threat assessment of the likelihood that an adversary will attack a critical asset, 2) consequence assessment should an adversary be successful in disrupting, disabling or destroying the asset and 3) effectiveness to prevent a successful attack against an operational component.

Three levels of physical security were selected for use in this study:

Level 1 Security provides no improved security for the selected asset. This security level would be applied to the barrier islands and the sand dunes. These features present a very low threat level of attack and basically no consequence if an attack occurred and is not applicable to this option.

Level 2 Security applies standard security measures such as road barricades, perimeter fencing, and intrusion detection systems for unoccupied buildings and vertical structures and security lighting. The intrusion detection systems will be connected to the local law enforcement office for response during an emergency. Facilities requiring this level of security would possess a higher threat level than those in Level 1 and would include assets such as levees, access roads and pumping stations.

Level 3 Security includes all of the features of Level 2 plus enhanced security measures such as the use of video cameras for real-time monitoring of the facility, monitors, motion detectors and alarm sound system in the occupied control buildings. Facilities requiring this level of security would possess the highest threat level of all the critical assets. Power plants would require this level of security.

3.3.8.5.7 Operation and Maintenance

Operation and maintenance activities for this project will be required on an annual basis. All pumps and gates will be operated to assure proper working order. Debris and shoaled sediment will be removed. Vegetation on the levees will be cut to facilitate inspection and to prevent roots from causing weak levee locations. Rills will be filled and damaged revetment will be repaired. Scheduled maintenance should include periodic greasing of all gears and coupled joints, maintaining any battery backup systems, and replacement of standby fuel supplies.

3.3.8.5.8 Cost Estimate

The costs for the various options included in this measure are presented in Section 3.3.8.7, Cost Summary. Construction costs for the various options are included in Table 3.3.8-1 and costs for the annualized Operation and Maintenance of the options are included in Table 3.3.8-2. Estimates are comparative-Level "Parametric Type" and are based on Historical Data, Recent Pricing, and Estimator's Judgment. Quantities listed within the estimates represent Major Elements of the Project Scope and were furnished by the Project Delivery Team. Price Level of Estimate is April 07. Estimates excludes project Escalation and HTRW Cost. The construction costs include real estate, engineering design (E&D), construction management, and contingencies. The E&D cost for preparation of construction contract plans and specifications includes a detailed contract survey, preparation of contract specifications and plan drawings, estimating bid quantities, preparation of bid estimate, preparation of final submittal and contract advertisement package, project engineering and

coordination, supervision technical review, computer costs and reproduction. Construction Contingency developed and assigned at 25% to cover the Cost Growth of the project.

3.3.8.5.9 Schedule for Design and Construction

After the authority for the design has been issued and funds have been provided, the design of these structures will require approximately 12 months including comprehensive plans and specifications, independent reviews and subsequent revisions. The construction of this option should require in excess of two years.

3.3.8.6 Option B – Elevation 30 ft NAVD88

This option consists of an earthen levee around the most populated areas of Ocean Springs. The only difference between the description of this option and preceding description of Option A is the height of the levee, pumping facilities, number of roadway and railroad intersections, and the length of the levee culverts. Other features and methods of analysis are the same.

3.3.8.6.1 Interior Drainage

Interior drainage analysis and culverts are the same as those for Option A, above, except that the culvert lengths through the levees would be longer.

3.3.8.6.2 Geotechnical Data

The Geology and Geotechnical paragraphs for Option B are the same as for Option A, above.

3.3.8.6.3 Jackson County Ring Levee. Ocean Springs. Option B - Elevation 30 ft NAVD88. Structural, Mechanical and Electrical

These data are the same as that presented for Option A and is not reproduced here. The only difference between the description of this option and preceding description of Option A is the height of the levee, pumping facilities, number of roadway and railroad intersections, and the length of the levee culverts. Culvert length variations are not presented but are incorporated into the cost estimate. The other data for Option B is presented below.

Pumping Facilities. Flow and Pump Sizes. Option B. Design hydraulic heads derived for the 14 pumping facilities included in the Ocean Springs Ring Levee system for the elevation 30 protection level varied from approximately 15 to 25 feet and the corresponding flows required varied from 70,915 to 401,703 gallons per minute. The plants thus derived varied in size from a plant having two 42-inch diameter, 290 horsepower pumps, to one having four 60-inch diameter pumps each running at 1000 horsepower

Levee and Roadway/Railway Intersections. Option B. With the installation of a ring levee around the Ocean Springs area to elevation 30, 76 roadway intersections would have to be accommodated. For this study it was estimated that 6 roller gate structures and 70 swing gate structures would be required.

3.3.8.6.4 HTRW

The HTRW paragraphs for Option B are the same as for Option A, above.

3.3.8.6.5 Construction and Water Control Plan

The Construction and Water Control Plan paragraphs for Option B are the same as for Option A, above.

3.3.8.6.6 Project Security

The Project Security paragraphs for Option B are the same as for Option A, above.

3.3.8.6.7 Operation and Maintenance

The Operation and Maintenance paragraphs for Option B are the same as for Option A, above.

3.3.8.6.8 Cost Estimate

The Cost Estimate paragraphs for Option B are the same as for Option A, above.

3.3.8.6.9 Schedule for Design and Construction

The Schedule for Design and Construction paragraphs for Option B are the same as for Option A, above.

3.3.8.7 Cost Estimate Summary

The costs for construction and for operations and maintenance of all options are shown in Tables 3.3.8-1 and 3.3.8-2, below. Estimates are comparative-Level "Parametric Type" and are based on Historical Data, Recent Pricing, and Estimator's Judgment. Quantities listed within the estimates represent Major Elements of the Project Scope and were furnished by the Project Delivery Team. Price Level of Estimate is April 07. Estimates excludes project Escalation and HTRW Cost.

Table 3.3.8-1.
Jackson Co Ocean Springs Ring Levee Construction Cost Summary

Option	Total project cost
Option A – Elevation 20 ft NAVD88	$152,100,000
Option B – Elevation 30 ft NAVD88	$327,000,000

Table 3.3.8-2.
Jackson Co Ocean Springs Ring Levee O & M Cost Summary

Option	O&M Cost
Option A – Elevation 20 ft NAVD88	$1,414,000
Option B – Elevation 30 ft NAVD88	$2,532,000

3.3.8.8 References

US Army Corps of Engineers (USACE) 1987. Hydrologic Analysis of Interior Areas. Engineer Manual EM 1110-2-1413. Department of the Army, US Army Corps of Engineers, Washington, D.C. 15 January 1987.

USACE 1993. Hydrologic Frequency Analysis. Engineer Manual EM 1110-2-1415. Department of the Army, US Army Corps of Engineers, Washington, D.C. 5 March 1993.

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Environmental Science Services Administration. 1968. "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.

Weather Bureau and USACE. 1956. 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.

3.3.9 Jackson County, Gulf Park Estates Ring Levee

3.3.9.1 General

Several high density residential and business areas in Jackson County were identified. They are : Pascagoula/Mosspoint, Gulf Park Estates, Belle Fontaine, Gulf Park Estates, and Ocean Springs. These are subject to damage from storm surges associated with hurricanes. Earthen ring levees were evaluated for protection of these areas. The levees were evaluated at elevations 20 ft NAVD88 and 30 ft NAVD88. The top width was assumed 15 ft with sideslopes of 1 vertical to 3 horizontal. Each of the levees is presented separately in this report. Additional options not evaluated in detail are described elsewhere in this report.

Evaluation of this option was done by comparing benefits computed by Hydrologic Engineering Center's (HEC) Flood Damage Analysis (FDA) computer application HEC-FDA and costs computed. HEC-FDA modeling was done comparing the study reaches using variations in expected sea-level rise and development. Details regarding the methodology are presented in Section 2.13 of the Engineering Appendix and in the Economic Appendix.

3.3.9.2 Location

The location of the Gulf Park Estate ring levee in Jackson County is shown below in Figure 3.3.9-1 and 3.3.9-2.

3.3.9.3 Existing Conditions

Gulf Park Estates Subdivision is located adjacent to and east of Ocean Springs. The area of study for the ring levee is bounded by Simmons Bayou on the north and the Mississippi Sound on the south. Ground elevations over most of the residential areas vary between elevation 10-20 ft NAVD88. The 4-ft(blue), 8-ft(dark green), 12-ft(light green), 16-ft(brown), and 20-ft(pink) ground contour lines and potential levee location (red) are shown below in Figure 3.3.9-3.

Drainage of the residential area is mostly to the north to Simmons Bayou. Only a small part of the area drains to Mississippi Sound.

Impacts from hurricanes are devastating to the area. Recent damage from Hurricane Katrina in August, 2005 the Gulf Park Estates area are shown below in Figures 3.3.9-4 and 3.3.9-5. Many homes are still un-repaired, pending settlement of insurance claims.

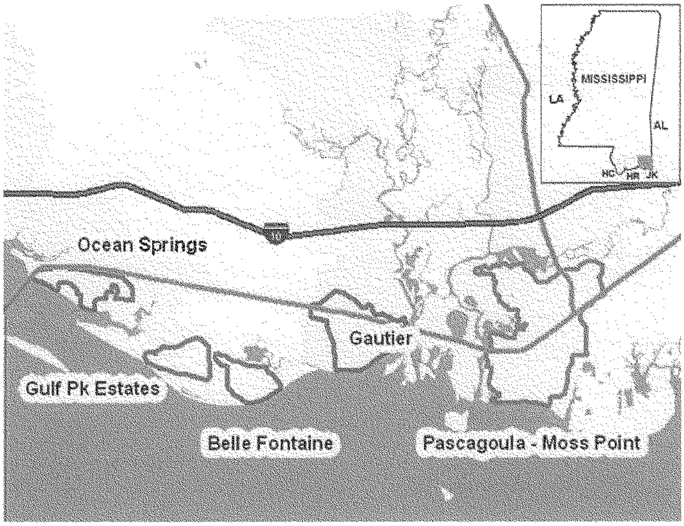


Figure 3.3.9-1. Vicinity Map Gulf Park Estates

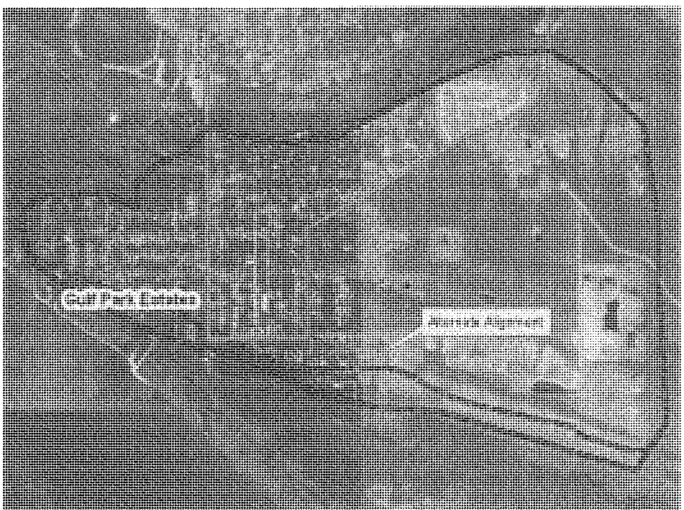


Figure 3.3.9-2. Gulf Park Estates Ring Levee

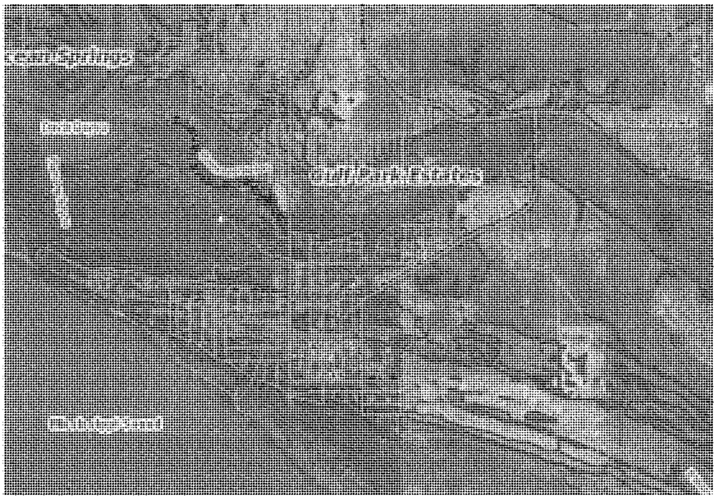


Figure 3.3.9-3. Existing Conditions Gulf Park Estates

Source: http://ngs.woc.noaa.gov/storms/katrina/24333182.jpg

Figure 3.3.9-4. Hurricane Katrina Damage Gulf Park Estates

SourceSpartan1's Photos: http://www.flickr.com/photo_zoom.gne?id=362158993&size=m&context=photostream

Figure 3.3.9-5. Hurricane Katrina Damage Gulf Park Estates, MS

3.3.8.4 Coastal and Hydraulic Data

Typical coastal data are shown in Section 1.4 of this report. High water marks taken by FEMA after Hurricane Katrina in 2005 as well as the 6-ft(blue), 12-ft(green), 16-ft(brown), and 20-ft(pink) ground contour lines major streets are shown below in Figure 3.3.9-6. The data indicates the Katrina high water was as high as 21 ft NAVD88 at the Mississippi Sound.

Stage-Frequency data for a suite of severe storms using Joint Probability Method (JPM) and hydrodynamic modeling were developed by the Engineer Research and Development Center (ERDC) for 80 locations along the study area. These data were combined with historical gage frequencies for smaller storms to establish stage-frequency curves at 54 economic reaches in the study area which were entered into Hydrologic Engineering Center's (HEC) Flood Damage Analysis (HEC-FDA) application to evaluate benefits. An expanded description of the procedure is shown in Section 2.13 of the Engineering Appendix and in the Economic Appendix. Points near Gulf Park Estates at which data from hydrodynamic modeling was saved are shown below in Figure 3.3.9-7.

Existing Condition Stage –Frequency data for Save Point 1, just off the coast of Gulf Park Estates, is shown below in Figure 3.3.9-8. The 95% confidence limits, approximately equally to plus and minus two standard deviations, are shown bounding the median curve. The elevations are presented at 100 ft higher than actual to facilitate HEC-FDA computations.

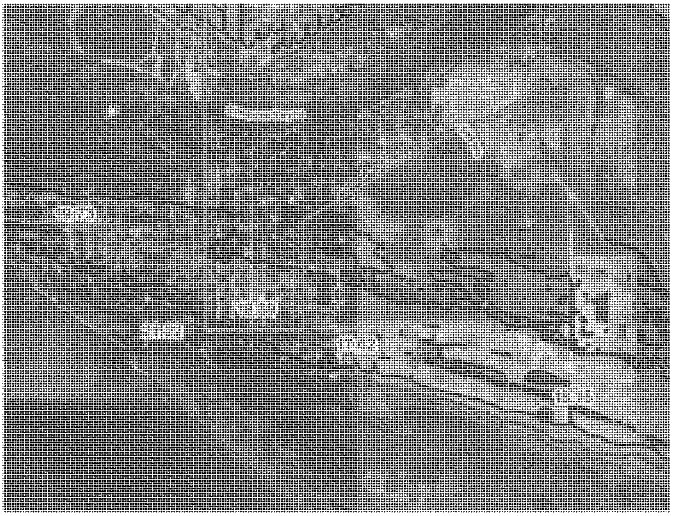


Figure 3.3.9-6. Ground Contours and Katrina High Water

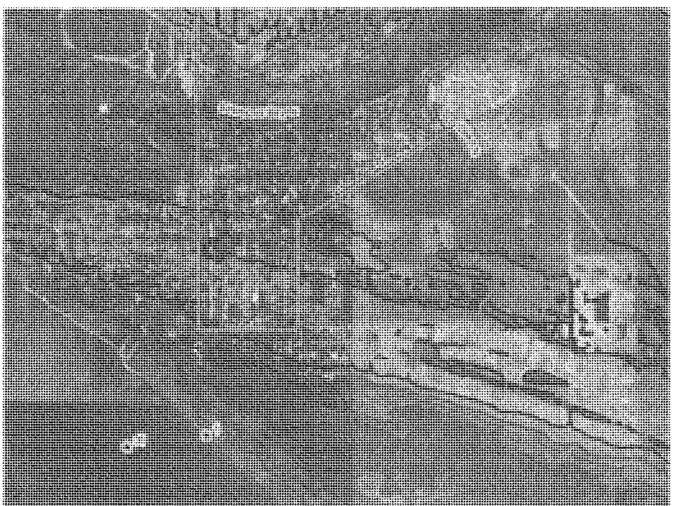


Figure 3.3.9-7. Hydrodynamic Modeling Save Points near Gulf Park Estates

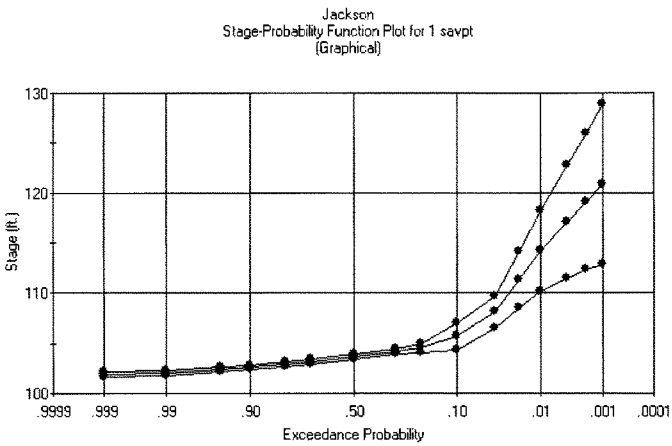


Figure 3.3.9-8. Existing Conditions at Save Point 1, near Gulf Park Estates

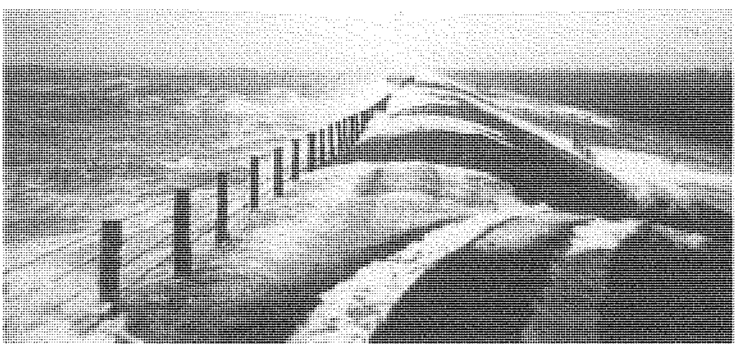
3.3.9.5 Option A – Elevation 20 ft NAVD88

This option consists of an earthen dike enclosing an area of 1473 acres around the most densely populated areas of Gulf Park Estates as shown on the following Figure 3.3.9-9, along with the internal sub-basins and levee culvert/pump locations. The levee would have a top width of 15 ft and slopes of 1 vertical to 3 horizontal.

Damage and failure by overtopping of levees could be caused by storm surges greater than the levee crest as shown on Figure 3.3.9-10.

Overtopping failures are caused by the high velocity of flow on the top and back side of the levee. Although significant wave attack on the seaward side of some of the New Orleans levees occurred during Hurricane Katrina, the duration of the wave attack was for such a short time that major damage did not occur from wave action. The erosion shown below in Figure 3.3.9-11 was caused by approximately 1-2 ft of overtopping crest depth.

Figure 3.3.9-9. Pump/Culvert/Sub-basin Locations



Source: Wave Overtopping Flow on Seadikes, Experimental and Theoretical Investigations, Holger Schüttrumpf, (Photo:Leichtweiss-Institute) http://kfki.baw.de/fileadmin/projects/E_35_134_Lit.pdf

Figure 3.3.9-10. North Sea, Germany, March 1976

Source: ERDC, Steven Hughes

Figure 3.3.9-11. Crown Scour from Hurricane Katrina at Mississippi River Gulf Outlet (MRGO) Levee in St. Bernard Parish, New Orleans, LA

Revetment would be included in the levee design to prevent overtopping failure.

The levee would be protected by gabions on filter cloth as shown in Figure 3.3.9-12, extending across a drainage ditch which carries water to nearby culverts and which would also serve to dissipate some of the supercritical flow energy during overtopping conditions.

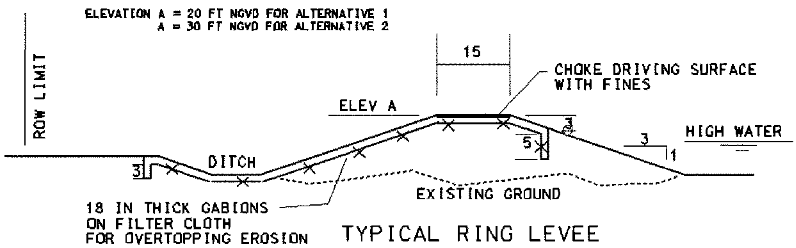


Figure 3.3.9-12. Typical Section at Ring Levee

3.3.9.5.1 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 in Figure 3.3.9-9. The culverts would have tidal 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 the upstream end at every culvert in the levee for manual control in the event the tidal gate malfunctions. A typical section is shown is shown below in Figure 3.3.9-13.

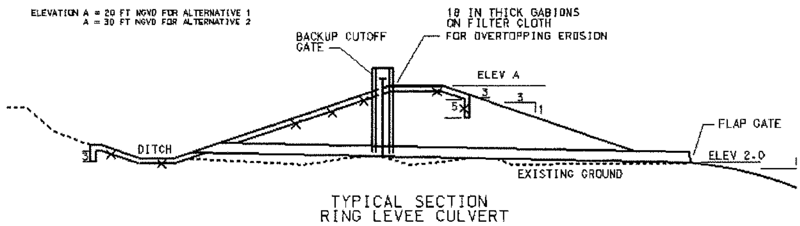


Figure 3.3.9-13. Typical Section at Culvert

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 ring levee into major sub-basins as shown in Figure 3.3.9-9 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 sub-basins is shown in Figure 3.3.9-14.

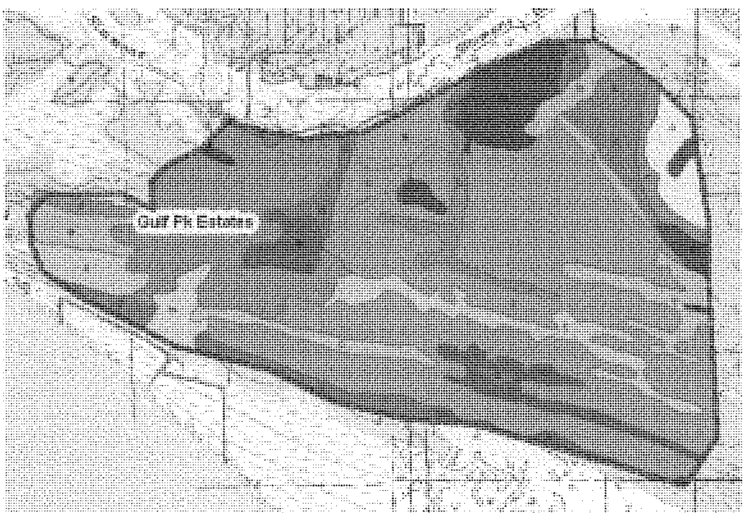


Figure 3.3.9-14. Gulf Park Estates Hydrologic Soil Groups

Hydrologic soil group A soils have low runoff potential and high infiltration rates, even with thoroughly wetted and a high rate of water transmission. Hydrologic soil group B soils have moderate infiltration rates when thoroughly wetted and a moderate rate of water transmission.

Hydrologic soil group C soils have low infiltration rates when thoroughly wetted and have a low rate of water transmission. Hydrologic soil group C soils have high runoff potential and a very low rate of water transmission.

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. For the culvert design, headwater elevations at the culverts were maintained at an elevation no greater than 5 ft NAVD88 with a tailwater elevation of 2.0 ft NAVD88 assumed. Drainage ditches along the toe of the levee will be required to assure that smaller basins can be drained to a culvert/pump site. These ditches were sized using a normal depth flow computation. Curve numbers, pump, and culvert capacity tables are not included in the report beyond that necessary to obtain a cost estimate. The data are considered beyond the level of detail required for this report.

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. This decision was 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. However, in some of the areas, existing storage could be adequate to pond water without causing damage, even without pumps. In other areas that do have pumps, some rise in interior water during interior events greater than the 10-yr rain could occur, but may not cause damage. Designing the pumps for the peak 10-yr flow provides a significant pumping capacity. Further studies will detail the requirement for the appropriate ponding areas, pump sizes, or buyouts in the affected areas.

During non-hurricane periods of low water in the sound, when rainfall greater than the 25-yr event occurs, the pumps could also be used to augment the flow capacity of the levee culverts.

3.3.9.5.2 Geotechnical Data

Geology: Citronelle formation is found above the Interstate 10 alignment and is a relatively thin unit of fluvial deposits of Plio-Pleistocene age consisting of gravelly sand and silty sand layers. Typically the formation is 30 to 80 feet thick, except where it has filled eroded channels in the underlying formations. The sand in the formation has a variety of colors, often associated with the presence of iron oxides in the form of hematite or goethite. Thin discontinuous clay layers are found in some areas. The iron oxide has occasionally cemented the sand into a friable sandstone, usually occurring only as a localized layer. Within the study area, this formation outcrops north of Interstate 10 and will not be encountered at project sites other than any levees that might extend northward to higher ground elevations.

Prairie formation is found along the rest of the Line 4 alignment within Jackson County. The Prairie formation is found southward of the Citronelle formation and is of Pleistocene age. This formation consists of fluvial and floodplain sediments that extend southward from the outcrop of the Citronelle formation to or near the mainland coastline. Sand found within this formation has an economic value as beach fill due to its color and quality. Southward from its outcrop area, the formation extends under the overlying Holocene deposits out into the Mississippi Sound.

Gulfport Formation is found along the coastline in most of western Jackson County at Belle Fontaine Beach. This formation of Pleistocene age overlies the Prairie formation and is present as well sorted sands that mark the edge of the coastline during the last high sea level stage of the Sangamonian Interglacial period. It does not extend under the Mississippi Sound.

Geotechnical: The inland barrier earthen levee section will have one vertical to three horizontal side slopes with a fifteen foot crest width. All work areas to receive the fill shall be cleared and grubbed of all trees and surface organics and all existing foundations, streets, utilities, etc. will be removed and the subsequent cavities backfilled and compacted. The levee will be constructed of sand clay materials obtained from off site commercial sources, trucked to the work area, placed in thin lifts and compacted to 95 percent of the maximum modified density. The final surface will be armored by the placement of 24 inch thick gabion mattress filled with small stone for erosion protection during an event that overtops the levee. The armoring will be anchored on the front face by trenching and extend across the downstream slope and the 25 foot easement area beyond the toe. The front side of the levee and all non critical surface areas will be subsequently covered by grassing. Road crossings will incorporate small gate structures or ramping over the embankment where the surface elevation is near that of the crest elevation. The elevation relationship of the crest and the adjacent railroad will be a governing factor. The surfaces will be paved with asphalt and the corresponding drainage will be accommodated. Those areas where the subgrade geology primarily consists of clean sands, seepage underneath the levee and the potential for erosion and instability must be considered. Final designs may require the installation of a bentonite concrete cutoff wall deep within the foundation. This condition will be investigated during any design phase and its requirement will be incorporated.

3.3.9.5.3 Structural, Mechanical and Electrical

Structural, Mechanical, and Electrical data are presented for culverts and pumping facilities. The sites are shown above in Figure 3.3.9-9.

3.3.9.5.3.1 Culverts

As any flood barrier is constructed the natural groundwater runoff would be inhibited. In order to maintain the natural runoff patterns culverts would be inserted through the protection line at appropriate locations. For this study these were configured as cast-in-place reinforced concrete box structures fitted with flap gates to minimize normal backflows and sluice gates to provide storm closure when needed. The shear number of these structures that would be required throughout the area covered by this study would dictate that an automated system be incorporated whereby the gates could be monitored and operated from some central location within defined districts. Detailed design of these monitoring and operating systems is beyond the scope of this study, however a parametric cost was developed for each site and included in the estimated construction cost for these facilities.

3.3.9.5.3.2 Pumping Facilities Structural

The layout of each pumping facility was made in conformance with Corp of Engineers Guidance document EM 1110-2-3105, Mechanical and Electrical Design of Pumping Stations. The basic plant dimensions for each site were set using approximate dimensions derived based on specific pump data (pump impeller diameter, pump bell bottom clearance, etc.). Each facility was roughly fitted to its site using existing ground elevations taken from available mapping and height of levee data. In every case the top of the pump floor was required to be above the 100 year flood elevation. Nominal sidewall and sump and pump floor thicknesses were assumed, along with wall and roof thicknesses for the pump room enclosure. Using these basic dimensions and the preliminary number and size of pumping units determined for each site, the overall plant footprint and elevations were set and quantities of basic construction materials computed. The pumping plants were configured, to the greatest extent possible with the data provided, to provide multiple pumps at each site.

Discharge piping for each plant was estimated using over the levee piping with one pipe per pumping unit. For estimating purposes the piping was sized to match the pump diameter. Each pipe was extended approximately 25 feet beyond the toe of the embankment on the discharge end to allow for energy dissipation features to be incorporated into the pipe discharge.

At the discharge end of the piping a heavy mat of grouted riprap was added as protection for the levee slope and immediately adjacent area. In each case the 4-foot deep stone mat was estimated as extending 30 feet up the levee slope and 50 feet out from the levee toe for a total width of 80 feet. The lateral extent was estimated at 10 feet per discharge pipe.

3.3.9.5.3.3 Pumping Stations Mechanical

Vertical shaft pumps were used for all of the pumping facilities. Preliminary mechanical design of the required pumping equipment was made by adaptation of manufacturer's stock pumping equipment to approximate hydraulic head and flow data developed for each pumping location. This data was coordinated with a pump manufacturer who supplied a cross check of the pump selections and cost data for use in preparation of project construction cost estimates. In consideration of the primary purpose which this equipment would serve, and in light of the widespread unavailability of electric power during and immediately after a major storm, it was determined that the pumps should be diesel engine driven.

3.3.9.5.3.4 Pumping Stations Electrical

The electrical design for these facilities would consist primarily of providing station power for the facilities. For each of the sites this would include installation of Power Poles, Cable, Power Pole Terminations, miscellaneous electrical appurtenances, and an Electrical 30 kW Diesel Generator Set for backup power.

Because of the number of pumping facilities involved and the need to closely control the pumping operations over a large area, a system of several operation and monitoring stations would be required from which the pumping facilities could be started and their operation monitored during and immediately following a storm event. The detailed design of this monitoring and operation system is beyond the scope of this study, however a parametric estimate of the cost involved in developing and installing such a system was made and included in the estimate of construction costs for these facilities.

3.3.9.5.3.5 Pumping Stations. Flow and Pump Sizes

Design hydraulic heads derived for the 8 pumping facilities included in the Gulf Park Estates Ring Levee system for the elevation 20 protection level varied from approximately 10 to 15 feet and the corresponding flows required varied from 32,316 to 333,481 gallons per minute. The plants thus derived varied in size from a plant having one 42-inch diameter, 154 horsepower pump, to one having four 60-inch diameter pumps each running at 560 horsepower.

3.3.9.5.3.6 Roadways

At each point where a roadway crosses the protection line the decision must be made whether to maintain this artery and adapt the protection line to accommodate it, or to terminate the artery at the protection line and divert traffic to cross the protection line at another location. For this study it was assumed that all roadways and railways crossing the levee alignment would be retained except where it was very evident that traffic could be combined without undue congestion.

Once the decision has been made to retain a particular roadway, it must then be determined how best to configure the artery to conduct traffic across the protection line. The simplest means of passing roadway traffic is to ramp the roadway over the protection line. This alternative is not always viable because of severe right-of-way restraints caused by extreme levee height, urban congestion, etc. In such instances other methods can be used including partial ramping in combination with low profile roller gates. In more restricted areas full height gates which would leave the roadway virtually unaltered might be preferable, even though this alternative would usually be more costly than ramping. In some extreme circumstances where high levees are required to pass through very congested areas, installation of tunnels with closure gates may be required.

Some economy could probably be achieved in this effort by combining smaller arteries and passing traffic through the protection line in fewer locations. However, in most instances this would involve detailed traffic routing studies and designs that are beyond the scope of this effort. These studies would be included in the next phase of the development of these options, should such be warranted.

3.3.9.5.3.7 Railways

Because of the extreme gradient restrictions necessarily placed on railway construction, it is practically never acceptable to elevate a railway up and over a levee. Therefore, the available alternatives would include gated pass through structures. Because of the vertical clearance requirements of railroad traffic all railroad pass through structures for this study were configured having vertical walls on either side of the railway with double swing gates extending to the full height of the levee.

3.3.9.5.3.8 Levee and Roadway/Railway Intersections

With the installation of a ring levee around Gulf Park Estates to elevation 20, 20 roadway intersections would have to be accommodated. For this study it was estimated that 2 roller gate structures and 18 swing gate structures would be required.

3.3.9.5.4 HTRW

Due to the extent and large number of real estate parcels along with the potential for re-alignment of the structural aspects of this project, no preliminary assessment was performed to identify the possibility of hazardous waste on the sites. These studies will be conducted during the next phase of work after the final siting of the various structures. The real estate costs appearing in this report therefore will not reflect any costs for remediation design and/or treatment and/or removal or disposal of these materials in the baseline cost estimate.

3.3.9.5.5 Construction Procedures and Water Control Plan

The construction procedures required for this option are similar to general construction in many respects in that the easement limits must be established and staked in the field, the work area cleared of all structures, pavements, utilities, trees, organics, etc. and the foundation prepared for the new work. Where the levee alignment crosses the existing streams or narrow bays, the alignment base shall be created by displacement with layers of crushed stone pushed ahead and compacted by the placement equipment and repeated until a stable platform is created. The required drainage culverts or other ancillary structures can then be constructed. The control of any surface water will be handled by temporary sheetpile cofferdams and pumping. The control of groundwater will be a series of wellpoints systems designed to keep the excavations dry to a depth and width sufficient to install the new work.

3.3.9.5.6 Project Security

The Protocol for security measures for this study has been performed in general accordance with the Risk Assessment Methodology for Dams (RAM-D) developed by the Interagency Forum for Infrastructure Protection (IFIP). This methodology has been used for physical security for the critical infrastructure throughout the Corps of Engineers. The determination of the level of physical security provided for each facility is based on the following critical elements: 1) threat assessment of the likelihood that an adversary will attack a critical asset, 2) consequence assessment should an adversary be successful in disrupting, disabling or destroying the asset and 3) effectiveness to prevent a successful attack against an operational component.

Three levels of physical security were selected for use in this study:

Level 1 Security provides no improved security for the selected asset. This security level would be applied to the barrier islands and the sand dunes. These features present a very low threat level of attack and basically no consequence if an attack occurred and is not applicable to this option.

Level 2 Security applies standard security measures such as road barricades, perimeter fencing, and intrusion detection systems for unoccupied buildings and vertical structures and security lighting. The intrusion detection systems will be connected to the local law enforcement office for response during an emergency. Facilities requiring this level of security would possess a higher threat level than those in Level 1 and would include assets such as levees, access roads and pumping stations.

Level 3 Security includes all of the features of Level 2 plus enhanced security measures such as the use of video cameras for real-time monitoring of the facility, monitors, motion detectors and alarm sound system in the occupied control buildings. Facilities requiring this level of security would possess the highest threat level of all the critical assets. Power plants would require this level of security.

3.3.9.5.7 Operation and Maintenance

Operation and maintenance activities for this project will be required on an annual basis. All pumps and gates will be operated to assure proper working order. Debris and shoaled sediment will be removed. Vegetation on the levees will be cut to facilitate inspection and to prevent roots from causing weak levee locations. Rills will be filled and damaged revetment will be repaired. Scheduled maintenance should include periodic greasing of all gears and coupled joints, maintaining any battery backup systems, and replacement of standby fuel supplies.

3.3.9.5.8 Cost Estimate

The costs for the various options included in this measure are presented in Section 3.3.9.10., Cost Summary. Construction costs for the various options are included in Table 3.3.9-1 and costs for the annualized Operation and Maintenance of the options are included in Table 3.3.9-2. Estimates are comparative-Level "Parametric Type" and are based on Historical Data, Recent Pricing, and Estimator's Judgment. Quantities listed within the estimates represent Major Elements of the Project Scope and were furnished by the Project Delivery Team. Price Level of Estimate is April 07. Estimates excludes project Escalation and HTRW Cost. The construction costs include real estate, engineering design (E&D), construction management, and contingencies. The E&D cost for preparation of construction contract plans and specifications includes a detailed contract survey, preparation of contract specifications and plan drawings, estimating bid quantities, preparation of bid estimate, preparation of final submittal and contract advertisement package, project engineering and coordination, supervision technical review, computer costs and reproduction. Construction Contingency developed and assigned at 25% to cover the Cost Growth of the project.

3.3.9.5.9 Schedule for Design and Construction

After the authority for the design has been issued and funds have been provided, the design of these structures will require approximately 12 months including comprehensive plans and specifications, independent reviews and subsequent revisions. The construction of this option should require in excess of two years.

3.3.9.6 Option B – Elevation 30 ft NAVD88

This option consists of an earthen levee around the most populated areas of Gulf Park Estates. The alignment of the levee is the same as Option A, above, and is not reproduced here. The only difference between the description of this option and preceding description of Option A is the height of the levee, pumping facilities, number of roadway and railroad intersections, and the length of the levee culverts. Other features and methods of analysis are the same.

3.3.9.6.1 Interior Drainage

Interior drainage analysis and culverts are the same as those for Option A, above, except that the culvert lengths through the levees would be longer.

3.3.9.6.2 Geotechnical Data

The Geology and Geotechnical paragraphs for Option B are the same as for Option A, above.

3.3.9.6.3 Structural, Mechanical and Electrical

The only difference between the description of this option and preceding description of Option A is the height of the levee, pumping facilities, number of roadway and railroad intersections, and the length of the levee culverts. Culvert length variations are not presented but are incorporated into the cost estimate. The other data for Option B is presented below.

3.3.9.6.3.1 Pumping Facilities. Flow and Pump Sizes

Design hydraulic heads derived for the 8 pumping facilities included in the Gulf Park Estates Ring Levee system for the elevation 30 protection level varied from approximately 20 to 25 feet and the corresponding flows required varied from 32,315 to 333,482 gallons per minute. The plants thus derived varied in size from a plant having one 42-inch diameter, 300 horsepower pump, to one having four 60-inch diameter pumps each running at 1000 horsepower.

3.3.9.6.3.2 Levee and Roadway/Railway Intersections

With the installation of a ring levee around Gulf Park Estates to elevation 30, 13 roadway intersections would have to be accommodated. For this study it was estimated that all 13 would require swing gate structures.

3.3.9.6.4 HTRW

The HTRW paragraphs for Option B are the same as for Option A, above.

3.3.9.6.5 Construction and Water Control Plan

The Construction and Water Control Plan paragraphs for Option B are the same as for Option A, above.

3.3.9.6.6 Project Security

The Project Security paragraphs for Option B are the same as for Option A, above.

3.3.9.6.7 Operation and Maintenance

The Operation and Maintenance paragraphs for Option B are the same as for Option A, above.

3.3.9.6.8 Cost Estimate

The Cost Estimate paragraphs for Option B are the same as for Option A, above.

3.3.9.6.9 Schedule for Design and Construction

The Schedule for Design and Construction paragraphs for Option B are the same as for Option A, above.

3.3.9.7 Option C – Alternate Alignment, Elevation 20 ft NAVD88

This option consists of an earthen levee at elevation 20 ft NAVD88 enclosing an area of 1355 acres around the most populated areas of Gulf Park Estates in an alignment slightly different from the alignment for Options A and B. The alignment of the levee is shown in Figure 3.3.9-15 below, which also shows the variation in the drainage sub-basins and the locations of the pumps and culverts.

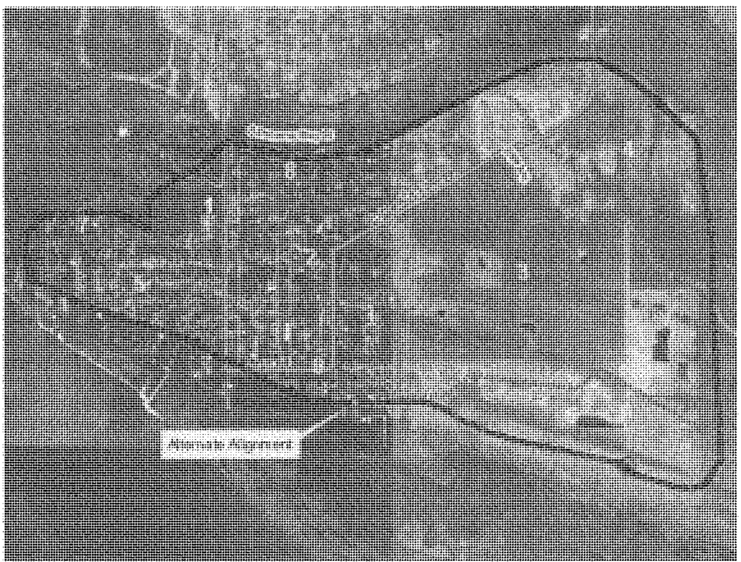


Figure 3.3.9-15. Alternative Alignment Pump/Culvert/Sub-basin Locations

3.3.9.7.1 Interior Drainage

Interior drainage flows are similar to those computed for Option A, above. However, the appropriate ditches, culverts and pumps were re-sized by either adjusting the previously computed flows by the ratio of the change in areas of the sub-basins to get the revised flows, or by computing flows by TR-55 methods.

3.3.9.7.2 Geotechnical Data

The Geology and Geotechnical paragraphs for Option C are the same as for Option A, above.

3.3.9.7.3 Structural, Mechanical and Electrical

The primary difference between the description of this option and preceding description of Option A is a slight alteration in the routing of the levee resulting in slight alteration to the required pumping facilities, number of roadway and railroad intersections, and the length of the levee culverts. Culvert length variations are not presented but are incorporated into the cost estimate. The other data for Option C is presented below.

3.3.9.7.3.1 Pumping Facilities Flow and Pump Sizes

Design hydraulic heads derived for the 9 pumping facilities included in the Gulf Park Estates Ring Levee system for the optional alignment at elevation 20 protection level varied from approximately 5 to 20 feet and the corresponding flows required varied from 31,544 to 333,387 gallons per minute. The plants thus derived varied in size from a plant having two 26-inch diameter, 150 horsepower pumps, to one having eight 42-inch diameter pumps each running at 300 horsepower.

3.3.9.7.3.2 Levee and Roadway/Railway Intersections.

With the installation of a ring levee around Gulf Park Estates to elevation 20, 18 roadway gates for intersections would have to be accommodated. For this study it was estimated that 14 would require swing gate structures with the remaining 4 requiring roller gates of varying heights.

3.3.9.7.4 HTRW

The HTRW paragraphs for Option C are the same as for Option A, above.

3.3.9.7.5 Construction and Water Control Plan

The Construction and Water Control Plan paragraphs for Option C are the same as for Option A, above.

3.3.9.7.6 Project Security

The Project Security paragraphs for Option C are the same as for Option A, above.

3.3.9.7.7 Operation and Maintenance

The Operation and Maintenance paragraphs for Option C are the same as for Option A, above.

3.3.9.7.8 Cost Estimate

The Cost Estimate paragraphs for Option C are the same as for Option A, above.

3.3.9.7.9 Schedule for Design and Construction

The Schedule for Design and Construction paragraphs for Option C are the same as for Option A, above.

3.3.9.8 Option D – Alternate Alignment, Elevation 30 ft NAVD88

This option consists of an earthen levee around the most populated areas of Gulf Park Estates. The alignment of the levee is the same as Option C, above, and is not reproduced here. The only difference between the description of this option and preceding description of Option C is the height of the levee, pumping facilities, number of roadway and railroad intersections, and the length of the levee culverts. Other features and methods of analysis are the same.

3.3.9.8.1 Interior Drainage

Interior drainage analysis and culverts are the same as those for Option C, above, except that the culvert lengths through the levees would be longer.

3.3.9.8.2 Geotechnical Data

The Geology and Geotechnical paragraphs for Option D are the same as for Option A, above.

3.3.9.8.3 Structural, Mechanical and Electrical

The primary difference between the description of this option and preceding description of Option A, besides the height of the levee, is a slight variation in the levee alignment, resulting in changes to the pumping facilities, number of roadway and railroad intersections, and the length of the levee culverts. Culvert length variations are not presented but are incorporated into the cost estimate. The other data for Option D is presented below.

3.3.9.8.3.1 Pumping Facilities. Flow and Pump Sizes.

Design hydraulic heads derived for the 8 pumping facilities included in the Gulf Park Estates Ring Levee system for the elevation 30 protection level varied from approximately 15 to 30 feet and the corresponding flows required varied from 31,544 to 333,387 gallons per minute. The plants thus derived varied in size from a plant having two 26-inch diameter, 200 horsepower pump, to one having eight 42-inch diameter pumps each running at 500 horsepower.

3.3.9.8.3.2 Levee and Roadway/Railway Intersections

With the installation of a ring levee around Gulf Park Estates to elevation 30, 15 roadway intersections would have to be accommodated. For this study it was estimated that all 15 would require 30 swing gate structures.

3.3.9.8.4 HTRW

The HTRW paragraphs for Option D are the same as for Option A, above.

3.3.9.8.5 Construction and Water Control Plan

The Construction and Water Control Plan paragraphs for Option D are the same as for Option A, above.

3.3.9.8.6 Project Security

The Project Security paragraphs for Option D are the same as for Option A, above.

3.3.9.8.7 Operation and Maintenance

The Operation and Maintenance paragraphs for Option D are the same as for Option A, above.

3.3.9.8.8 Cost Estimate

The Cost Estimate paragraphs for Option D are the same as for Option A, above.

3.3.9.9 Schedule for Design and Construction

The Schedule for Design and Construction paragraphs for Option D are the same as for Option A, above.

3.3.9.10 Cost Estimate Summary

The costs for construction and for operations and maintenance of all options are shown in Tables 3.3.9-1 and 3.3.9-2, below. Estimates are comparative-Level "Parametric Type" and are based on Historical Data, Recent Pricing, and Estimator's Judgment. Quantities listed within the estimates represent Major Elements of the Project Scope and were furnished by the Project Delivery Team. Price Level of Estimate is April 07. Estimates excludes project Escalation and HTRW Cost.

Table 3.3.9-1.
Jackson Co Gulf Park Estates Ring Levee Construction Cost Summary

Option	Total project cost
Option A – Elevation 20 ft NAVD88	$149,200,000
Option B – Elevation 30 ft NAVD88	$220,600,000
Option C – Elevation 20 ft NAVD88	$158,900,000
Option D – Elevation 30 ft NAVD88	$208,700,000

Table 3.3.9-2.
Jackson Co Gulf Park Estates Ring Levee O & M Cost Summary

Option	O&M Cost
Option A – Elevation 20 ft NAVD88	$1,499,000
Option B – Elevation 30 ft NAVD88	$2,404,000
Option C – Elevation 20 ft NAVD88	$1,295,000
Option D – Elevation 30 ft NAVD88	$1,906,000

3.3.9.11 References

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3.3.10 Jackson County, Belle Fontaine Ring Levee

3.3.10.1 General

Several high density residential and business areas in Jackson County were identified. They are : Pascagoula/Mosspoint, Gautier, Belle Fontaine, Gulf Park Estates, and Ocean Springs. These are subject to damage from storm surges associated with hurricanes. Earthen ring levees were evaluated for protection of these areas. The levees were evaluated at elevations 20 ft NAVD88 and 30 ft NAVD88. The top width was assumed 15 ft with sideslopes of 1 vertical to 3 horizontal. Each of the levees is presented separately in this report. Additional options not evaluated in detail are described elsewhere in this report.

Evaluation of this option was done by comparing benefits computed by Hydrologic Engineering Center's (HEC) Flood Damage Analysis (FDA) computer application HEC-FDA and costs computed. HEC-FDA modeling was done comparing the study reaches using variations in expected sea-level rise and development. Details regarding the methodology are presented in Section 2.13 of the Engineering Appendix and in the Economic Appendix.

3.3.10.2 Location

The location of the Belle Fontaine ring levee in Jackson County is shown below in Figures 3.3.10-1 and 3.3.10-2. Two alignments are shown on Figure 3.3.10-2. These are evaluated separately.

3.3.10.3 Existing Conditions

The subdivision of Belle Fontaine is located just west of Gautier along the gulf coast on Mississippi Sound. The northeastern part of the subdivision is near elevation 10-14 ft NAVD88 and very flat. Ground elevations over the southwestern part of the area vary between elevation 16-20 ft NAVD88. The 4-ft(blue), 8-ft (dark green), 12-ft(light green), 16-ft(brown), and 20-ft(pink) ground contour lines and levee limits (red) are shown below in Figure 3.3.10-3.

The area is drained by very small natural and some improved channels. These channels drain to the north to Graveline Bayou, and to Mississippi Sound.

Drainage from ordinary rainfall is hindered on occasions when the gulf is high, but impacts from hurricanes are devastating. Damage from Hurricane Katrina in August, 2005 in the Belle Fontaine area are shown below in Figures 3.3.10-4 and Figure 3.3.10-5. Many homes are still un-repaired, pending settlement of insurance claims.

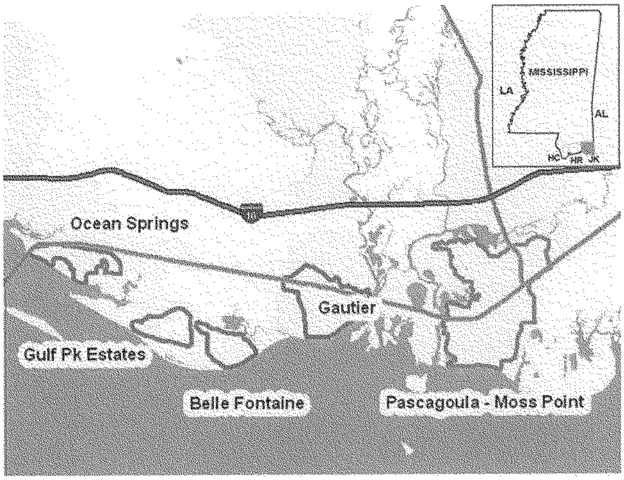


Figure 3.3.10-1. Vicinity Map, Jackson County

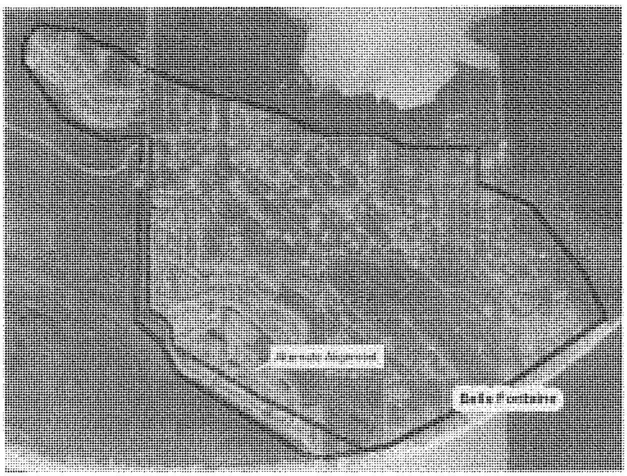


Figure 3.3.10-2. Belle Fontaine Ring Levee

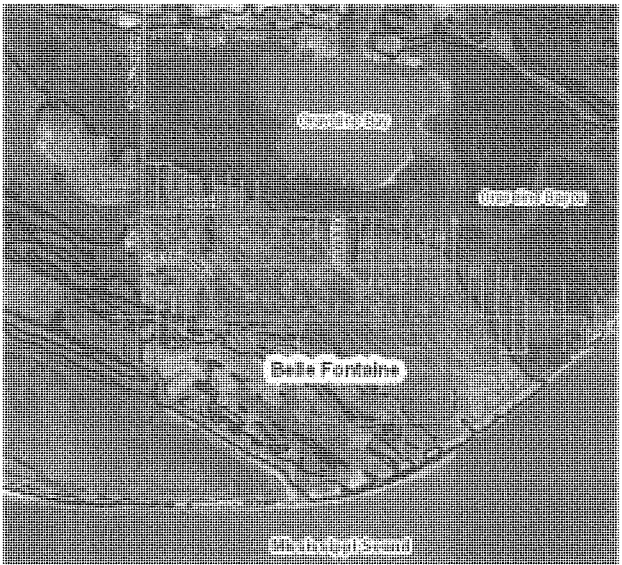
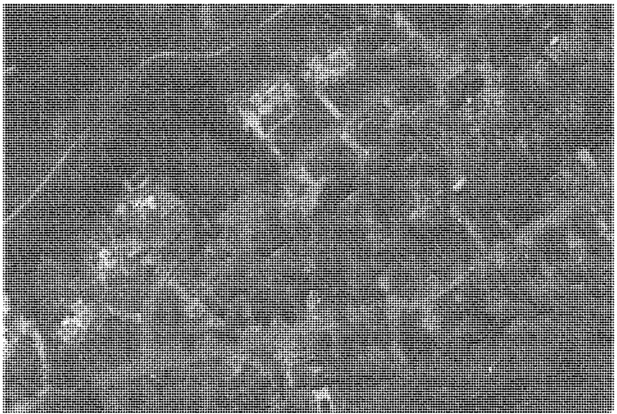


Figure 3.3.10-3. Existing Condition, Belle Fontaine

Source : http://ngs.woc.noaa.gov/storms/katrina/24330547.jpg

Figure 3.3.10-4. Hurricane Katrina Damage in Belle Fontaine



Source: http://ngs.woc.noaa.gov/storms/katrina/24330558.jpg

Figure 3.3.10-5. Hurricane Katrina Damage, Belle Fontaine

3.3.10.4 Coastal and Hydraulic Data

Typical coastal data are shown in Section 1.4 of this report. High water marks taken by FEMA after Hurricane Katrina in 2005 as well as the 4-ft(blue), 8ft(dark green), 12-ft(light green), 16-ft(brown), and 20-ft(pink) ground contour lines and levee limits are shown below in Figure 3.3.10-6. The data indicates the Katrina high water was as high as 21 ft NAVD88 near the Mississippi Sound, totally inundating the area.

Stage-Frequency data for a suite of severe storms using Joint Probability Method (JPM) and hydrodynamic modeling were developed by the Engineer Research and Development Center (ERDC) for 80 locations along the study area. These data were combined with historical gage frequencies for smaller storms to establish stage-frequency curves at 54 economic reaches in the study area which were entered into Hydrologic Engineering Center's (HEC) Flood Damage Analysis (HEC-FDA) application to evaluate benefits. An expanded description of the procedure is shown in Section 2.13 of the Engineering Appendix and in the Economic Appendix. Points near Belle Fontaine at which data from hydrodynamic modeling was saved are shown below in Figure 3.3.10-7.

Existing Condition Stage –Frequency data for Save Point 30, just off the coast of Belle Fontaine, is shown below in Figure 3.3.10-8. The 95% and 5% confidence limits, approximately equally to plus and minus two standard deviations, are shown bounding the median curve. The elevations are presented at 100 ft higher than actual to facilitate HEC-FDA computations.

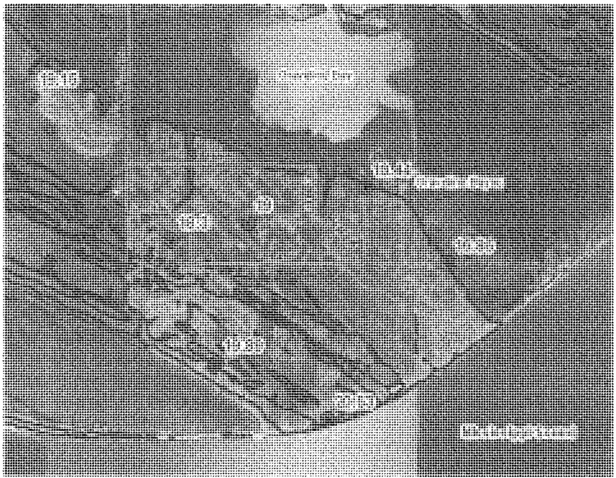


Figure 3.3.10-6. Ground Contours and Katrina High Water Elevations, Belle Fontaine

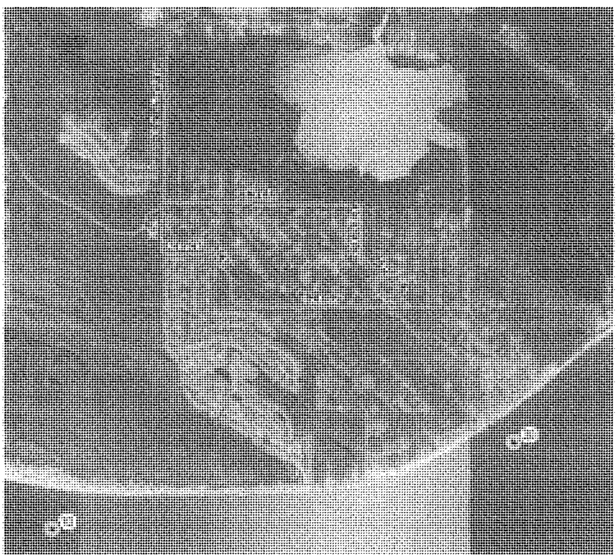


Figure 3.3.10-7. Hydrodynamic Modeling Save Points near Belle Fontaine

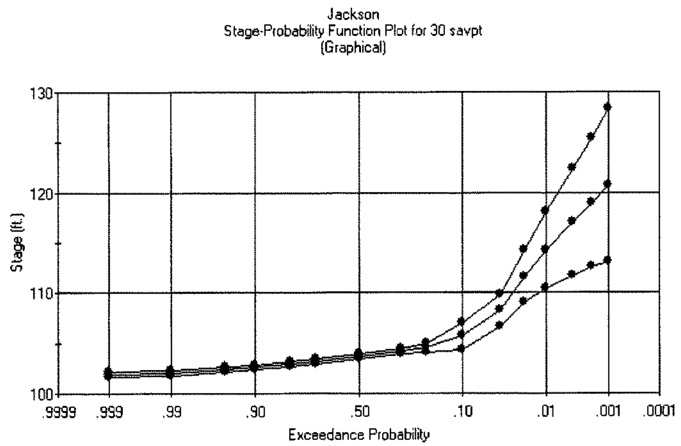


Figure 3.3.10-8. Existing Conditions at Save Point 30, near Belle Fontaine, MS

3.3.10.5 Option A – Elevation 20 ft NAVD88

This option consists of an earthen dike enclosing an area of 1440 acres around the subdivision of Belle Fontaine as shown on the following Figure 3.3.10-9, along with the internal sub-basins and levee culvert/pump locations. The levee would have a top width of 15 ft and slopes of 1 vertical to 3 horizontal.

Damage and failure by overtopping of levees could be caused by storms surges greater than the levee crest as shown in Figure 3.3.10-10.

Overtopping failures are caused by the high velocity of flow on the top and back side of the levee. Although significant wave attack on the seaward side of some of the New Orleans levees occurred during Hurricane Katrina, the duration of the wave attack was for such a short time that major damage did not occur from wave action. The erosion shown in Figure 3.3.10-11 was caused by approximately 1-2 ft of overtopping crest depth.

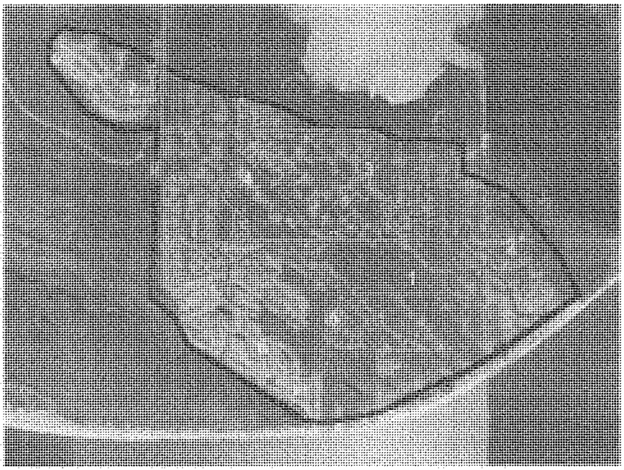
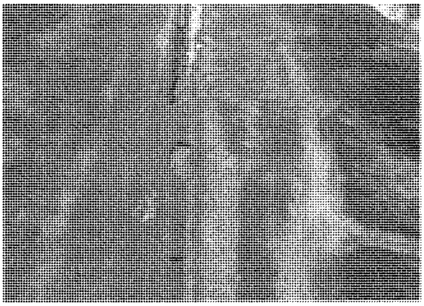


Figure 3.3.10-9. Pump/Culvert/Sub-basin Locations

Source: Wave Overtopping Flow on Seadikes, Experimental and Theoretical Investigations, Holger Schüttrumpf, (Photo:Leichtweiss-Institute) http://kfki.baw.de/fileadmin/projects/E_35_134_Lit.pdf

Figure 3.3.10-10. North Sea, Germany, March 1976



Source: ERDC, Steven Hughes

Figure 3.3.10-11. Crown Scour from Hurricane Katrina at Mississippi River Gulf Outlet (MRGO) Levee in St. Bernard Parish, New Orleans, LA

Revetment would be included in the levee design to prevent overtopping failure.

The levee would be protected by gabions on filter cloth as shown in Figure 3.3.10-12, extending across a drainage ditch which carries water to nearby culverts and which would also serve to dissipate some of the supercritical flow energy during overtopping conditions.

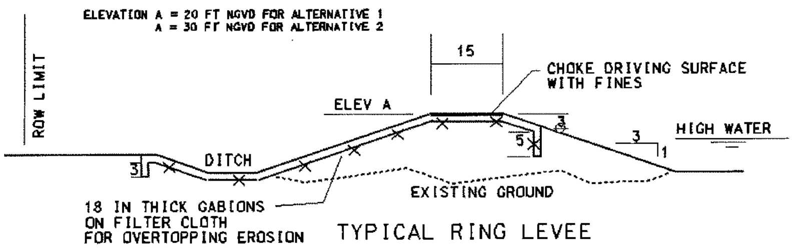


Figure 3.3.10-12. Typical Section at Ring Levee

3.3.10.5.1 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 3.3.10-13.

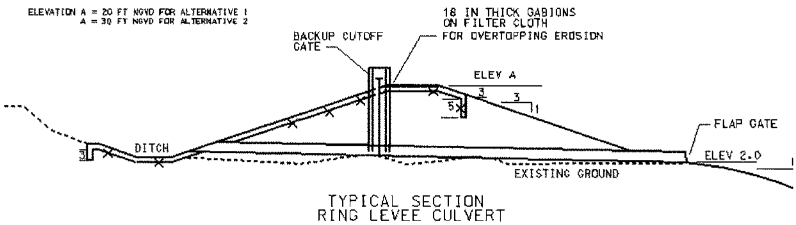


Figure 3.3.10-13. Typical Section at Culvert

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 ring levee 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 are shown below in Figure 3.3.10-14.

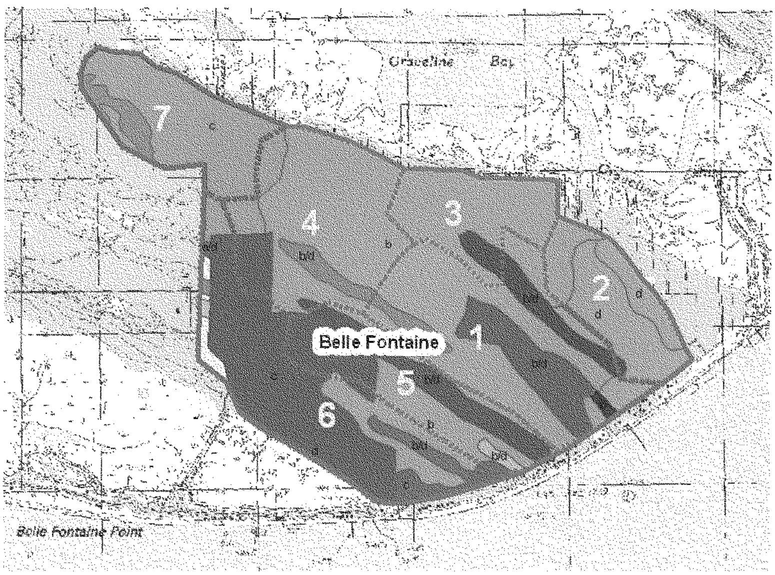


Figure 3.3.10-14. Belle Fontaine Hydrologic Soil Groups

Hydrologic soil group A soils have low runoff potential and high infiltration rates, even with thoroughly wetted and a high rate of water transmission. Hydrologic soil group B soils have moderate infiltration rates when thoroughly wetted and a moderate rate of water transmission. Hydrologic soil group C soils have low infiltration rates when thoroughly wetted and have a low rate of water transmission. Hydrologic soil group C soils have high runoff potential and a very low rate of water transmission.

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. For the culvert design, headwater elevations at the culverts were maintained at an elevation no greater than 5 ft NAVD88 with a tailwater elevation of 2.0 ft NAVD88 assumed. Drainage ditches along the toe of the levee will be required to assure that smaller basins can be drained to a culvert/pump site. These ditches were sized using a normal depth flow computation. Curve numbers, pump, and culvert capacity tables are not included in the report beyond that necessary to obtain a cost estimate. The data are considered beyond the level of detail required for this report.

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. This decision was 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. However, in some of the areas, existing storage could be adequate to pond water without causing damage, even without pumps. In other areas that do have pumps, some rise in interior water during interior events greater than the 10-yr rain could occur, but may not cause damage. Designing the pumps for the peak 10-yr flow provides a significant pumping capacity. Further studies will detail the requirement for the appropriate ponding areas, pump sizes, or buyouts in the affected areas.

During non-hurricane periods of low water in the sound, when rainfall greater than the 25-yr event occurs, the pumps could also be used to augment the flow capacity of the levee culverts.

3.3.10.5.2 Geotechnical Data

Geology: Citronelle formation is found above the Interstate 10 alignment and is a relatively thin unit of fluvial deposits of Plio-Pleistocene age consisting of gravelly sand and silty sand layers. Typically the formation is 30 to 80 feet thick, except where it has filled eroded channels in the underlying formations. The sand in the formation has a variety of colors, often associated with the presence of iron oxides in the form of hematite or goethite. Thin discontinuous clay layers are found in some areas. The iron oxide has occasionally cemented the sand into a friable sandstone, usually occurring only as a localized layer. Within the study area, this formation outcrops north of Interstate 10 and will not be encountered at project sites other than any levees that might extend northward to higher ground elevations.

Prairie formation is found along the rest of the Line 4 alignment within Jackson County. The Prairie formation is found southward of the Citronelle formation and is of Pleistocene age. This formation consists of fluvial and floodplain sediments that extend southward from the outcrop of the Citronelle formation to or near the mainland coastline. Sand found within this formation has an economic value as beach fill due to its color and quality. Southward from its outcrop area, the formation extends under the overlying Holocene deposits out into the Mississippi Sound.

Gulfport Formation is found along the coastline in most of western Jackson County at Belle Fontaine Beach. This formation of Pleistocene age overlies the Prairie formation and is present as well sorted sands that mark the edge of the coastline during the last high sea level stage of the Sangamonian Interglacial period. It does not extend under the Mississippi Sound.

Geotechnical: The inland barrier earthen levee section will have one vertical to three horizontal side slopes with a fifteen foot crest width. All work areas to receive the fill shall be cleared and grubbed of all trees and surface organics and all existing foundations, streets, utilities, etc. will be removed and the subsequent cavities backfilled and compacted. The levee will be constructed of sand clay materials obtained from off site commercial sources, trucked to the work area, placed in thin lifts and compacted to 95 percent of the maximum modified density. The final surface will be armored by the placement of 24 inch thick gabion mattress filled with small stone for erosion protection during an event that overtops the levee. The armoring will be anchored on the front face by trenching and extend across the downstream slope and the 25 foot easement area beyond the toe. The front side of the levee and all non critical surface areas will be subsequently covered by grassing. Road crossings will incorporate small gate structures or ramping over the embankment where the surface elevation is near that of the crest elevation. The elevation relationship of the crest and the adjacent railroad will be a governing factor. The surfaces will be paved with asphalt and the corresponding drainage will be accommodated. Those areas where the subgrade geology primarily consists of clean sands, seepage underneath the levee and the potential for erosion and instability must be considered. Final designs may require the installation of a bentonite concrete cutoff wall deep within the foundation. This condition will be investigated during any design phase and its requirement will be incorporated.

3.3.10.5.3 Structural, Mechanical and Electrical

Structural, Mechanical, and Electrical data are presented for culverts and pumping facilities. The sites are shown above.

3.3.10.5.3.1 Culverts

As any flood barrier is constructed the natural groundwater runoff would be inhibited. In order to maintain the natural runoff patterns culverts would be inserted through the protection line at appropriate locations. For this study these were configured as cast-in-place reinforced concrete box structures fitted with flap gates to minimize normal backflows and sluice gates to provide storm closure when needed. The shear number of these structures that would be required throughout the area covered by this study would dictate that an automated system be incorporated whereby the gates could be monitored and operated from some central location within defined districts. Detailed design of these monitoring and operating systems is beyond the scope of this study, however a parametric cost was developed for each site and included in the estimated construction cost for these facilities.

3.3.10.5.3.2 Pumping Facilities Structural

The layout of each pumping facility was made in conformance with Corp of Engineers Guidance document EM 1110-2-3105, Mechanical and Electrical Design of Pumping Stations. The basic plant dimensions for each site were set using approximate dimensions derived based on specific pump data (pump impeller diameter, pump bell bottom clearance, etc.). Each facility was roughly fitted to its site using existing ground elevations taken from available mapping and height of levee data. In every case the top of the pump floor was required to be above the 100 year flood elevation. Nominal sidewall and sump and pump floor thicknesses were assumed, along with wall and roof thicknesses for the pump room enclosure. Using these basic dimensions and the preliminary number and size of pumping units determined for each site, the overall plant footprint and elevations were set and quantities of basic construction materials computed. The pumping plants were configured, to the greatest extent possible with the data provided, to provide multiple pumps at each site.

Discharge piping for each plant was estimated using over the levee piping with one pipe per pumping unit. For estimating purposes the piping was sized to match the pump diameter. Each pipe was extended approximately 25 feet beyond the toe of the embankment on the discharge end to allow for energy dissipation features to be incorporated into the pipe discharge.

At the discharge end of the piping a heavy mat of grouted riprap was added as protection for the levee slope and immediately adjacent area. In each case the 4-foot deep stone mat was estimated as extending 30 feet up the levee slope and 50 feet out from the levee toe for a total width of 80 feet. The lateral extent was estimated at 10 feet per discharge pipe.

3.3.10.5.3.3 Pumping Stations Mechanical

Vertical shaft pumps were used for all of the pumping facilities. Preliminary mechanical design of the required pumping equipment was made by adaptation of manufacturer's stock pumping equipment to approximate hydraulic head and flow data developed for each pumping location. This data was coordinated with a pump manufacturer who supplied a cross check of the pump selections and cost data for use in preparation of project construction cost estimates. In consideration of the primary purpose which this equipment would serve, and in light of the widespread unavailability of electric power during and immediately after a major storm, it was determined that the pumps should be diesel engine driven.

3.3.10.5.3.4 Pumping Stations Electrical

The electrical design for these facilities would consist primarily of providing station power for the facilities. For each of the sites this would include installation of Power Poles, Cable, Power Pole Terminations, miscellaneous electrical appurtenances, and an Electrical 30 kW Diesel Generator Set for backup power.

Because of the number of pumping facilities involved and the need to closely control the pumping operations over a large area, a system of several operation and monitoring stations would be required from which the pumping facilities could be started and their operation monitored during and immediately following a storm event. The detailed design of this monitoring and operation system is beyond the scope of this study, however a parametric estimate of the cost involved in developing and installing such a system was made and included in the estimate of construction costs for these facilities.

3.3.10.5.3.5 Pumping Stations. Flow and Pump Sizes

Design hydraulic heads derived for the 7 pumping facilities included in the Bellfontaine Ring Levee system for the elevation 20 protection level varied from approximately 10 to 15 feet and the corresponding flows required varied from 99,191 to 273,787 gallons per minute. The plants thus derived varied in size from a plant having two 42-inch diameter, 290 horsepower pumps, to one having four 60-inch diameter pumps each running at 560 horsepower.

3.3.10.5.3.6 Roadways

At each point where a roadway crosses the protection line the decision must be made whether to maintain this artery and adapt the protection line to accommodate it, or to terminate the artery at the protection line and divert traffic to cross the protection line at another location. For this study it was assumed that all roadways and railways crossing the levee alignment would be retained except where it was very evident that traffic could be combined without undue congestion.

Once the decision has been made to retain a particular roadway, it must then be determined how best to configure the artery to conduct traffic across the protection line. The simplest means of passing roadway traffic is to ramp the roadway over the protection line. This alternative is not always viable because of severe right-of-way restraints caused by extreme levee height, urban congestion, etc. In such instances other methods can be used including partial ramping in combination with low profile roller gates. In more restricted areas full height gates which would leave the roadway virtually unaltered might be preferable, even though this alternative would usually be more costly than ramping. In some extreme circumstances where high levees are required to pass through very congested areas, installation of tunnels with closure gates may be required.

Some economy could probably be achieved in this effort by combining smaller arteries and passing traffic through the protection line in fewer locations. However, in most instances this would involve detailed traffic routing studies and designs that are beyond the scope of this effort. These studies would be included in the next phase of the development of these options, should such be warranted.

3.3.10.5.3.7 Railways

Because of the extreme gradient restrictions necessarily placed on railway construction, it is practically never acceptable to elevate a railway up and over a levee. Therefore, the available alternatives would include gated pass through structures. Because of the vertical clearance requirements of railroad traffic all railroad pass through structures for this study were configured having vertical walls on either side of the railway with double swing gates extending to the full height of the levee.

3.3.10.5.3.8 Levee and Roadway/Railway Intersections

With the installation of a ring levee around the Bellefontaine area to elevation 20, 10 roadway intersections would have to be accommodated. For this study it was estimated that 5 roller gate structures and 5 swing gate structures would be required.

3.3.10.5.4 HTRW

Due to the extent and large number of real estate parcels along with the potential for re-alignment of the structural aspects of this project, no preliminary assessment was performed to identify the possibility of hazardous waste on the sites. These studies will be conducted during the next phase of work after the final siting of the various structures. The real estate costs appearing in this report therefore will not reflect any costs for remediation design and/or treatment and/or removal or disposal of these materials in the baseline cost estimate.

3.3.10.5.5 Construction Procedures and Water Control Plan

The construction procedures required for this option are similar to general construction in many respects in that the easement limits must be established and staked in the field, the work area cleared of all structures, pavements, utilities, trees, organics, etc. and the foundation prepared for the new work. Where the levee alignment crosses the existing streams or narrow bays, the alignment base shall be created by displacement with layers of crushed stone pushed ahead and compacted by the placement equipment and repeated until a stable platform is created. The required drainage culverts or other ancillary structures can then be constructed. The control of any surface water will be handled by temporary sheetpile cofferdams and pumping. The control of groundwater will be a series of wellpoints systems designed to keep the excavations dry to a depth and width sufficient to install the new work.

3.3.10.5.6 Project Security

The Protocol for security measures for this study has been performed in general accordance with the Risk Assessment Methodology for Dams (RAM-D) developed by the Interagency Forum for Infrastructure Protection (IFIP). This methodology has been used for physical security for the critical infrastructure throughout the Corps of Engineers. The determination of the level of physical security provided for each facility is based on the following critical elements: 1) threat assessment of the likelihood that an adversary will attack a critical asset, 2) consequence assessment should an adversary be successful in disrupting, disabling or destroying the asset and 3) effectiveness to prevent a successful attack against an operational component.

Three levels of physical security were selected for use in this study:

Level 1 Security provides no improved security for the selected asset. This security level would be applied to the barrier islands and the sand dunes. These features present a very low threat level of attack and basically no consequence if an attack occurred and is not applicable to this option.

Level 2 Security applies standard security measures such as road barricades, perimeter fencing, and intrusion detection systems for unoccupied buildings and vertical structures and security lighting. The intrusion detection systems will be connected to the local law enforcement office for response during an emergency. Facilities requiring this level of security would possess a higher threat level than those in Level 1 and would include assets such as levees, access roads and pumping stations.

Level 3 Security includes all of the features of Level 2 plus enhanced security measures such as the use of video cameras for real-time monitoring of the facility, monitors, motion detectors and alarm sound system in the occupied control buildings. Facilities requiring this level of security would possess the highest threat level of all the critical assets. Power plants would require this level of security.

3.3.10.5.7 Operation and Maintenance

Operation and maintenance activities for this project will be required on an annual basis. All pumps and gates will be operated to assure proper working order. Debris and shoaled sediment will be removed. Vegetation on the levees will be cut to facilitate inspection and to prevent roots from causing weak levee locations. Rills will be filled and damaged revetment will be repaired. Scheduled maintenance should include periodic greasing of all gears and coupled joints, maintaining any battery backup systems, and replacement of standby fuel supplies.

3.3.10.5.8 Cost Estimate

The costs for the various options included in this measure are presented in Section 3.3.10.9, Cost Summary. Construction costs for the various options are included in Table 3.3.10-1 and costs for the annualized Operation and Maintenance of the options are included in Table 3.3.10-2. Estimates are comparative-Level "Parametric Type" and are based on Historical Data, Recent Pricing, and Estimator's Judgment. Quantities listed within the estimates represent Major Elements of the Project Scope and were furnished by the Project Delivery Team. Price Level of Estimate is April 07. Estimates excludes project Escalation and HTRW Cost. The construction costs include real estate, engineering design (E&D), construction management, and contingencies. The E&D cost for preparation of construction contract plans and specifications includes a detailed contract survey, preparation of contract specifications and plan drawings, estimating bid quantities, preparation of bid estimate, preparation of final submittal and contract advertisement package, project engineering and

coordination, supervision technical review, computer costs and reproduction. Construction Contingency developed and assigned at 25% to cover the Cost Growth of the project.

3.3.10.5.9 Schedule for Design and Construction

After the authority for the design has been issued and funds have been provided, the design of these structures will require approximately 12 months including comprehensive plans and specifications, independent reviews and subsequent revisions. The construction of this option should require in excess of two years.

3.3.10.6 Option B – Elevation 30 ft NAVD88

This option consists of an earthen levee around the most populated areas of Belle Fontaine. The alignment of the levee is the same as Option A, above, and is not reproduced here. The only difference between the description of this option and preceding description of Option A is the height of the levee, pumping facilities, number of roadway and railroad intersections, and the length of the levee culverts. Other features and methods of analysis are the same.

3.3.10.6.1 Interior Drainage

Interior drainage analysis and culverts are the same as those for Option A, above, except that the culvert lengths through the levees would be longer.

3.3.10.6.2 Geotechnical Data

The Geology and Geotechnical paragraphs for Option B are the same as for Option A, above.

3.3.10.6.3 Structural, Mechanical and Electrical

The only difference between the description of this option and preceding description of Option A is the height of the levee, pumping facilities, number of roadway and railroad intersections, and the length of the levee culverts. Culvert length variations are not presented but are incorporated into the cost estimate. The other data for Option B is presented below.

3.3.10.6.3.1 Flow and Pump Sizes

Design hydraulic heads derived for the 7 pumping facilities included in the Bellefontaine Ring Levee system for the elevation 30 protection level varied from approximately 20 to 25 feet and the corresponding flows required varied from 99,191 to 273,787 gallons per minute. The plants thus derived varied in size from a plant having two 42-inch diameter, 475 horsepower pumps, to one having four 54-inch diameter pumps each running at 775 horsepower.

3.3.10.6.3.2 Levee and Roadway/Railway Intersections

With the installation of a ring levee around the Bellefontaine area to elevation 30, 13 roadway intersections would have to be accommodated. For this study it was estimated that all 13 would require swing gate structures.

3.3.10.6.4 HTRW

The HTRW paragraphs for Option B are the same as for Option A, above.

3.3.10.6.5 Construction and Water Control Plan

The Construction and Water Control Plan paragraphs for Option B are the same as for Option A, above.

3.3.10.6.6 Project Security

The Project Security paragraphs for Option B are the same as for Option A, above.

3.3.10.6.7 Operation and Maintenance

The Operation and Maintenance paragraphs for Option B are the same as for Option A, above.

3.3.10.6.8 Cost Estimate

The Cost Estimate paragraphs for Option B are the same as for Option A, above.

3.3.10.6.9 Schedule for Design and Construction

The Schedule for Design and Construction paragraphs for Option B are the same as for Option A, above.

3.3.10.7 Option C – Alternate Alignment, Elevation 20 ft NAVD88

This option consists of an earthen levee at elevation 20 ft NAVD88 enclosing an area of 1341 acres around the most populated areas of Belle Fontaine in an alignment slightly different from the alignment for Options A and B. The alignment of the levee is shown in Figure 3.3.10-15 below, which also shows the variation in the drainage sub-basins and the locations of the pumps and culverts.

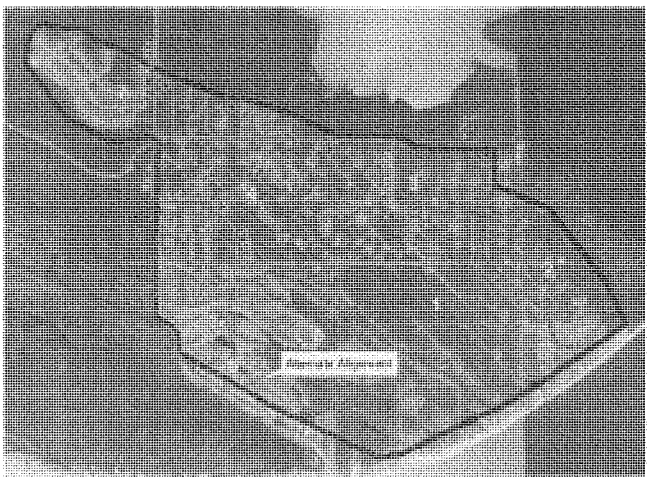


Figure 3.3.10-15. Alternative Alignment Pump/Culvert/Sub-basin Locations

3.3.10.7.1 Interior Drainage

Interior drainage flows are similar to those computed for Option A, above. However, ditches, culverts and pumps were re-sized by adjusting the previously computed flows by the ratio of the change in areas of the sub-basins to get the revised flows.

3.3.10.7.2 Geotechnical Data

The Geology and Geotechnical paragraphs for Option C are the same as for Option A, above.

3.3.10.7.3 Structural, Mechanical and Electrical

The only difference between the description of this option and preceding description of Option A is the height of the levee, pumping facilities, number of roadway and railroad intersections, and the length of the levee culverts. Culvert length variations are not presented but are incorporated into the cost estimate. The other data for Option C is presented below.

3.3.10.7.3.1 Pumping Stations. Flow and Pump Sizes

Design hydraulic heads derived for the 7 pumping facilities included in the Bellefontaine Ring Levee system for the elevation 20 protection level varied from approximately 10 to 20 feet and the corresponding flows required varied from 99,453 to 274,644 gallons per minute. The plants thus derived varied in size from a plant having two 42-inch diameter, 290 horsepower pumps, to one having five 42-inch diameter pumps each running at 475 horsepower.

3.3.10.7.3.2 Levee and Roadway/Railway Intersections

With the installation of a ring levee around the Bellefontaine area to elevation 20, 13 roadway intersections would have to be accommodated. For this study it was estimated that 5 of these would require 10 swing gate structures with the remaining 8 requiring roller gates of varying heights.

3.3.10.7.4 HTRW

The HTRW paragraphs for Option C are the same as for Option A, above.

3.3.10.7.5 Construction and Water Control Plan

The Construction and Water Control Plan paragraphs for Option C are the same as for Option A, above.

3.3.10.7.6 Project Security

The Project Security paragraphs for Option C are the same as for Option A, above.

3.3.10.7.7 Operation and Maintenance

The Operation and Maintenance paragraphs for Option C are the same as for Option A, above.

3.3.10.7.8 Cost Estimate

The Cost Estimate paragraphs for Option C are the same as for Option A, above.

3.3.10.7.9 Schedule for Design and Construction

The Schedule for Design and Construction paragraphs for Option C are the same as for Option A, above.

3.3.10.8 Option D – Alternate Alignment, Elevation 30 ft NAVD88

This option consists of an earthen levee around the most populated areas of Belle Fontaine. The alignment of the levee is the same as Option C, above, and is not reproduced here. The only difference between the description of this option and preceding description of Option C is the height of the levee, pumping facilities, number of roadway and railroad intersections, and the length of the levee culverts. Other features and methods of analysis are the same.

3.3.10.8.1 Interior Drainage

Interior drainage analysis and culverts are the same as those for Option C, above, except that the culvert lengths through the levees would be longer.

3.3.10.8.2 Geotechnical Data

The Geology and Geotechnical paragraphs for Option D are the same as for Option A, above.

3.3.10.8.3 Structural, Mechanical and Electrical

The only difference between the description of this option and preceding description of Option A is the height of the levee, pumping facilities, number of roadway and railroad intersections, and the length of the levee culverts. Culvert length variations are not presented but are incorporated into the cost estimate. The other data for Option D is presented below.

3.3.10.8.3.1 Pumping Stations. Flow and Pump Sizes.

Design hydraulic heads derived for the 7 pumping facilities included in the Bellefontaine Ring Levee system for the elevation 30 protection level varied from approximately 20 to 30 feet and the corresponding flows required varied from 99,453 to 274,644 gallons per minute. The plants thus derived varied in size from a plant having two 42-inch diameter, 475 horsepower pumps, to one having three 60-inch diameter pumps each running at 1150 horsepower.

3.3.10.8.3.2 Levee and Roadway/Railway Intersections

With the installation of a ring levee around the Bellefontaine area to elevation 30, 11 roadway intersections would have to be accommodated. For this study it was estimated that all 11 would require 22 swing gate structures.

3.3.10.8.4 HTRW

The HTRW paragraphs for Option D are the same as for Option A, above.

3.3.10.8.5 Construction and Water Control Plan

The Construction and Water Control Plan paragraphs for Option D are the same as for Option A, above.

3.3.10.8.6 Project Security

The Project Security paragraphs for Option D are the same as for Option A, above.

3.3.10.8.7 Operation and Maintenance

The Operation and Maintenance paragraphs for Option D are the same as for Option A, above.

3.3.10.8.8 Cost Estimate

The Cost Estimate paragraphs for Option D are the same as for Option A, above.

3.3.10.8.9 Schedule for Design and Construction

The Schedule for Design and Construction paragraphs for Option D are the same as for Option A, above.

3.3.10.9 Cost Estimate Summary

The costs for construction and for operations and maintenance of all options are shown in Tables 3.3.10-1 and 3.3.10-2, below. Estimates are comparative-Level "Parametric Type" and are based on Historical Data, Recent Pricing, and Estimator's Judgment. Quantities listed within the estimates represent Major Elements of the Project Scope and were furnished by the Project Delivery Team. Price Level of Estimate is April 07. Estimates excludes project Escalation and HTRW Cost.

Table 3.3.10-1.
Jackson Co Belle Fontaine Ring Levee Construction Cost Summary

Option	Total project cost
Option A – Elevation 20 ft NAVD88	$137,600,000
Option B – Elevation 30 ft NAVD88	$191,900,000
Option C – Elevation 30 ft NAVD88	$103,900,000
Option D – Elevation 30 ft NAVD88	$142,900,000

Table 3.3.10-2.
Jackson Co Belle Fontaine Ring Levee O & M Cost Summary

Option	O&M Cost
Option A – Elevation 20 ft NAVD88	$1,371,000
Option B – Elevation 30 ft NAVD88	$1,939,000
Option C – Elevation 30 ft NAVD88	$989,000
Option D – Elevation 30 ft NAVD88	$1,414,000

3.3.10.10 References

US Army Corps of Engineers (USACE) 1987. Hydrologic Analysis of Interior Areas. Engineer Manual EM 1110-2-1413. Department of the Army, US Army Corps of Engineers, Washington, D.C. 15 January 1987.

USACE 1993. Hydrologic Frequency Analysis. Engineer Manual EM 1110-2-1415. Department of the Army, US Army Corps of Engineers, Washington, D.C. 5 March 1993.

USACE 1995. Hydrologic Engineering Requirements for Flood Damage Reduction Studies. Engineer Manual EM 1110-2-1419. Department of the Army, US Army Corps of Engineers, Washington, D.C. 31 January 1995.

USACE 2006. Risk Analysis for Flood Damage Reduction Studies. Engineer Regulation ER 1105-2-101. Department of the Army, US Army Corps of Engineers, Washington, D.C. 3 January 2006.

National Resource Conservation Service (NRCS). 2003. WinTR5-55 User Guide (Draft). Agricultural Research Service. 7 May 2003.

Environmental Science Services Administration. 1968. "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.

Weather Bureau and USACE. 1956. 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.

3.3.11 Jackson County, Gautier Ring Levee

3.3.11.1 General

Several high density residential and business areas in Jackson County were identified. They are: Pascagoula/Mosspoint, Gautier, Belle Fontaine, Gulf Park Estates, and Ocean Springs. These are subject to damage from storm surges associated with hurricanes. Earthen ring levees were evaluated for protection of these areas. The levees were evaluated at elevations 20 ft NAVD88 and 30 ft NAVD88. The top width was assumed 15 ft with sideslopes of 1 vertical to 3 horizontal. Each of the levees is presented separately in this report. Additional options not evaluated in detail are described elsewhere in this report.

Evaluation of this option was done by comparing benefits computed by Hydrologic Engineering Center's (HEC) Flood Damage Analysis (FDA) computer application HEC-FDA and costs computed. HEC-FDA modeling was done comparing the study reaches using variations in expected sea-level rise and development. Details regarding the methodology are presented in Section 2.13 of the Engineering Appendix and in the Economic Appendix.

3.3.11.2 Location

The location of the Gautier ring levee in Jackson County is shown below in Figures 3.3.11-1 and 3.3.11-2.

3.3.11.3 Existing Conditions

Gautier is located on the west side of the Pascagoula River delta at the mouth of the West Pascagoula River at the Mississippi Sound. Ground elevations over most of the residential and business areas vary between elevation 10-20 ft NAVD88. The southern-most part of the area is drained by drowned natural drainage ways. The 6-ft(blue), 12-ft(green), 16-ft(brown), and 20-ft(pink) ground contour lines and city limits are shown below in Figure 3.3.11-3.

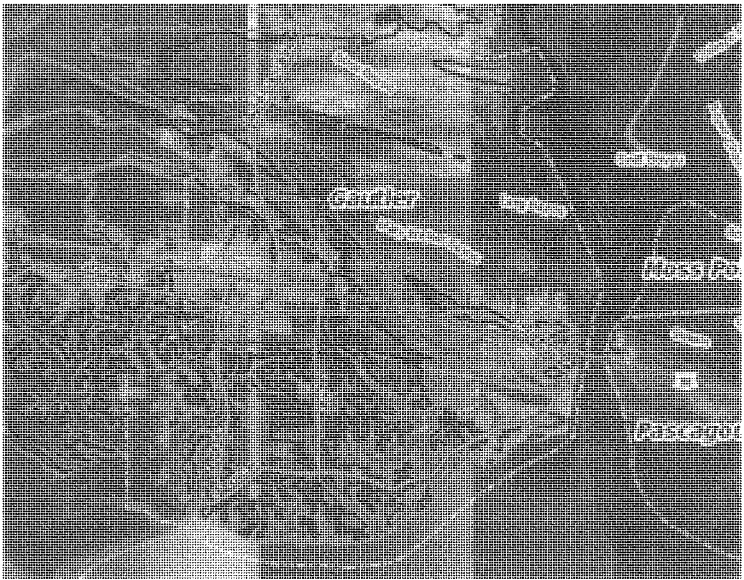


Figure 3.3.11-1 Vicinity Map, Gautier, MS

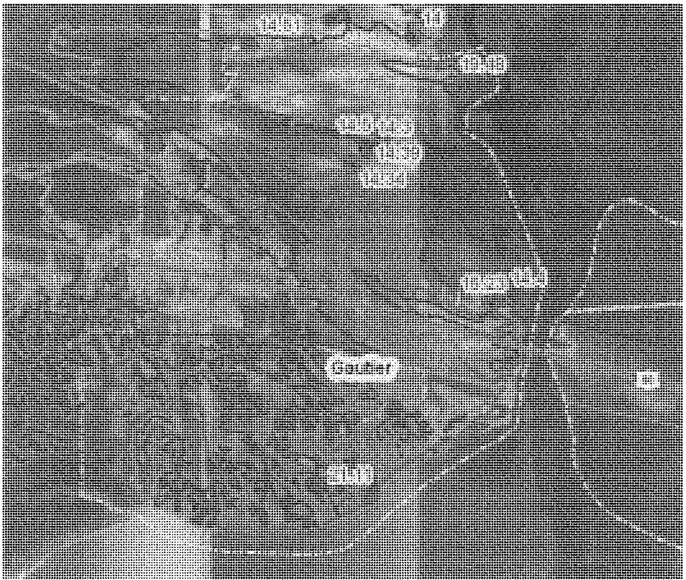


Figure 3.3.11-2 Gautier Ring Levee

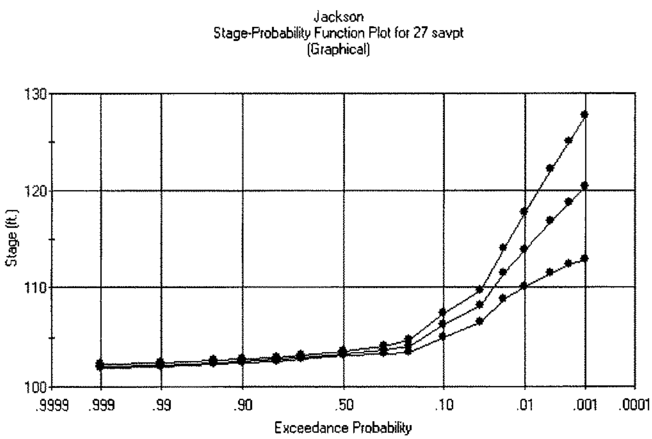


Figure 3.3.11-3. Existing Conditions

Drainage in the southern part of the city is through drowned streams that empty into Mississippi Sound. These are therefore unusually wider at the mouth and have productive environmental and recreational benefits.

Drainage from ordinary rainfall is hindered on occasions when either of the rivers or the gulf is high, but impacts from hurricanes are devastating.

Recent damage from Hurricane Katrina in August, 2005 the Gautier area are shown below in Figure 3.3.11-4 and 3.3.11-5. Many homes are still un-repaired, pending settlement of insurance claims.

Source: http://coastal.er.usgs.gov/hurricanes/katrina/quickphotos/gautier/

Figure 3.3.11-4. Hurricane Katrina Damage in Gautier, MS

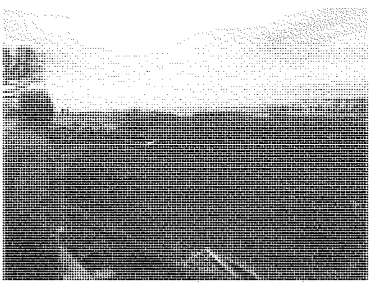


Figure 3.3.11-5. Hurricane Katrina Damage in Gautier, MS

3.3.11.4 Coastal and Hydraulic Data

Typical coastal data are shown in Section 1.4, of this report. High water marks taken by FEMA after Hurricane Katrina in 2005 as well as the 6-ft(blue), 12-ft(green), 16-ft(brown), and 20-ft(pink) ground contour lines and city limits are shown below in Figure 3.3.10-6. The data indicates the Katrina high water was as high as 21 ft NAVD88 at the Mississippi Sound and 15 ft NAVD88 north of Hwy 90.

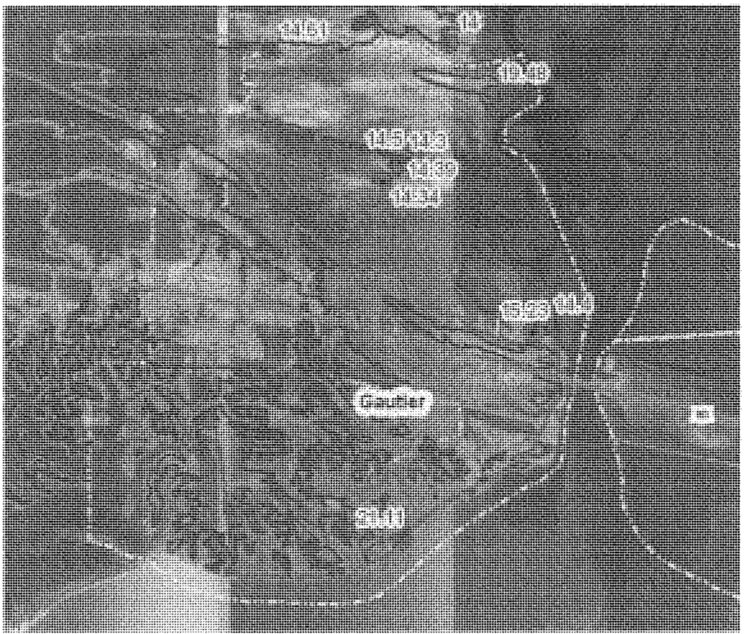


Figure 3.3.11-6. Ground Contours and Katrina High Water Elevations

Stage-Frequency data for a suite of severe storms using Joint Probability Method (JPM) and hydrodynamic modeling were developed by the Engineer Research and Development Center (ERDC) for 80 locations along the study area. These data were combined with historical gage frequencies for smaller storms to establish stage-frequency curves at 54 economic reaches in the study area which were entered into Hydrologic Engineering Center's (HEC) Flood Damage Analysis (HEC-FDA) application to evaluate benefits. An expanded description of the procedure is shown in Section 2.13 of the Engineering Appendix and in the Economic Appendix 3.3.11.2. Points near Gautier at which data from hydrodynamic modeling was saved are shown below in Figure 3.3.11-7.

Existing Condition Stage –Frequency data for Save Point 27, just off the coast of Gautier, is shown below in Figure 3.3.11-8. The 95% confidence limits, approximately equally to plus and minus two standard deviations, are shown bounding the median curve. The elevations are presented at 100 ft higher than actual to facilitate HEC-FDA computations.

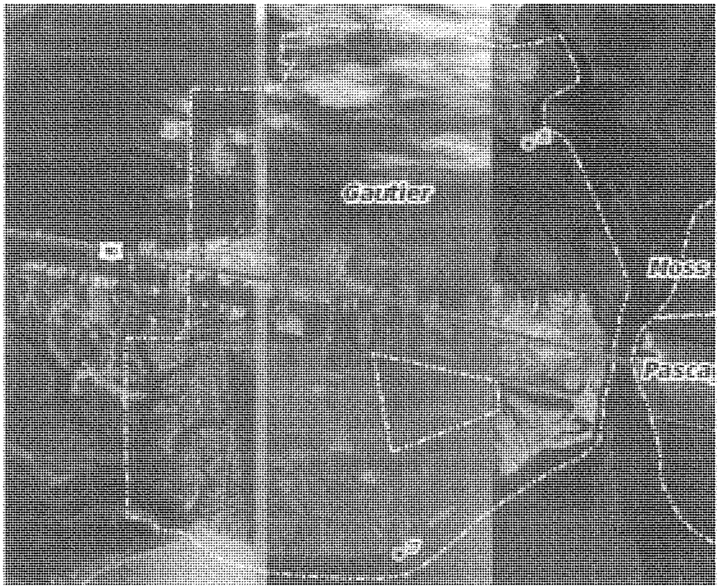


Figure 3.3.11-7. Hydrodynamic Modeling Save Points near Gautier

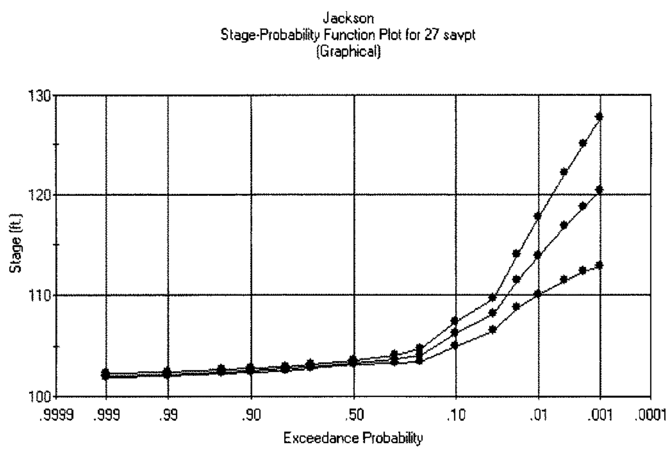


Figure 3.3.11-8. Existing Conditions at Save Point 27, near Gautier, MS

3.3.11.5 Option A – Elevation 20 ft NAVD88

This option consists of an earthen dike enclosing an area of 4833 acres around the most densely populated areas of Gautier as shown on the following Figure 3.3.11-9, along with the internal sub-basins and levee culvert/pump locations. The levee would have a top width of 15 ft and slopes of 1 vertical to 3 horizontal. A small boat access structure is also shown at the mouth of several basins. Rising sector gates will be provided at these sites allowing shallow draft traffic most of the time. The gates will be closed prior to hurricane storm surge. Damage and failure by overtopping of levees could be caused by storms surges greater than the levee crest as shown below in Figure 3.3.11-10.

Overtopping failures are caused by the high velocity of flow on the top and back side of the levee. Although significant wave attack on the seaward side of some of the New Orleans levees occurred during Hurricane Katrina, the duration of the wave attack was for such a short time that major damage did not occur from wave action. The erosion shown below in Figure 3.3.11-11 was caused by approximately 1-2 ft of overtopping crest depth.

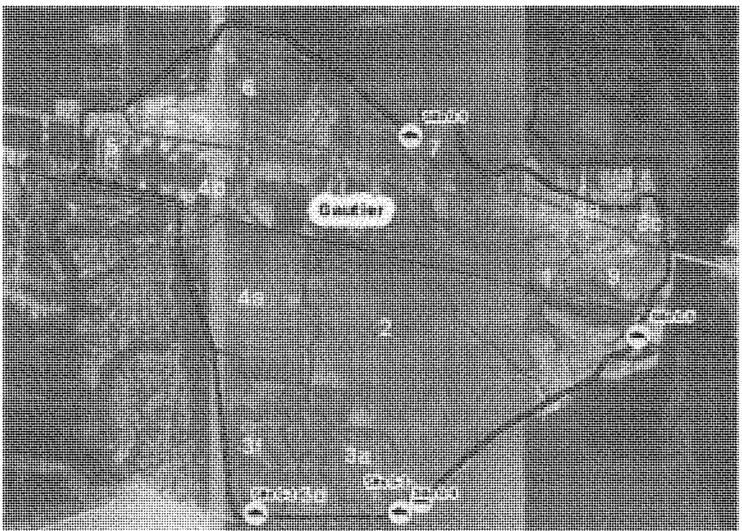
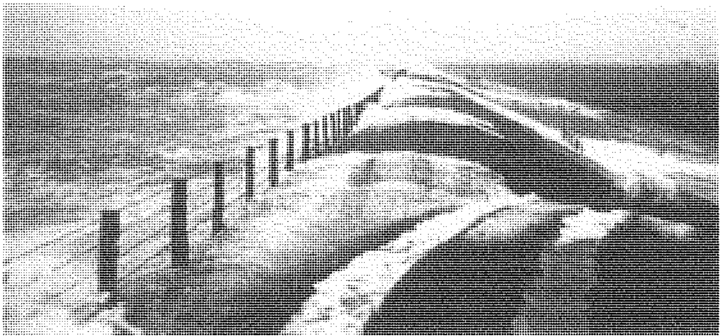
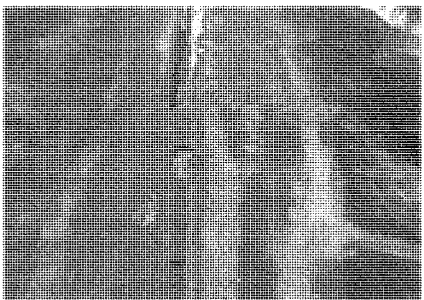


Figure 3.3.11-9. Pump/Culvert/Sub-basin/Boat Access Site Locations



Source: Wave Overtopping Flow on Seadikes, Experimental and Theoretical Investigations, Holger Schüttrumpf, (Photo:Leichtweiss-Institute) http://kfki.baw.de/fileadmin/projects/E_35_134_Lit.pdf

Figure 3.3.11-10. North Sea, Germany, March 1976



Source: ERDC, Steven Hughes

Figure 3.3.11-11. Crown Scour from Hurricane Katrina at Mississippi River Gulf Outlet (MRGO) Levee in St. Bernard Parish, New Orleans, LA

Revetment would be included in the levee design to prevent overtopping failure.

The levee would be protected by gabions on filter cloth as shown in Figure 3.3.11-12, extending across a drainage ditch which carries water to nearby culverts and which would also serve to dissipate some of the supercritical flow energy during overtopping conditions.

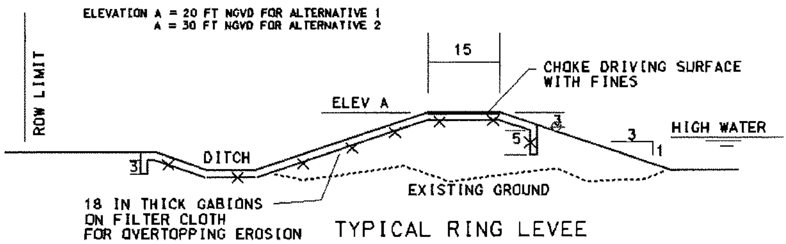


Figure 3.3.11-12. Typical Section at Ring Levee

3.3.11.5.1 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 in Figure 3.3.11-9. The culverts would have tidal 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 the upstream end at every culvert in the levee for manual control in the event the tidal gate malfunctions. A typical section is shown is shown below in Figure 3.3.11-13.

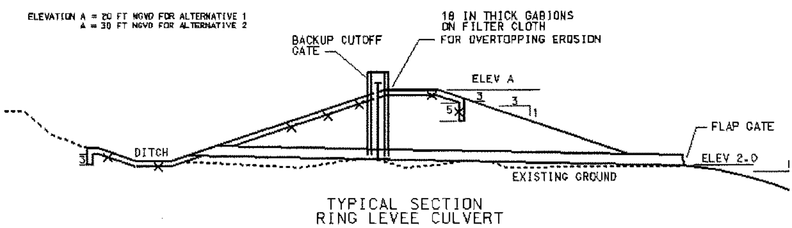


Figure 3.3.11-13. Typical Section at Culvert

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 ring levee into major sub-basins as shown above in Figure 3.3.11-9 and computing flow for each sub-basin by USGS computer application WinTR55. The method incorporates soil type shown below in Figure 3.3.11-14 and land use to determine a run-off curve number. The variation in soil type, hydrologic soil groups, and sub-basins is shown below in Figure 3.3.11-14.

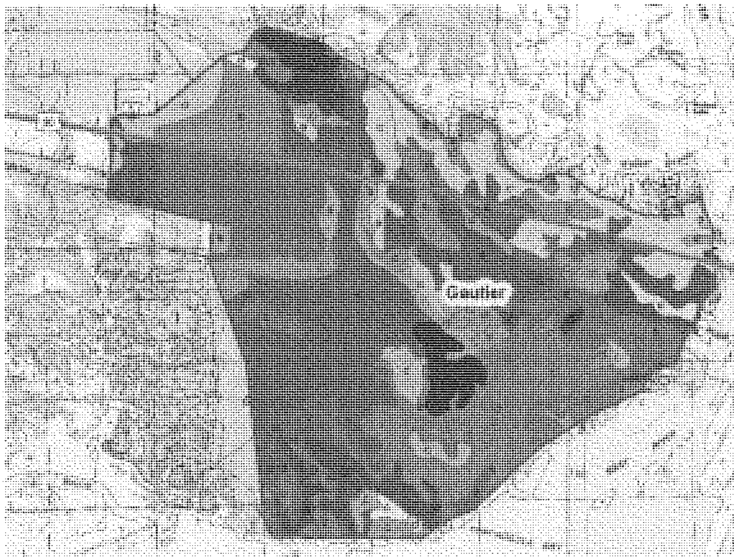


Figure 3.3.11-14. Gautier Hydrologic Soil Groups

Hydrologic soil group A soils have low runoff potential and high infiltration rates, even with thoroughly wetted and a high rate of water transmission. Hydrologic soil group B soils have moderate infiltration rates when thoroughly wetted and a moderate rate of water transmission. Hydrologic soil group C soils have low infiltration rates when thoroughly wetted and have a low rate of water transmission. Hydrologic soil group C soils have high runoff potential and a very low rate of water transmission.

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. For the culvert design, headwater elevations at the culverts were maintained at an elevation no greater than 5 ft NAVD88 with a tailwater elevation of 2.0 ft NAVD88 assumed. Drainage ditches along the toe of the levee will be required to assure that smaller basins can be drained to a culvert/pump site. These ditches were sized using a normal depth flow computation. Curve numbers, pump, and culvert capacity tables are not included in the report beyond that necessary to obtain a cost estimate. The data are considered beyond the level of detail required for this report.

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. This decision was based on an evaluation of rainfall observed during hurricane and tropical storm events as presented in two sources. The first is "Frequency and Aerial 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. However, in some of the areas, existing storage could be adequate to pond water without causing damage, even without pumps. In other areas that do have pumps, some rise in interior water during interior events greater than the 10-yr rain could occur, but may not cause damage. Designing the pumps for the peak 10-yr flow provides a significant pumping capacity. Further studies will detail the requirement for the appropriate ponding areas, pump sizes, or buyouts in the affected areas.

During non-hurricane periods of low water in the sound, when rainfall greater than the 25-yr event occurs, the pumps could also be used to augment the flow capacity of the levee culverts.

3.3.11.5.2 Geotechnical Data

Geology: Citronelle formation is found above the Interstate 10 alignment and is a relatively thin unit of fluvial deposits of Plio-Pleistocene age consisting of gravelly sand and silty sand layers. Typically the formation is 30 to 80 feet thick, except where it has filled eroded channels in the underlying formations. The sand in the formation has a variety of colors, often associated with the presence of iron oxides in the form of hematite or goethite. Thin discontinuous clay layers are found in some areas. The iron oxide has occasionally cemented the sand into a friable sandstone, usually occurring only as a localized layer. Within the study area, this formation outcrops north of Interstate 10 and will not be encountered at project sites other than any levees that might extend northward to higher ground elevations.

Prairie formation is found along the rest of the Line 4 alignment within Jackson County. The Prairie formation is found southward of the Citronelle formation and is of Pleistocene age. This formation consists of fluvial and floodplain sediments that extend southward from the outcrop of the Citronelle formation to or near the mainland coastline. Sand found within this formation has an economic value as beach fill due to its color and quality. Southward from its outcrop area, the formation extends under the overlying Holocene deposits out into the Mississippi Sound.

Gulfport Formation is found along the coastline in most of western Jackson County at Belle Fontaine Beach. This formation of Pleistocene age overlies the Prairie formation and is present as well sorted sands that mark the edge of the coastline during the last high sea level stage of the Sangamonian Interglacial period. It does not extend under the Mississippi Sound.

Geotechnical: The inland barrier earthen levee section will have one vertical to three horizontal side slopes with a fifteen foot crest width. All work areas to receive the fill shall be cleared and grubbed of all trees and surface organics and all existing foundations, streets, utilities, etc. will be removed and the subsequent cavities backfilled and compacted. The levee will be constructed of sand clay materials obtained from off site commercial sources, trucked to the work area, placed in thin lifts and compacted to 95 percent of the maximum modified density. The final surface will be armored by the placement of 24 inch thick gabion mattress filled with small stone for erosion protection during an event that overtops the levee. The armoring will be anchored on the front face by trenching and extend across the downstream slope and the 25 foot easement area beyond the toe. The front side of the levee and all non critical surface areas will be subsequently covered by grassing. Road crossings will incorporate small gate structures or ramping over the embankment where the surface elevation is near that of the crest elevation. The elevation relationship of the crest and the adjacent railroad will be a governing factor. The surfaces will be paved with asphalt and the corresponding drainage will be accommodated. Those areas where the subgrade geology primarily consists of clean sands, seepage underneath the levee and the potential for erosion and instability must be considered. Final designs may require the installation of a bentonite concrete cutoff wall deep within the foundation. This condition will be investigated during any design phase and its requirement will be incorporated.

3.3.11.5.3 Structural, Mechanical and Electrical

Structural, Mechanical, and Electrical data are presented for culverts, pumping facilities and for boat access sites. The sites are shown above in Figure 3.3.11-9.

3.3.11.5.3.1 Culverts

As any flood barrier is constructed the natural groundwater runoff would be inhibited. In order to maintain the natural runoff patterns culverts would be inserted through the protection line at appropriate locations. For this study these were configured as cast-in-place reinforced concrete box structures fitted with flap gates to minimize normal backflows and sluice gates to provide storm closure when needed. The shear number of these structures that would be required throughout the area covered by this study would dictate that an automated system be incorporated whereby the gates could be monitored and operated from some central location within defined districts. Detailed design of these monitoring and operating systems is beyond the scope of this study, however a parametric cost was developed for each site and included in the estimated construction cost for these facilities.

3.3.11.5.3.2 Pumping Facilities Structural

The layout of each pumping facility was made in conformance with Corp of Engineers Guidance document EM 1110-2-3105, Mechanical and Electrical Design of Pumping Stations. The basic plant dimensions for each site were set using approximate dimensions derived based on specific pump data (pump impeller diameter, pump bell bottom clearance, etc.). Each facility was roughly fitted to its site using existing ground elevations taken from available mapping and height of levee data. In every case the top of the pump floor was required to be above the 100 year flood elevation. Nominal sidewall and sump and pump floor thicknesses were assumed, along with wall and roof thicknesses for the pump room enclosure. Using these basic dimensions and the preliminary number and size of pumping units determined for each site, the overall plant footprint and elevations were set and quantities of basic construction materials computed. The pumping plants were configured, to the greatest extent possible with the data provided, to provide multiple pumps at each site.

Discharge piping for each plant was estimated using over the levee piping with one pipe per pumping unit. For estimating purposes the piping was sized to match the pump diameter. Each pipe was extended approximately 25 feet beyond the toe of the embankment on the discharge end to allow for energy dissipation features to be incorporated into the pipe discharge.

At the discharge end of the piping a heavy mat of grouted riprap was added as protection for the levee slope and immediately adjacent area. In each case the 4-foot deep stone mat was estimated as extending 30 feet up the levee slope and 50 feet out from the levee toe for a total width of 80 feet. The lateral extent was estimated at 10 feet per discharge pipe.

3.3.11.5.3.3 Pumping Facilities Mechanical

Vertical shaft pumps were used for all of the pumping facilities. Preliminary mechanical design of the required pumping equipment was made by adaptation of manufacturer's stock pumping equipment to approximate hydraulic head and flow data developed for each pumping location. This data was coordinated with a pump manufacturer who supplied a cross check of the pump selections and cost data for use in preparation of project construction cost estimates. In consideration of the primary purpose which this equipment would serve, and in light of the widespread unavailability of electric power during and immediately after a major storm, it was determined that the pumps should be diesel engine driven.

3.3.11.5.3.4 Pumping Facilities Electrical

The electrical design for these facilities would consist primarily of providing station power for the facilities. For each of the sites this would include installation of Power Poles, Cable, Power Pole Terminations, miscellaneous electrical appurtenances, and an Electrical 30 kW Diesel Generator Set for backup power.

Because of the number of pumping facilities involved and the need to closely control the pumping operations over a large area, a system of several operation and monitoring stations would be required from which the pumping facilities could be started and their operation monitored during and immediately following a storm event. The detailed design of this monitoring and operation system is beyond the scope of this study, however a parametric estimate of the cost involved in developing and installing such a system was made and included in the estimate of construction costs for these facilities.

3.3.11.5.3.5 Pumping Stations. Flow and Pump Sizes

Design hydraulic heads derived for the 11 facilities included in the Gautier Ring Levee system for the elevation 20 protection level varied from approximately 15 to 20 feet and the corresponding flows required varied from 65,081 to 558,795 gallons per minute. The plants thus derived varied in size from a plant having two 42-inch diameter, 300 horsepower pumps, to one having six 60-inch diameter pumps each running at 560 horsepower.

3.3.11.5.3.6 Boat Access Structure

At five sites the Gautier ring levee alignment would cross a moderately sized water course where it is apparent that boats currently traverse the area. (See Figure 3.3.11-9 above). To allow continued free boat access to the areas behind the levee this site was fitted with a scaled down adaptation of the larger rising sector gate structure used for the bay barriers at Biloxi and Bay Saint Louis. This structure would, for the most part, be much smaller and lighter than those used in the bays, however it would be substantial. The operation would be similarly critical in time of storm and they would require the same attention from an Operations and Maintenance standpoint as their larger, heavier counterparts. The structure is shown below in Figure 3.3.11-15 and in Table 3.3.11-1.

Table 3.3.11-1.
Boat Access Structure Dimensional Data by Site

Site Designation	Protection Elevation, ft NAVD88	Ll ft	PW ft	H ft
G-1	20.0	50	18	29.5
	30.0	50	18	42.0
G-2	20.0	70	18	29.5
	30.0	70	18	42.0
G-3	20.0	32	18	29.5
	30.0	32	18	42.0
G-4	20.0	132	18	29.5
	30.0	132	18	42.0
G-5	20.0	104	18	29.5
	30.0	104	18	42.0

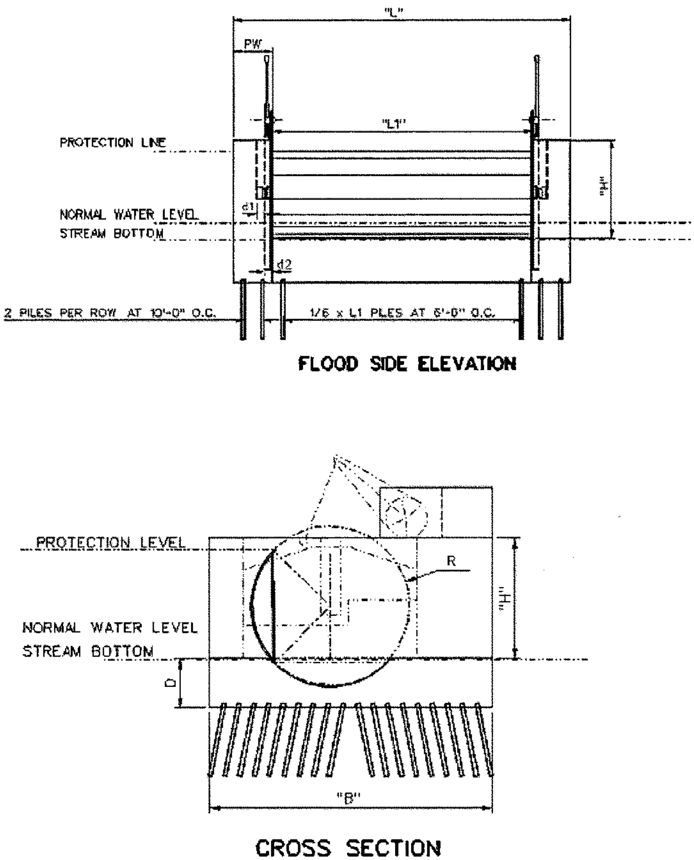


Figure 3.3.11-15. Typical Small Boat Access Structure

3.3.11.5.3.7 Boat Access Structure. Mechanical

The mechanical equipment and operating system for these structures would be similar to those used for the bay barriers, and would include steel gate linkages and hydraulic rams and pivot pins for operation of the gates. Each gate would rotate on large bearings and pivot hubs at the ends of the gate. Various operating hydraulic and lubrication oil systems would also be required. It is estimated that each gate would have a maximum opening/closing time of 15 minutes.

3.3.11.5.3.8 Boat Access Structure. Electrical

Primary electrical power for operating these gates would be provided using dedicated, standard transformers with emergency back-up generators. The electrical load demand at these facilities would be low by comparison to the bay barrier structures. The supplemental generation aspect was considered to be a vital component of the design because of the very high cost of commercial standby power and because commercial electric power would almost certainly be unavailable during and immediately following a storm event.

3.3.11.5.3.9 Roadways

At each point where a roadway crosses the protection line the decision must be made whether to maintain this artery and adapt the protection line to accommodate it, or to terminate the artery at the protection line and divert traffic to cross the protection line at another location. For this study it was assumed that all roadways and railways crossing the levee alignment would be retained except where it was very evident that traffic could be combined without undue congestion.

Once the decision has been made to retain a particular roadway, it must then be determined how best to configure the artery to conduct traffic across the protection line. The simplest means of passing roadway traffic is to ramp the roadway over the protection line. This alternative is not always viable because of severe right-of-way restraints caused by extreme levee height, urban congestion, etc. In such instances other methods can be used including partial ramping in combination with low profile roller gates. In more restricted areas full height gates which would leave the roadway virtually unaltered might be preferable, even though this alternative would usually be more costly than ramping. In some extreme circumstances where high levees are required to pass through very congested areas, installation of tunnels with closure gates may be required.

Some economy could probably be achieved in this effort by combining smaller arteries and passing traffic through the protection line in fewer locations. However, in most instances this would involve detailed traffic routing studies and designs that are beyond the scope of this effort. These studies would be included in the next phase of the development of these options, should such be warranted.

3.3.11.5.3.10 Railways

Because of the extreme gradient restrictions necessarily placed on railway construction, it is practically never acceptable to elevate a railway up and over a levee. Therefore, the available alternatives would include gated pass through structures. Because of the vertical clearance requirements of railroad traffic all railroad pass through structures for this study were configured having vertical walls on either side of the railway with double swing gates extending to the full height of the levee.

3.3.11.5.3.11 Levee and Roadway/Railway Intersections

With the installation of a ring levee around the Gautier area to elevation 20, 20 roadway intersections would have to be accommodated. For this study it was estimated that 11 roller gate structures and 11 swing gate structures would be required.

3.3.11.5.4 HTRW

Due to the extent and large number of real estate parcels along with the potential for re-alignment of the structural aspects of this project, no preliminary assessment was performed to identify the possibility of hazardous waste on the sites. These studies will be conducted during the next phase of work after the final siting of the various structures. The real estate costs appearing in this report therefore will not reflect any costs for remediation design and/or treatment and/or removal or disposal of these materials in the baseline cost estimate.

3.3.11.5.5 Construction Procedures and Water Control Plan

The construction procedures required for this option are similar to general construction in many respects in that the easement limits must be established and staked in the field, the work area cleared of all structures, pavements, utilities, trees, organics, etc. and the foundation prepared for the new work. Where the levee alignment crosses the existing streams or narrow bays, the alignment base shall be created by displacement with layers of crushed stone pushed ahead and compacted by the placement equipment and repeated until a stable platform is created. The required drainage culverts or other ancillary structures can then be constructed. The control of any surface water will be handled by temporary sheetpile cofferdams and pumping. The control of groundwater will be a series of wellpoints systems designed to keep the excavations dry to a depth and width sufficient to install the new work.

3.3.11.5.6 Project Security

The Protocol for security measures for this study has been performed in general accordance with the Risk Assessment Methodology for Dams (RAM-D) developed by the Interagency Forum for Infrastructure Protection (IFIP). This methodology has been used for physical security for the critical infrastructure throughout the Corps of Engineers. The determination of the level of physical security provided for each facility is based on the following critical elements: 1) threat assessment of the likelihood that an adversary will attack a critical asset, 2) consequence assessment should an adversary be successful in disrupting, disabling or destroying the asset and 3) effectiveness to prevent a successful attack against an operational component.

Three levels of physical security were selected for use in this study:

Level 1 Security provides no improved security for the selected asset. This security level would be applied to the barrier islands and the sand dunes. These features present a very low threat level of attack and basically no consequence if an attack occurred and is not applicable to this option.

Level 2 Security applies standard security measures such as road barricades, perimeter fencing, and intrusion detection systems for unoccupied buildings and vertical structures and security lighting. The intrusion detection systems will be connected to the local law enforcement office for response during an emergency. Facilities requiring this level of security would possess a higher threat level than those in Level 1 and would include assets such as levees, access roads and pumping stations.

Level 3 Security includes all of the features of Level 2 plus enhanced security measures such as the use of video cameras for real-time monitoring of the facility, monitors, motion detectors and alarm sound system in the occupied control buildings. Facilities requiring this level of security would possess the highest threat level of all the critical assets. Boat access gates and power plants would require this level of security.

3.3.11.5.7 Operation and Maintenance

Operation and maintenance activities for this project will be required on an annual basis. All pumps and gates will be operated to assure proper working order. Debris and shoaled sediment will be removed. Vegetation on the levees will be cut to facilitate inspection and to prevent roots from causing weak levee locations. Rills will be filled and damaged revetment will be repaired. Scheduled maintenance should include periodic greasing of all gears and coupled joints, maintaining any battery backup systems, and replacement of standby fuel supplies.

3.3.11.5.8 Cost Estimate

The costs for the various options included in this measure are presented in Section 3.3.11.7, Cost Summary. Construction costs for the various options are included in Table 3.3.11-2 and costs for the annualized Operation and Maintenance of the options are included in Table 3.3.11-3. Estimates are comparative-Level "Parametric Type" and are based on Historical Data, Recent Pricing, and Estimator's Judgment. Quantities listed within the estimates represent Major Elements of the Project Scope and were furnished by the Project Delivery Team. Price Level of Estimate is April 07. Estimates excludes project Escalation and HTRW Cost. The construction costs include real estate, engineering design (E&D), construction management, and contingencies. The E&D cost for preparation of construction contract plans and specifications includes a detailed contract survey, preparation of contract specifications and plan drawings, estimating bid quantities, preparation of bid estimate, preparation of final submittal and contract advertisement package, project engineering and coordination, supervision technical review, computer costs and reproduction. Construction Contingency developed and assigned at 25% to cover the Cost Growth of the project.

3.3.11.5.9 Schedule for Design and Construction

After the authority for the design has been issued and funds have been provided, the design of these structures will require approximately 12 months including comprehensive plans and specifications, independent reviews and subsequent revisions. The construction of this option should require in excess of two years.

3.3.11.6 Option B – Elevation 30 ft NAVD88

This option consists of an earthen levee around the most populated areas of Gautier The alignment of the levee is the same as Option A, above, and is not reproduced here. The only difference between the description of this option and preceding description of Option A is the height of the levee, pumping facilities, and the length of the levee culverts. Other features and methods of analysis are the same.

3.3.11.6.1 Interior Drainage

Interior drainage analysis and culverts are the same as those for Option A, above, except that the culvert lengths through the levees would be longer.

3.3.11.6.2 Geotechnical Data

The Geology and Geotechnical paragraphs for Option B are the same as for Option A, above.

3.3.11.6.3 Structural, Mechanical and Electrical

These data are the same as that presented for Option A and is not reproduced here. The only difference between the description of this option and preceding description of Option A is the height of the levee, pumping facilities, number of roadway and railroad intersections, and the length of the levee culverts. Culvert length variations are not presented but are incorporated into the cost estimate. The other data for Option B are presented below.

3.3.11.6.3.1 Pumping Stations Flow and Pump Sizes

Design hydraulic heads derived for the 11 facilities included in the Gautier Ring Levee system for the elevation 20 protection level were steady at approximately 25 feet and the corresponding flows required varied from 65,081 to 558,795 gallons per minute. The plants thus derived varied in size from a plant having two 42-inch diameter, 500 horsepower pumps, to one having six 60-inch diameter pumps each running at 1000 horsepower.

3.3.11.6.3.2 Levee and Roadway/Railway Intersections

With the installation of a ring levee around the Gautier area to elevation 30, 23 roadway intersections would have to be accommodated. For this study it was estimated that all 23 would require swing gate structures.

3.3.11.6.4 HTRW

The HTRW paragraphs for Option B are the same as for Option A, above.

3.3.11.6.5 Construction and Water Control Plan

The Construction and Water Control Plan paragraphs for Option B are the same as for Option A, above.

3.3.11.6.6 Project Security

The Project Security paragraphs for Option B are the same as for Option A, above.

3.3.11.6.7 Operation and Maintenance.

The Operation and Maintenance paragraphs for Option B are the same as for Option A, above.

3.3.11.6.8 Cost Estimate

The Cost Estimate paragraphs for Option B are the same as for Option A, above.

3.3.11.6.9 Schedule for Design and Construction

The Schedule for Design and Construction paragraphs for Option B are the same as for Option A, above.

3.3.11.7 Cost Estimate Summary

The costs for construction and for operations and maintenance of all options are in Tables 3.3.11-2 and 3.3.11-3, shown below. Estimates are comparative-Level "Parametric Type" and are based on Historical Data, Recent Pricing, and Estimator's Judgment. Quantities listed within the estimates represent Major Elements of the Project Scope and were furnished by the Project Delivery Team. Price Level of Estimate is April 07. Estimates excludes project Escalation and HTRW Cost.

Table 3.3.11-2.
Jackson Co Gautier Ring Levee Construction Cost Summary

Option	Total project cost
Option A – Elevation 20 ft NAVD88	$348,300,000
Option B – Elevation 30 ft NAVD88	$450,100,000

Table 3.3.11-3.
Jackson Co Gautier Ring Levee O & M Cost Summary

Option	Cost for O&M
Option A – Elevation 20 ft NAVD88	$3,744,000
Option B – Elevation 30 ft NAVD88	$4,904,000

3.3.11.8 References

US Army Corps of Engineers (USACE) 1987. Hydrologic Analysis of Interior Areas. Engineer Manual EM 1110-2-1413. Department of the Army, US Army Corps of Engineers, Washington, D.C. 15 January 1987.

USACE 1993. Hydrologic Frequency Analysis. Engineer Manual EM 1110-2-1415. Department of the Army, US Army Corps of Engineers, Washington, D.C. 5 March 1993.

USACE 1995. Hydrologic Engineering Requirements for Flood Damage Reduction Studies. Engineer Manual EM 1110-2-1419. Department of the Army, US Army Corps of Engineers, Washington, D.C. 31 January 1995.

USACE 2006. Risk Analysis for Flood Damage Reduction Studies. Engineer Regulation ER 1105-2-101. Department of the Army, US Army Corps of Engineers, Washington, D.C. 3 January 2006.

National Resource Conservation Service (NRCS). 2003. WinTR5-55 User Guide (Draft). Agricultural Research Service. 7 May 2003.

Environmental Science Services Administration. 1968. "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.

Weather Bureau and USACE. 1956. 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.

3.3.12 Jackson County, Pascagoula/Moss Point Ring Levee

3.3.12.1 General

Several high density residential and business areas in Jackson County were identified. They are: Pascagoula/Mosspoint, Gautier, Belle Fontaine, Gulf Park Estates, and Ocean Springs. These are subject to damage from storm surges associated with hurricanes. Earthen ring levees were evaluated for protection of these areas. The levees were evaluated at elevations 20 ft NAVD88 and 30 ft NAVD88. The top width was assumed 15 ft with sideslopes of 1 vertical to 3 horizontal. Each of the levees is presented separately in this report. Additional options not evaluated in detail are described elsewhere in this report.

Evaluation of this option was done by comparing benefits computed by Hydrologic Engineering Center's (HEC) Flood Damage Analysis (FDA) computer application HEC-FDA and costs computed. HEC-FDA modeling was done comparing the study reaches using variations in expected sea-level rise and development. Details regarding the methodology are presented in Section 2.13 of the Engineering Appendix and in the Economic Appendix.

3.3.12.2 Location

The general location of the Pascagoula/Moss Point ring levee in Jackson County is shown below in Figure 3.3.12-1. Four optional alignments are presented. Each has two levee height options. Each one is presented separately. The optional alignments are shown in Figure 3.3.12-2.

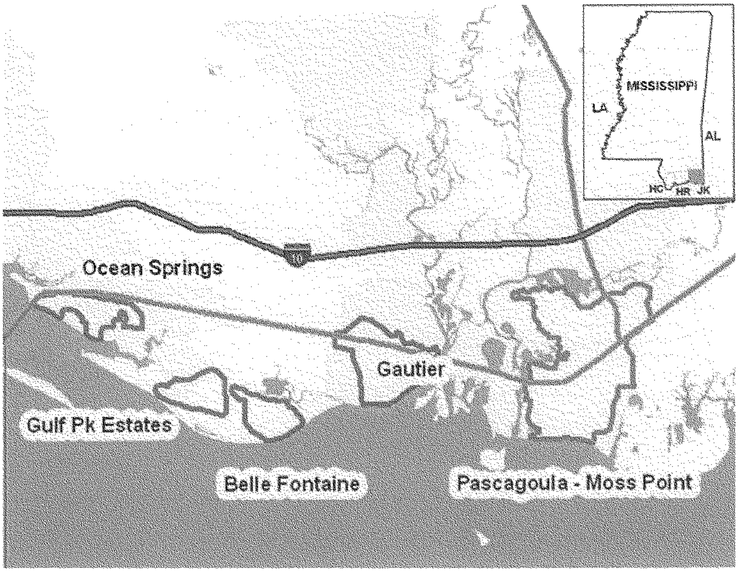


Figure 3.3.12-1. Vicinity Map Pascagoula, MS

The basic alignment is the most extensive and covers the main residential area in Pascagoula and Moss Point.

The Washington Ave. Alternate Alignment is the same as the basic alignment except that the alignment follows Washington Ave. on the southernmost leg of the levee.

The Moss Point Alternate Alignment is the same as the basic alignment except that the alignment follows higher ground on the northernmost part of the levee.

The Combined Washington Ave. and Moss Point Alternate Alignment is the same as the basic alignment except that in includes both the Washington Ave. and the Moss Point modifications on the north and south.

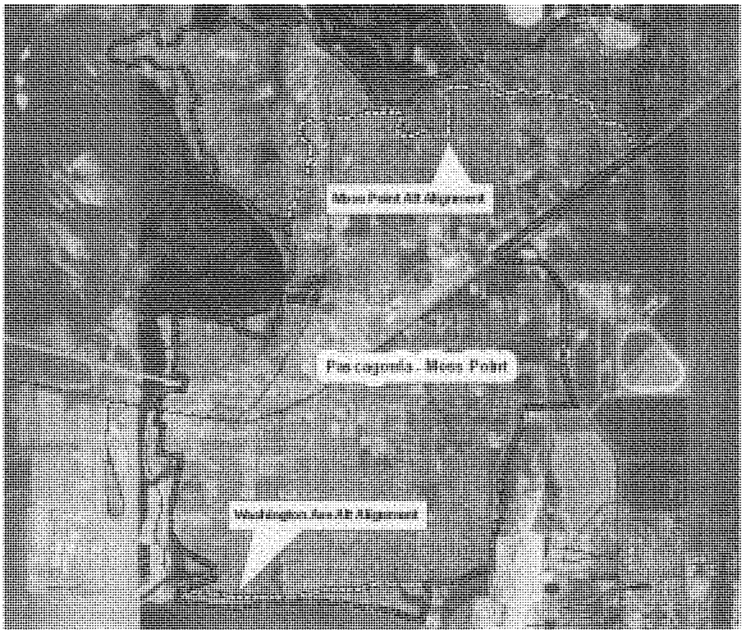


Figure 3.3.12-2. Pascagoula/Moss Point Ring Levees

3.3.12.3 Existing Conditions

The cities of Moss Point and Pascagoula lie at the confluence of the Escatawpa and Pascagoula Rivers along the gulf coast on Mississippi Sound. Both the northern part of Moss Point and the southern part of Pascagoula are very flat. Ground elevations over most of the residential and business areas vary between elevation 10-12 ft NAVD88 in the southern part of the area (Pascagoula) and 14-20 ft NAVD88 in the northern part (Moss Point). The 6-ft(blue), 12-ft(green), 16-ft(brown), and 20-ft(pink) ground contour lines and city limits are shown below in Figure 3.3.12-3.

The cities are drained by natural and some improved channels. These channels drain to the north to the Escatawpa River, the west to the Pascagoula River, to the south to the gulf, and to the east to Grand Bay Swamp, thence to the gulf. All are obviously subject to tidal influence.

Drainage from ordinary rainfall is hindered on occasions when either of the rivers or the gulf is high, but impacts from hurricanes are devastating.

Damage from Hurricane Katrina in August, 2005 in the Pascagoula area are shown below in Figures 3.3.12-4 and 3.3.12-5. Many homes are still un-repaired, pending settlement of insurance claims.

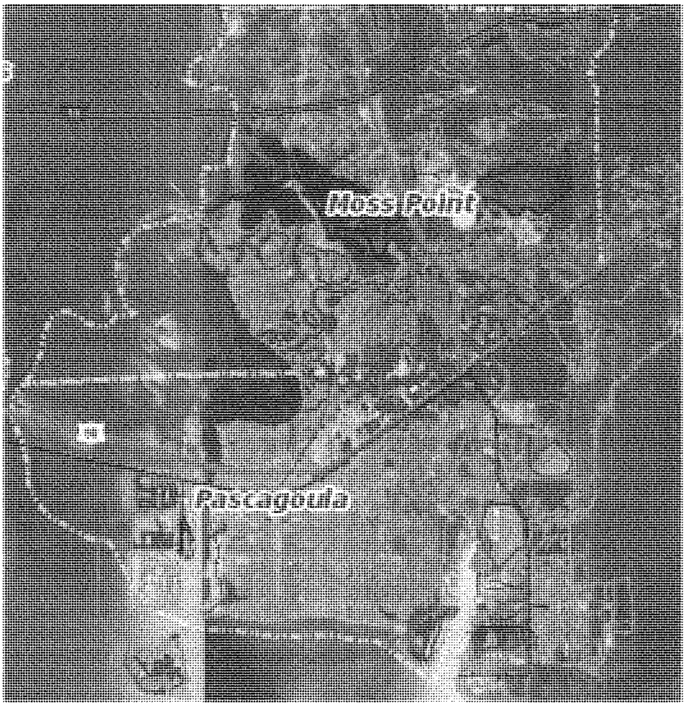
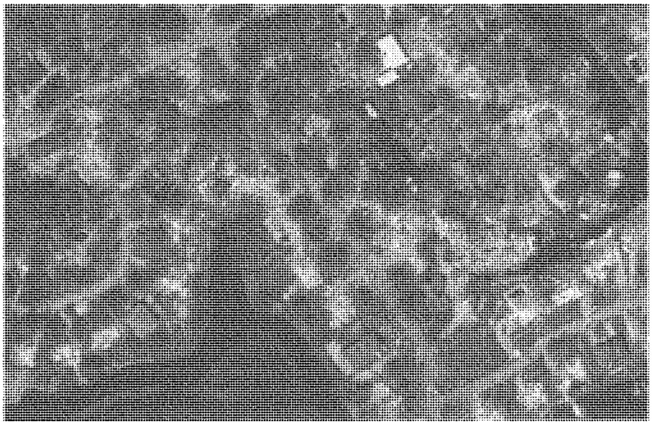


Figure 3.3.12-3. Existing Conditions Pascagoula, MS



Source : http://ngs.woc.noaa.gov/storms/katrina/24330050.jpg

Figure 3.3.12-4. Hurricane Katrina Damage Pascagoula, MS

Source: http://www.wunderground.com/hurricane/Katrinas_surge_part15.asp

Figure 3.3.12-5. Hurricane Katrina Damage Pascagoula, MS

3.3.12.4 Coastal and Hydraulic Data

Typical coastal data are shown in Section 1.4 of this report. High water marks taken by FEMA after Hurricane Katrina in 2005 as well as the 6-ft(blue), 12-ft(green), 16-ft(brown), and 20-ft(pink) ground contour lines and city limits are shown below in Figure 3.3.12-6. The data indicates the Katrina high water was as high as 18-20 ft NAVD88 near the Mississippi Sound at Pascagoula and 12-15 ft NAVD88 in Moss Point.

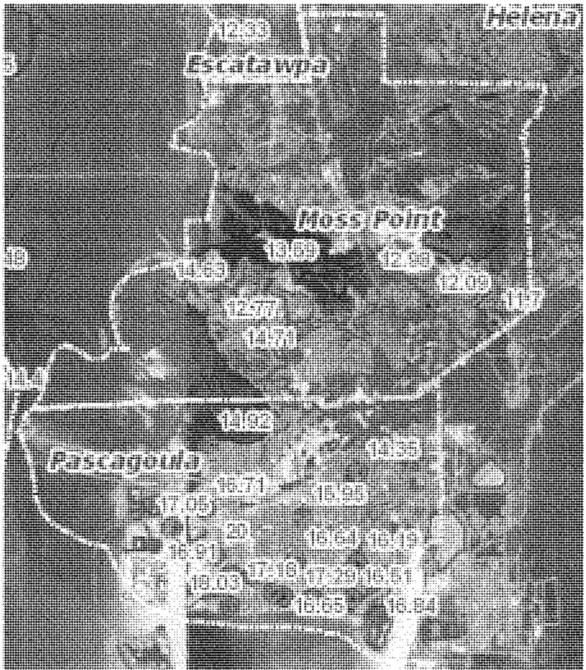


Figure 3.3.12-6. Ground Contours and Katrina High Water Elevations

Stage-Frequency data for a suite of severe storms using Joint Probability Method (JPM) and hydrodynamic modeling were developed by the Engineer Research and Development Center (ERDC) for 80 locations along the study area. These data were combined with historical gage frequencies for smaller storms to establish stage-frequency curves at 54 economic reaches in the study area which were entered into Hydrologic Engineering Center's (HEC) Flood Damage Analysis (HEC-FDA) application to evaluate benefits. An expanded description of the procedure is shown in Section 2.13 of the Engineering Appendix and in the Economic Appendix. Points near Pascagoula at which data from hydrodynamic modeling was saved are shown below in Figure 3.3.12-7.

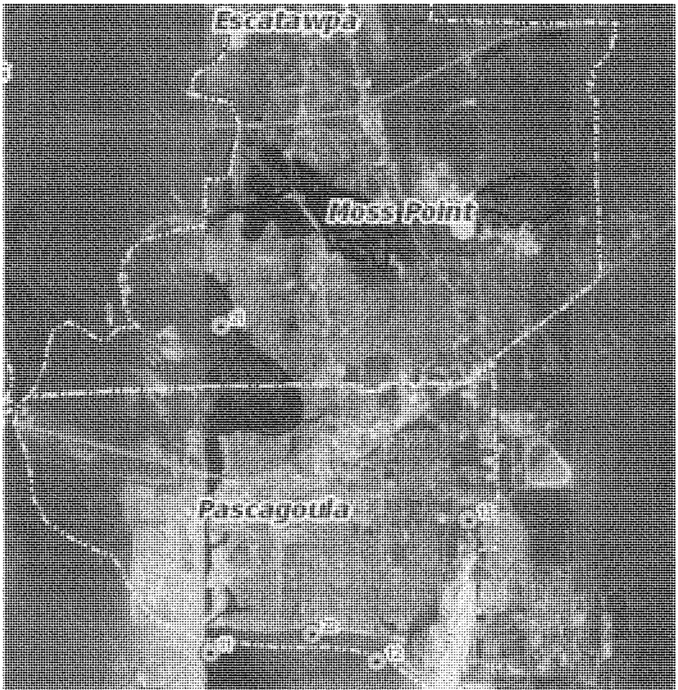


Figure 3.3.12-7. Hydrodynamic Modeling Save Points near Pascagoula

Existing Condition Stage –Frequency data for Save Point 22, just off the coast of Pascagoula, is shown below in Figure 3.3.12-8. The 95% confidence limits, approximately equally to plus and minus two standard deviations, are shown bounding the median curve. The elevations are presented at 100 ft higher than actual to facilitate HEC-FDA computations.

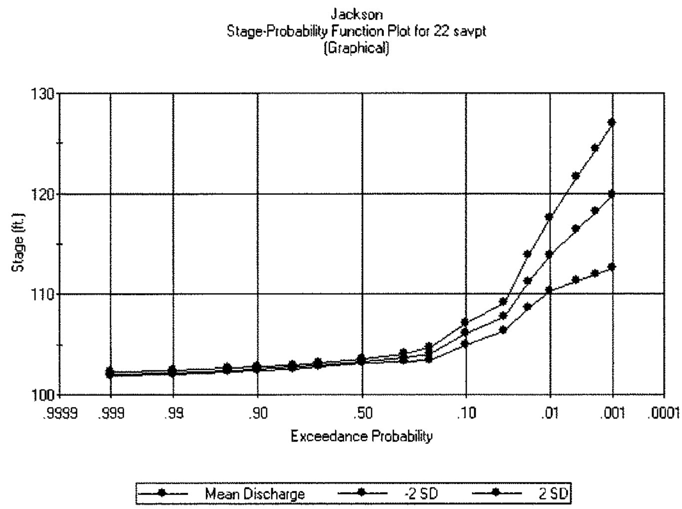


Figure 3.3.12-8. Existing Conditions at Save Point 22, near Pascagoula, MS

3.3.12.5 Option A – Elevation 20 ft NAVD88

This option consists of an earthen dike enclosing an area of 9523 acres around the most densely populated areas of Moss Point and Pascagoula as shown on the following Figure 3.3.12-9, along with the internal sub-basins and levee culvert/pump locations. The levee would have a top width of 15 ft and slopes of 1 vertical to 3 horizontal. A small boat access structure is also shown at the mouth of Basin 20, PG-1 Site. Rising sector gates will be provided at this site allowing shallow draft traffic most of the time. The gates will be closed prior to hurricane storm surge. A drawing of a typical boat access gate is shown in Figure 3.3.12-15.

Damage and failure by overtopping of levees could be caused by storms surges greater than the levee crest as shown in Figure 3.3.12-10.

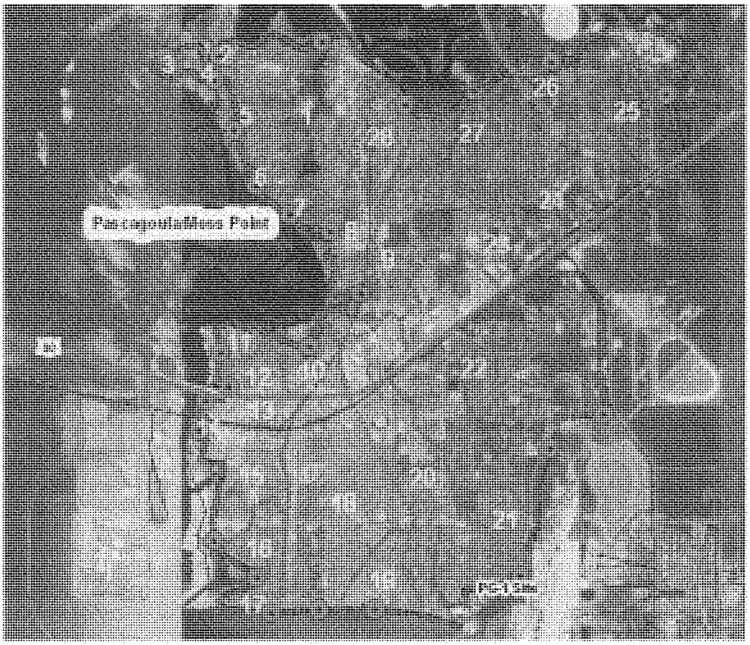
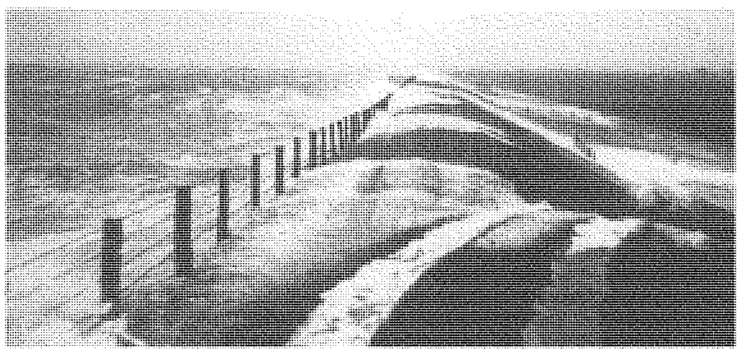


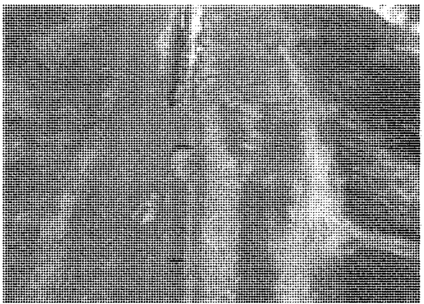
Figure 3.3.12-9. Basic Alignment Pump/Culvert/Sub-basin/Boat Access Site Locations



Source: Wave Overtopping Flow on Seadikes, Experimental and Theoretical Investigations, Holger Schüttrumpf, (Photo:Leichtweiss-Institute) http://kfki.baw.de/fileadmin/projects/E_35_134_Lit.pdf

Figure 3.3.12-10. North Sea, Germany, March 1976

Overtopping failures are caused by the high velocity of flow on the top and back side of the levee. Although significant wave attack on the seaward side of some of the New Orleans levees occurred during Hurricane Katrina, the duration of the wave attack was for such a short time that major damage did not occur from wave action. The erosion shown below in Figure 3.3.12-11 was caused by approximately 1-2 ft of overtopping crest depth.



Source: ERDC, Steven Hughes

Figure 3.3.12-11. Crown Scour from Hurricane Katrina at Mississippi River Gulf Outlet (MRGO) Levee in St. Bernard Parish, New Orleans, LA

Revetment would be included in the levee design to prevent overtopping failure.

The levee would be protected by gabions on filter cloth as shown on Figure 3.3.12-12, extending across a drainage ditch which carries water to nearby culverts and which would also serve to dissipate some of the supercritical flow energy during overtopping conditions.

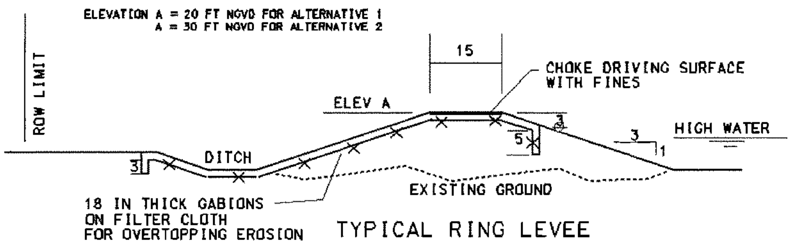


Figure 3.3.12-12. Typical Section at Ring Levee

3.3.12.5.1 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 in Figure 3.3.12-9. 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 3.3.12-13.

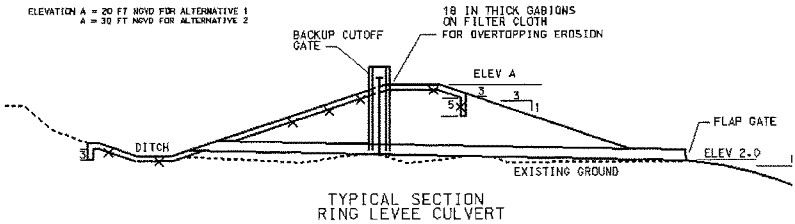


Figure 3.3.12-13. Typical Section at Culvert

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 ring levee into major sub-basins as shown above in Figure 3.3.12-9 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 sub-basins is shown below in Figure 3.3.12-14.

Hydrologic soil group A soils have low runoff potential and high infiltration rates, even with thoroughly wetted and a high rate of water transmission. Hydrologic soil group B soils have moderate infiltration rates when thoroughly wetted and a moderate rate of water transmission. Hydrologic soil group C soils have low infiltration rates when thoroughly wetted and have a low rate of water transmission. Hydrologic soil group C soils have high runoff potential and a very low rate of water transmission.

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. For the culvert design, headwater elevations at the culverts were maintained at an elevation no greater than 5 ft NAVD88 with a tailwater elevation of 2.0 ft NAVD88 assumed. Drainage ditches along the toe of the levee will be required to assure that smaller basins can be drained to a culvert/pump site. These ditches were sized using a normal depth flow computation. Curve numbers, pump, and culvert capacity tables are not included in the report beyond that necessary to obtain a cost estimate. The data are considered beyond the level of detail required for this report.

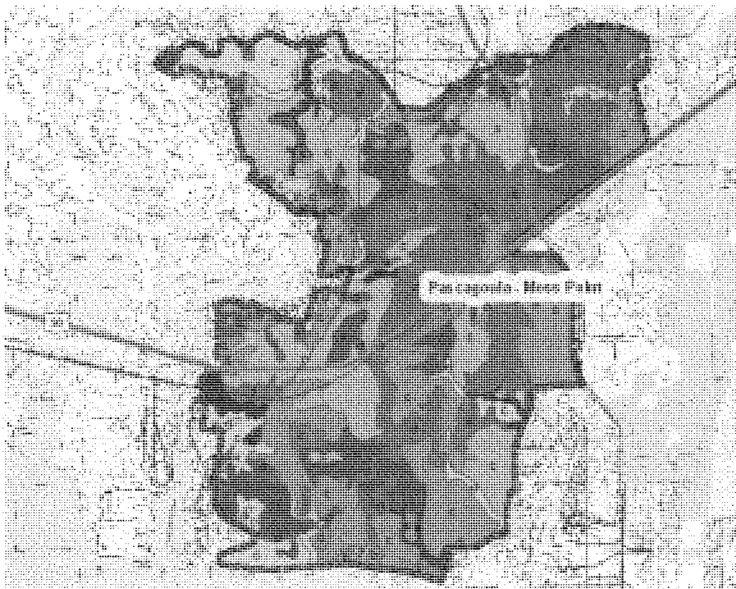


Figure 3.3.12-14. Pascagoula/Moss Point Hydrologic Soil Groups

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. This decision was 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. However, in some of the areas, existing storage could be adequate to pond water without causing damage, even without pumps. In other areas that do have pumps, some rise in interior water during interior events greater than the 10-yr rain could occur, but may not cause damage. Designing the pumps for the peak 10-yr flow provides a significant pumping capacity. Further studies will detail the requirement for the appropriate ponding areas, pump sizes, or buyouts in the affected areas.

During non-hurricane periods of low water in the sound, when rainfall greater than the 25-yr event occurs, the pumps could also be used to augment the flow capacity of the levee culverts.

3.3.12.5.2 Geotechnical Data

Geology: Citronelle formation is found above the Interstate 10 alignment and is a relatively thin unit of fluvial deposits of Plio-Pleistocene age consisting of gravelly sand and silty sand layers. Typically the formation is 30 to 80 feet thick, except where it has filled eroded channels in the underlying formations. The sand in the formation has a variety of colors, often associated with the presence of iron oxides in the form of hematite or goethite. Thin discontinuous clay layers are found in some areas. The iron oxide has occasionally cemented the sand into a friable sandstone, usually occurring only as a localized layer. Within the study area, this formation outcrops north of Interstate 10 and will not be encountered at project sites other than any levees that might extend northward to higher ground elevations.

Prairie formation is found along the rest of the Line 4 alignment within Jackson County. The Prairie formation is found southward of the Citronelle formation and is of Pleistocene age. This formation consists of fluvial and floodplain sediments that extend southward from the outcrop of the Citronelle formation to or near the mainland coastline. Sand found within this formation has an economic value as beach fill due to its color and quality. Southward from its outcrop area, the formation extends under the overlying Holocene deposits out into the Mississippi Sound.

Gulfport Formation is found along the coastline in most of western Jackson County at Belle Fontaine Beach. This formation of Pleistocene age overlies the Prairie formation and is present as well sorted sands that mark the edge of the coastline during the last high sea level stage of the Sangamonian Interglacial period. It does not extend under the Mississippi Sound.

Geotechnical: The inland barrier earthen levee section will have one vertical to three horizontal side slopes with a fifteen foot crest width. All work areas to receive the fill shall be cleared and grubbed of all trees and surface organics and all existing foundations, streets, utilities, etc. will be removed and the subsequent cavities backfilled and compacted. The levee will be constructed of sand clay materials obtained from off site commercial sources, trucked to the work area, placed in thin lifts and compacted to 95 percent of the maximum modified density. The final surface will be armored by the placement of 24 inch thick gabion mattress filled with small stone for erosion protection during an event that overtops the levee. The armoring will be anchored on the front face by trenching and extend across the downstream slope and the 25 foot easement area beyond the toe. The front side of the levee and all non critical surface areas will be subsequently covered by grassing. Road crossings will incorporate small gate structures or ramping over the embankment where the surface elevation is near that of the crest elevation. The elevation relationship of the crest and the adjacent railroad will be a governing factor. The surfaces will be paved with asphalt and the corresponding drainage will be accommodated. Those areas where the subgrade geology primarily consists of clean sands, seepage underneath the levee and the potential for erosion and instability must be considered. Final designs may require the installation of a bentonite concrete cutoff wall deep within the foundation. This condition will be investigated during any design phase and its requirement will be incorporated.

3.3.12.5.3 Structural, Mechanical and Electrical

Structural, Mechanical, and Electrical data are presented for culverts, pumping facilities and for boat access sites. The sites are shown above in Figure 3.3.12-9.

3.3.12.5.3.1 Culverts

As any flood barrier is constructed the natural groundwater runoff would be inhibited. In order to maintain the natural runoff patterns culverts would be inserted through the protection line at appropriate locations. For this study these were configured as cast-in-place reinforced concrete box structures fitted with flap gates to minimize normal backflows and sluice gates to provide storm closure when needed. The shear number of these structures that would be required throughout the area covered by this study would dictate that an automated system be incorporated whereby the gates could be monitored and operated from some central location within defined districts. Detailed design of these monitoring and operating systems is beyond the scope of this study, however a parametric cost was developed for each site and included in the estimated construction cost for these facilities.

3.3.12.5.3.2 Pumping Facilities Structural

The layout of each pumping facility was made in conformance with Corp of Engineers Guidance document EM 1110-2-3105, Mechanical and Electrical Design of Pumping Stations. The basic plant dimensions for each site were set using approximate dimensions derived based on specific pump data (pump impeller diameter, pump bell bottom clearance, etc.). Each facility was roughly fitted to its site using existing ground elevations taken from available mapping and height of levee data. In every case the top of the pump floor was required to be above the 100 year flood elevation. Nominal sidewall and sump and pump floor thicknesses were assumed, along with wall and roof thicknesses for the pump room enclosure. Using these basic dimensions and the preliminary number and size of pumping units determined for each site, the overall plant footprint and elevations were set and quantities of basic construction materials computed. The pumping plants were configured, to the greatest extent possible with the data provided, to provide multiple pumps at each site.

Discharge piping for each plant was estimated using over the levee piping with one pipe per pumping unit. For estimating purposes the piping was sized to match the pump diameter. Each pipe was extended approximately 25 feet beyond the toe of the embankment on the discharge end to allow for energy dissipation features to be incorporated into the pipe discharge.

At the discharge end of the piping a heavy mat of grouted riprap was added as protection for the levee slope and immediately adjacent area. In each case the 4-foot deep stone mat was estimated as extending 30 feet up the levee slope and 50 feet out from the levee toe for a total width of 80 feet. The lateral extent was estimated at 10 feet per discharge pipe.

3.3.12.5.3.3 Pumping Facilities Mechanical

Vertical shaft pumps were used for all of the pumping facilities. Preliminary mechanical design of the required pumping equipment was made by adaptation of manufacturer's stock pumping equipment to approximate hydraulic head and flow data developed for each pumping location. This data was coordinated with a pump manufacturer who supplied a cross check of the pump selections and cost data for use in preparation of project construction cost estimates. In consideration of the primary purpose which this equipment would serve, and in light of the widespread unavailability of electric power during and immediately after a major storm, it was determined that the pumps should be diesel engine driven.

3.3.12.5.3.4 Pumping Facilities. Electrical

The electrical design for these facilities would consist primarily of providing station power for the facilities. For each of the sites this would include installation of Power Poles, Cable, Power Pole Terminations, miscellaneous electrical appurtenances, and an Electrical 30 kW Diesel Generator Set for backup power.

Because of the number of pumping facilities involved and the need to closely control the pumping operations over a large area, a system of several operation and monitoring stations would be required from which the pumping facilities could be started and their operation monitored during and immediately following a storm event. The detailed design of this monitoring and operation system is beyond the scope of this study, however a parametric estimate of the cost involved in developing and installing such a system was made and included in the estimate of construction costs for these facilities.

3.3.12.5.3.5 Pumping Stations. Flow and Pump Sizes

The design hydraulic heads derived for the 28 facilities included in the Pascagoula-Mosspoint Ring Levee system for the elevation 20 protection level varied from approximately 10 to 20 feet and the corresponding flows required varied from 24,200 to 860,900 gallons per minute. The plants thus derived varied in size from a plant having one 42-inch diameter, 290 horsepower pump, to one including 10, 54-inch diameter pumps each running at 420 horsepower.

3.3.12.5.3.6 Boat Access Structure

At Site PG-1 the ring levee alignment would cross a moderately sized water course where it is apparent that boats currently traverse the area. (See Figures 3.3.12-9 above and Figure 3.3.12-15 and Table 3.3.12-1, below). To allow continued free boat access to the areas behind the levee this site was fitted with a scaled down adaptation of the larger rising sector gate structure used for the bay barriers at Biloxi and Bay Saint Louis. This structure would, for the most part, be much smaller and lighter than those used in the bays, however it would be substantial. The operation would be similarly critical in time of storm and they would require the same attention from an Operations and Maintenance standpoint as their larger, heavier counterparts.

3.3.12.5.3.7 Boat Access Structure. Mechanical. Option A

The mechanical equipment and operating system for these structures would be similar to those used for the bay barriers, and would include steel gate linkages and hydraulic rams and pivot pins for operation of the gates. Each gate would rotate on large bearings and pivot hubs at the ends of the gate. Various operating hydraulic and lubrication oil systems would also be required. It is estimated that each gate would have a maximum opening/closing time of 15 minutes.

3.3.12.5.3.8 Boat Access Structure. Electrical

Primary electrical power for operating these gates would be provided using dedicated, standard transformers with emergency back-up generators. The electrical load demand at these facilities would be low by comparison to the bay barrier structures. The supplemental generation aspect was considered to be a vital component of the design because of the very high cost of commercial standby power and because commercial electric power would almost certainly be unavailable during and immediately following a storm event.

3.3.12.5.3.9 Mechanical and Electrical. Roadways

At each point where a roadway crosses the protection line the decision must be made whether to maintain this artery and adapt the protection line to accommodate it, or to terminate the artery at the protection line and divert traffic to cross the protection line at another location. For this study it was assumed that all roadways and railways crossing the levee alignment would be retained except where it was very evident that traffic could be combined without undue congestion.

Once the decision has been made to retain a particular roadway, it must then be determined how best to configure the artery to conduct traffic across the protection line. The simplest means of passing roadway traffic is to ramp the roadway over the protection line. This alternative is not always viable because of severe right-of-way restraints caused by extreme levee height, urban congestion, etc. In such instances other methods can be used including partial ramping in combination with low profile roller gates. In more restricted areas full height gates which would leave the roadway virtually unaltered might be preferable, even though this alternative would usually be more costly than ramping. In some extreme circumstances where high levees are required to pass through very congested areas, installation of tunnels with closure gates may be required.

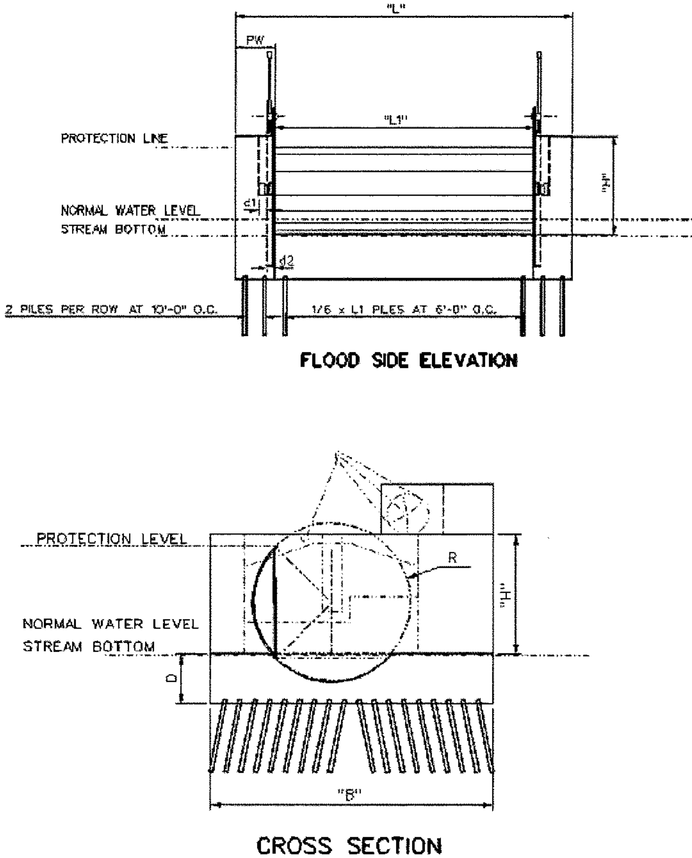


Figure 3.3.12-15. Typical Small Boat Access Structure

Table 3.3.12-1.
Boat Access Structure Dimensional Data by Site

Site Designation	Protection Elevation, ft NAVD88	L1 ft	PW ft	H ft
PG-1	20.0	75	18	29.5

Some economy could probably be achieved in this effort by combining smaller arteries and passing traffic through the protection line in fewer locations. However, in most instances this would involve detailed traffic routing studies and designs that are beyond the scope of this effort. These studies would be included in the next phase of the development of these options, should such be warranted.

3.3.12.5.3.10 Railways

Because of the extreme gradient restrictions necessarily placed on railway construction, it is practically never acceptable to elevate a railway up and over a levee. Therefore, the available alternatives would include gated pass through structures. Because of the vertical clearance requirements of railroad traffic all railroad pass through structures for this study were configured having vertical walls on either side of the railway with double swing gates extending to the full height of the levee.

3.3.12.5.3.11 Levee and Roadway/Railway Intersections

With the installation of a ring levee around the Pascagoula-Moss Point areas to elevation 20, 68 roadway/railway intersections would have to be accommodated. For this study it was estimated that 29 roller gate structures and 35 swing gate structures would be required at the points where roadways would cross the protection line. In addition, 8 railroad gate structures would be required.

3.3.12.5.4 HTRW

Due to the extent and large number of real estate parcels along with the potential for re-alignment of the structural aspects of this project, no preliminary assessment was performed to identify the possibility of hazardous waste on the sites. These studies will be conducted during the next phase of work after the final siting of the various structures. The real estate costs appearing in this report therefore will not reflect any costs for remediation design and/or treatment and/or removal or disposal of these materials in the baseline cost estimate.

3.3.12.5.5 Construction Procedures and Water Control Plan

The construction procedures required for this option are similar to general construction in many respects in that the easement limits must be established and staked in the field, the work area cleared of all structures, pavements, utilities, trees, organics, etc. and the foundation prepared for the new work. Where the levee alignment crosses the existing streams or narrow bays, the alignment base shall be created by displacement with layers of crushed stone pushed ahead and compacted by the placement equipment and repeated until a stable platform is created. The required drainage culverts or other ancillary structures can then be constructed. The control of any surface water will be handled by temporary sheetpile cofferdams and pumping. The control of groundwater will be a series of wellpoints systems designed to keep the excavations dry to a depth and width sufficient to install the new work.

3.3.12.5.6 Project Security

The Protocol for security measures for this study has been performed in general accordance with the Risk Assessment Methodology for Dams (RAM-D) developed by the Interagency Forum for

Infrastructure Protection (IFIP). This methodology has been used for physical security for the critical infrastructure throughout the Corps of Engineers. The determination of the level of physical security provided for each facility is based on the following critical elements: 1) threat assessment of the likelihood that an adversary will attack a critical asset, 2) consequence assessment should an adversary be successful in disrupting, disabling or destroying the asset and 3) effectiveness to prevent a successful attack against an operational component.

Three levels of physical security were selected for use in this study:

Level 1 Security provides no improved security for the selected asset. This security level would be applied to the barrier islands and the sand dunes. These features present a very low threat level of attack and basically no consequence if an attack occurred and is not applicable to this option.

Level 2 Security applies standard security measures such as road barricades, perimeter fencing, and intrusion detection systems for unoccupied buildings and vertical structures and security lighting. The intrusion detection systems will be connected to the local law enforcement office for response during an emergency. Facilities requiring this level of security would possess a higher threat level than those in Level 1 and would include assets such as levees, access roads and pumping stations.

Level 3 Security includes all of the features of Level 2 plus enhanced security measures such as the use of video cameras for real-time monitoring of the facility, monitors, motion detectors and alarm sound system in the occupied control buildings. Facilities requiring this level of security would possess the highest threat level of all the critical assets. Boat access gates and power plants would require this level of security.

3.3.12.5.7 Operation and Maintenance

Operation and maintenance activities for this project will be required on an annual basis. All pumps and gates will be operated to assure proper working order. Debris and shoaled sediment will be removed. Vegetation on the levees will be cut to facilitate inspection and to prevent roots from causing weak levee locations. Rills will be filled and damaged revetment will be repaired. Scheduled maintenance should include periodic greasing of all gears and coupled joints, maintaining any battery backup systems, and replacement of standby fuel supplies.

3.3.12.5.8 Cost Estimate

The costs for the various options included in this measure are presented in Section 3.3.12.13, Cost Summary. Construction costs for the various options are included in Table 3.3.12-2 and costs for the annualized Operation and Maintenance of the options are included in Table 3.3.12-3. Estimates are comparative-Level "Parametric Type" and are based on Historical Data, Recent Pricing, and Estimator's Judgment. Quantities listed within the estimates represent Major Elements of the Project Scope and were furnished by the Project Delivery Team. Price Level of Estimate is April 07. Estimates excludes project Escalation and HTRW Cost. The construction costs include real estate, engineering design (E&D), construction management, and contingencies. The E&D cost for preparation of construction contract plans and specifications includes a detailed contract survey, preparation of contract specifications and plan drawings, estimating bid quantities, preparation of bid estimate, preparation of final submittal and contract advertisement package, project engineering and coordination, supervision technical review, computer costs and reproduction. Construction Contingency developed and assigned at 25% to cover the Cost Growth of the project.

3.3.12.5.9 Schedule for Design and Construction

After the authority for the design has been issued and funds have been provided, the design of these structures will require approximately 12 months including comprehensive plans and specifications, independent reviews and subsequent revisions. The construction of this option should require in excess of two years.

3.3.12.6 Option B – Elevation 30 ft NAVD88

This option consists of an earthen levee around the most populated areas of Pascagoula and Moss Point. The alignment of the levee is the same as Option A, above, and is not reproduced here. The only difference between the description of this option and preceding description of Option A is the height of the levee, pumping facilities, and the length of the levee culverts. Other features and methods of analysis are the same.

3.3.12.6.1 Interior Drainage

Interior drainage analysis and culverts are the same as those for Option A, above, except that the culvert lengths through the levees would be longer.

3.3.12.6.2 Geotechnical Data

The Geology and Geotechnical paragraphs for Option B are the same as for Option A, above.

3.3.12.6.3 Structural, Mechanical and Electrical

These data are the same as that presented for Option A and is not reproduced here. The only difference between the description of this option and preceding description of Option A is the height of the levee, pumping facilities, number of roadway and railroad intersections, and the length of the levee culverts. Culvert length variations are not presented but are incorporated into the cost estimate. The other data for Option B is presented below.

3.3.12.6.3.1 Pumping Stations. Flow and Pump Sizes. Option B

The design hydraulic heads derived for the 28 facilities included in the Pascagoula-Mosspoint Ring Levee system for the elevation 30 protection level varied from approximately 20 to 30 feet and the corresponding flows required varied from 24,200 to 860,900 gallons per minute. The plants thus derived varied in size from a plant having one 42-inch diameter, 475 horsepower pump, to one including 10, 54-inch diameter pumps each running at 775 horsepower.

3.3.12.6.3.2 Levee and Roadway/Railway Intersections. Option B

With the installation of a ring levee around the Pascagoula-Moss Point areas to elevation 30, 79 roadway intersections would have to be accommodated. For this study it was estimated that 1 roller gate structure and 73 swing gate structures would be required at the points where roadways would cross the protection line. In addition, 5 railroad gate structures would be required.

3.3.12.6.4 HTRW

The HTRW paragraphs for Option B are the same as for Option A, above.

3.3.12.6.5 Construction and Water Control Plan

The Construction and Water Control paragraphs for Option B are the same as for Option A, above.

3.3.12.6.6 Project Security

The Project Security paragraphs for Option B are the same as for Option A, above.

3.3.12.6.7 Operation and Maintenance

The Operation and Maintenance paragraphs for Option B are the same as for Option A, above.

3.3.12.6.8 Cost Estimate

The Cost Estimate paragraphs for Option B are the same as for Option A, above.

3.3.12.6.9 Schedule for Design and Construction

The Schedule for Design and Construction paragraphs for Option B are the same as for Option A, above.

3.3.12.7 Option C – Washington Ave. Alternate Alignment, Elevation 20 ft NAVD88

This option consists of an earthen levee enclosing an area of 9350 acres around the most populated areas of Pascagoula and Moss Point. The alignment of the levee is the same as Option A, above, except that is follows Washington Avenue on the south leg of the levee. The alignment is shown below in Figure 3.3.12-16.

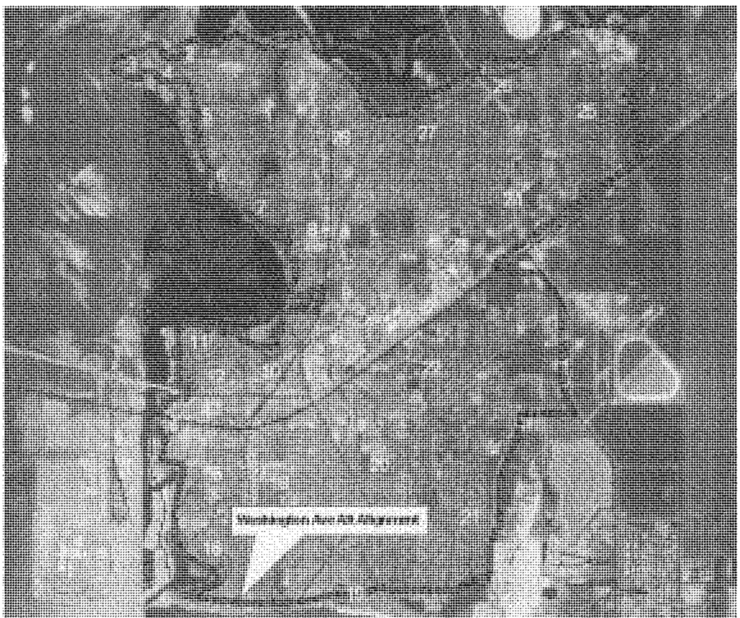


Figure 3.3.12-16. Washington Ave Alternate Alignment Pump/Culvert/Sub-basin/Boat Access Site Locations

3.3.12.7.1 Interior Drainage

Interior drainage analysis and culverts are the same as those for Option A, above, except that the culvert lengths through the levees would be longer.

3.3.12.7.2 Geotechnical Data

The Geology and Geotechnical paragraphs for Option C are the same as for Option A, above.

3.3.12.7.3 Structural, Mechanical and Electrical

The only difference between the description of this option and preceding description of Option A is the alteration of the levee alignment to roughly follow Washington Avenue. This variance occasioned changes to the pumping requirements and facilities for the sub-basins 16-20 on the south leg of the levee, and alteration of the number of roadway and railroad intersections. This changed data for Option C is presented below.

3.3.12.7.3.1 Pumping Stations. Flow and Pump Sizes. Option C

The design hydraulic heads derived for the facilities included in the Pascagoula-Mosspoint Option C Ring Levee system for the elevation 20 protection level varied from approximately 10 to 20 feet and the corresponding flows required varied from 171,578 to 490,124 gallons per minute. The plants thus derived varied in size from a plant having three 48-inch diameter, 340 horsepower pump, to one including seven 54-inch diameter pumps each running at 290 horsepower.

3.3.12.7.3.2 Levee and Roadway/Railway Intersections. Option C

With the installation of a ring levee around the Pascagoula-Moss Point areas to elevation 20 and the inclusion of the Washington Avenue alignment, 76 roadway intersections would have to be accommodated. For this study it was estimated that 24 roller gate structures and 108 swing gate structures would be required at the points where roadways would cross the protection line. In addition, 14 railroad gate structures would be required.

3.3.12.7.4 HTRW

The HTRW paragraphs for Option C are the same as for Option A, above.

3.3.12.7.5 Construction and Water Control Plan

The Construction and Water Control paragraphs for Option C are the same as for Option A, above.

3.3.12.7.6 Project Security

The Project Security paragraphs for Option C are the same as for Option A, above.

3.3.12.7.7 Operation and Maintenance

The Operation and Maintenance paragraphs for Option C are the same as for Option A, above.

3.3.12.7.8 Cost Estimate

The Cost Estimate paragraphs for Option C are the same as for Option A, above.

3.3.12.7.9 Schedule for Design and Construction

The Schedule for Design and Construction paragraphs for Option C are the same as for Option A, above.

3.3.12.8 Option D – Washington. Alternate Alignment, Elevation 30 ft NAVD88

This option consists of an earthen levee around the most populated areas of Pascagoula and Moss Point. The alignment of the levee is the same as Option C, above, and is not reproduced here. The only difference between the description of this option and preceding description of Option C is the height of the levee, pumping facilities, and the length of the levee culverts. Other features and methods of analysis are the same.

3.3.12.8.1 Interior Drainage

Interior drainage analysis and culverts are the same as those for Option C, above, except that the culvert lengths through the levees would be longer.

3.3.12.8.2 Geotechnical Data

The Geology and Geotechnical paragraphs for Option D are the same as for Option A, above.

3.3.12.8.3 Structural, Mechanical and Electrical

The only difference between the description of this option and preceding description of Option C is the height of the levee and the resulting differences in the required pumping facilities, number of roadway and railroad intersections, the length of the levee culverts, and the exclusion of the Boat Access Structure. The changed data for Option D is presented below.

3.3.12.8.3.1 Pumping Stations. Flow and Pump Sizes. Option D

The design hydraulic heads derived for the 6 facilities included in the Pascagoula-Mosspoint Ring Levee system for the elevation 30 protection level varied from approximately 20 to 30 feet and the corresponding flows required varied from 171,578 to 490,124 gallons per minute. The plants thus derived varied in size from a plant having three 48-inch diameter, 600 horsepower pumps, to one including five 60-inch diameter pumps each running at 1150 horsepower.

3.3.12.8.3.2 Levee and Roadway/Railway Intersections. Option D

With the installation of a ring levee around the Pascagoula-Moss Point areas to elevation 30, 87 roadway intersections would have to be accommodated. For this study it was estimated that 1 roller gate structure and 180 swing gate structures would be required at the points where roadways would cross the protection line. In addition, 18 railroad gate structures of varying height would be required.

3.3.12.8.4 HTRW

The HTRW paragraphs for Option D are the same as for Option A, above.

3.3.12.8.5 Construction and Water Control Plan

The Construction and Water Control paragraphs for Option D are the same as for Option A, above.

3.3.12.8.6 Project Security

The Project Security paragraphs for Option D are the same as for Option A, above.

3.3.12.8.7 Operation and Maintenance

The Operation and Maintenance paragraphs for Option D are the same as for Option A, above.

3.3.12.8.8 Cost Estimate

The Cost Estimate paragraphs for Option D are the same as for Option A, above.

3.3.12.8.9 Schedule for Design and Construction

The Schedule for Design and Construction paragraphs for Option D are the same as for Option A, above.

3.3.12.9 Option E – Moss Point Alternate Alignment, Elevation 20 ft NAVD88

This option consists of an earthen levee enclosing an area of 7535 acres around the most populated areas of Pascagoula and Moss Point. The alignment of the levee is the same as Option A, above, except that is follows a modified alignment through Moss Point on the north leg of the levee. The alignment is shown below in Figure 3.3.12-17.

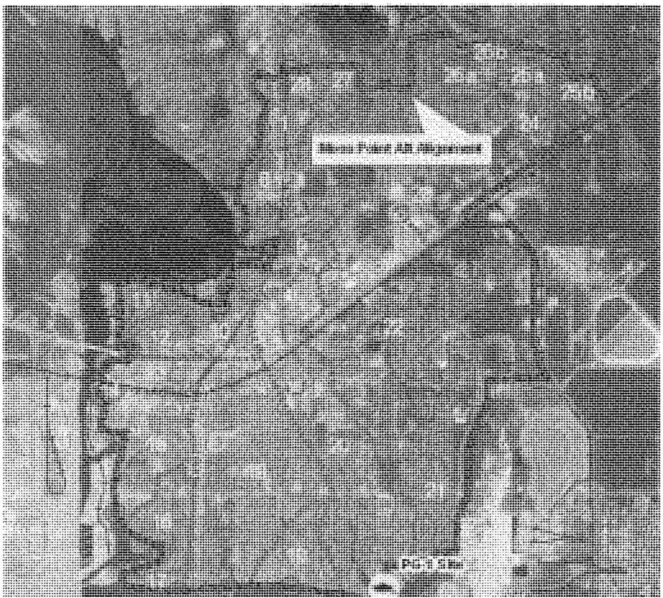


Figure 3.3.12-17. Moss Point Alignment Pump/Culvert/Sub-basin/Boat Access Site Locations

3.3.12.9.1 Interior Drainage

Interior drainage analysis and culvert design methods are the same as those for Option A, above. Culvert/Pump locations are shown in Figure 3.3.12-17, above.

3.3.12.9.2 Geotechnical Data

The Geology and Geotechnical paragraphs for Option E are the same as for Option A, above.

3.3.12.9.3 Structural, Mechanical and Electrical

The only difference between the description of this option and preceding description of Option A is the incorporation of the Moss Point Levee with that for Pascagoula and the resulting variance in the pumping requirements and facilities for the sub-basins on the north leg of the levee and the number of roadway and railroad intersections. The changed data for Option E is presented below.

3.3.12.9.3.1 Pumping Stations. Flow and Pump Sizes. Option E

The design hydraulic heads derived for the facilities included in the Pascagoula-Mosspoint Option E Ring Levee system for the elevation 20 protection level varied from approximately 5 to 20 feet and the corresponding flows required varied from 62,549 to 490,083 gallons per minute. The plants thus derived varied in size from a plant having two 36-inch diameter, 125 horsepower pumps, to one including seven 54-inch diameter pumps each running at 290 horsepower.

3.3.12.9.3.2 Levee and Roadway/Railway Intersections. Option E

With the installation of a ring levee around the Pascagoula-Moss Point areas to elevation 20, 43 roadway intersections would have to be accommodated. For this study it was estimated that 15 roller gate structures and 56 swing gate structures would be required at the points where roadways would cross the protection line. In addition, 10 railroad gate structures would be required.

3.3.12.9.4 HTRW

The HTRW paragraphs for Option E are the same as for Option A, above.

3.3.12.9.5 Construction and Water Control Plan

The Construction and Water Control paragraphs for Option E are the same as for Option A, above.

3.3.12.9.6 Project Security

The Project Security paragraphs for Option E are the same as for Option A, above.

3.3.12.9.7 Operation and Maintenance

The Operation and Maintenance paragraphs for Option E are the same as for Option A, above.

3.3.12.9.8 Cost Estimate

The Cost Estimate paragraphs for Option E are the same as for Option A, above.

3.3.12.9.9 Schedule for Design and Construction

The Schedule for Design and Construction paragraphs for Option E are the same as for Option A, above.

3.3.12.10 Option F – Moss Point Alternate Alignment, Elevation 30 ft NAVD88

This option consists of an earthen levee around the most populated areas of Pascagoula and Moss Point. The alignment of the levee is the same as Option E, above, and is not reproduced here. The only difference between the description of this option and preceding description of Option E is the height of the levee, pumping facilities, and the length of the levee culverts. Other features and methods of analysis are the same.

3.3.12.10.1 Interior Drainage

Interior drainage analysis and culverts are the same as those for Option E, above, except that the culvert lengths through the levees would be longer.

3.3.12.10.2 Geotechnical Data

The Geology and Geotechnical paragraphs for Option F are the same as for Option A, above.

3.3.12.10.3 Structural, Mechanical and Electrical

The primary differences between the description of this option and preceding description of Option A is the incorporation of the Moss Point levee with that for Pascagoula and the increased height of the levee and the resulting changes in the pumping facilities, number of roadway and railroad intersections, and the length of the levee culverts. Culvert length variations are not presented but are incorporated into the cost estimate. The changed data for Option F is presented below.

3.3.12.10.3.1 Pumping Stations. Flow and Pump Sizes. Option F

The design hydraulic heads derived for the 10 facilities included in the Pascagoula-Moss Point Ring Levee system for the elevation 30 protection level varied from approximately 15 to 30 feet and the corresponding flows required varied from 62,549 to 490,083 gallons per minute. The plants thus derived varied in size from a plant having two 36-inch diameter, 250 horsepower pumps, to one including five 60-inch diameter pumps each running at 750 horsepower.

3.3.12.10.3.2 Levee and Roadway/Railway Intersections. Option F

With the installation of a ring levee around the Pascagoula-Moss Point areas to elevation 30, 75 roadway intersections would have to be accommodated. For this study it was estimated that all of these structures would be swing gates. In addition, seven sites with 14 railroad gate structures would be required.

3.3.12.10.4 HTRW

The HTRW paragraphs for Option F are the same as for Option A, above.

3.3.12.10.5 Construction and Water Control Plan

The Construction and Water Control paragraphs for Option F are the same as for Option A, above.

3.3.12.10.6 Project Security

The Project Security paragraphs for Option F are the same as for Option A, above.

3.3.12.10.7 Operation and Maintenance

The Operation and Maintenance paragraphs for Option F are the same as for Option A, above.

3.3.12.10.8 Cost Estimate

The Cost Estimate paragraphs for Option F are the same as for Option A, above.

3.3.12.10.9 Schedule for Design and Construction

The Schedule for Design and Construction paragraphs for Option F are the same as for Option A, above.

3.3.12.11 Option G – Combined Washington Ave and Moss Point Alternate Alignments, Elevation 20 ft NAVD88

This option consists of an earthen levee enclosing an area of 7356 acres around the most populated areas of Pascagoula and Moss Point. The alignment of the levee is the same as Option A, above, except that is follows the same modified alignment along Washington Ave as shown for Options C and D on the south, and the modified alignment in Moss Point as shown for Options E and F along the north leg of the levee. The alignment is shown below in Figure 3.3.12-18.

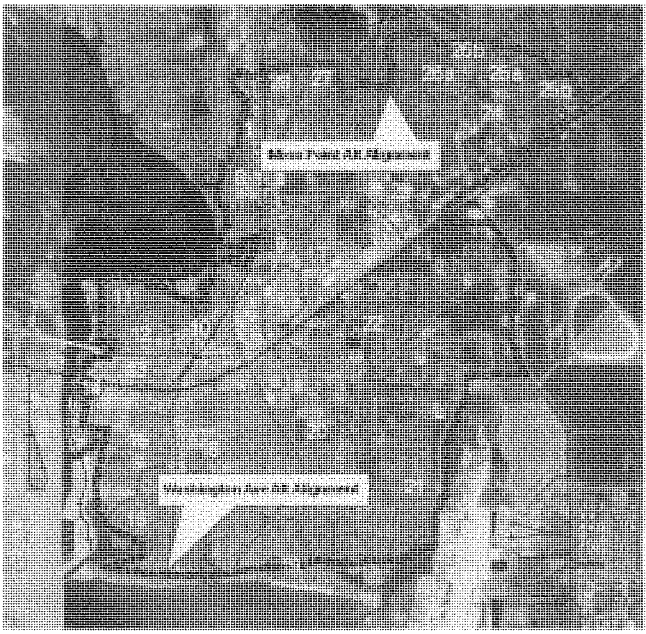


Figure 3.3.12-18. Moss Point Alignment Pump/Culvert/Sub-basin Locations

3.3.12.11.1 Interior Drainage

Interior drainage analysis and culvert design methods are the same as those for Option A, above. Culvert/Pump locations are shown in Figure 3.3.12-18, above.

3.3.12.11.2 Geotechnical Data

The Geology and Geotechnical paragraphs for Option G are the same as for Option A, above.

3.3.12.11.3 Structural, Mechanical and Electrical

The primary differences between the description of this option and preceding description of Option A would be the combination of the Pascagoula with Washington Avenue, and the Moss Point alignments resulting in an variation in the pumping requirements and facilities for the sub-basins on the north leg of the levee, number of roadway and railroad intersections, and the omission of the Boat Access Structure south of the revised alignment. The other data for Option G is presented below.

3.3.12.11.3.1 Pumping Stations. Flow and Pump Sizes. Option G

The design hydraulic heads derived for the facilities included in the Pascagoula-Mosspoint Option G Ring Levee system for the elevation 20 protection level varied from approximately 5 to 20 feet and the corresponding flows required varied from 62,388 to 490,083 gallons per minute. The plants thus derived varied in size from a plant having two 36-inch diameter, 125 horsepower pump, to one including seven 54-inch diameter pumps each running at 750 horsepower.

3.3.12.11.3.2 Levee and Roadway/Railway Intersections. Option G

With the installation of a ring levee around the Pascagoula-Moss Point areas to elevation 20, 48 roadway intersections would have to be accommodated. For this study it was estimated that 15 roller gate structure and 72 swing gate structures would be required at the points where roadways would cross the protection line. In addition, five sites with 10 railroad gate structures would be required.

3.3.12.11.4 HTRW

The HTRW paragraphs for Option G are the same as for Option A, above.

3.3.12.11.5 Construction and Water Control Plan

The Construction and Water Control paragraphs for Option G are the same as for Option A, above.

3.3.12.11.6 Project Security

The Project Security paragraphs for Option G are the same as for Option A, above.

3.3.12.11.7 Operation and Maintenance

The Operation and Maintenance paragraphs for Option G are the same as for Option A, above.

3.3.12.11.8 Cost Estimate

The Cost Estimate paragraphs for Option G are the same as for Option A, above.

3.3.12.11.9 Schedule for Design and Construction

The Schedule for Design and Construction paragraphs for Option G are the same as for Option A, above.

3.3.12.12 *Option H – Combined Washington Ave and Moss Point Alternate Alignment, Elevation 30 ft NAVD88*

This option consists of an earthen levee around the most populated areas of Pascagoula and Moss Point. The alignment of the levee is the same as Option G, above, and is not reproduced here. The only difference between the description of this option and preceding description of Option G is the height of the levee, pumping facilities, and the length of the levee culverts. Other features and methods of analysis are the same.

3.3.12.12.1 Interior Drainage

Interior drainage analysis and culverts are the same as those for Option G, above, except that the culvert lengths through the levees would be longer.

3.3.12.12.2 Geotechnical Data

The Geology and Geotechnical paragraphs for Option H are the same as for Option A, above.

3.3.12.12.3 Structural, Mechanical and Electrical

The primary differences between the description of this option and preceding description of Option A are the incorporation of the Pascagoula with Washington Avenue levee, with that for Moss Point, the change in the height of the levee, and the resulting changes in the pumping facilities, number of roadway and railroad intersections, the length of the levee culverts, and the omission of the Boat Access Structure. Culvert length variations are not presented but are incorporated into the cost estimate. The changed data for Option H are presented below.

3.3.12.12.3.1 Pumping Stations. Flow and Pump Sizes. Option H

The design hydraulic heads derived for the 14 facilities included in the Pascagoula-Mosspoint Ring Levee system for the elevation 30 protection level varied from approximately 15 to 30 feet and the corresponding flows required varied from 62,388 to 490,083 gallons per minute. The plants thus derived varied in size from a plant having two 36-inch diameter, 250 horsepower pumps, to one including five 60-inch diameter pumps each running at 1150 horsepower.

3.3.12.12.3.2 Levee and Roadway/Railway Intersections. Option H

With the installation of a ring levee around the Pascagoula-Moss Point areas to elevation 30, 79 roadway intersections would have to be accommodated. For this study it was estimated that all of these would be swing gate structures. Fourteen railroad gate structures would be required.

3.3.12.12.4 HTRW

The HTRW paragraphs for Option H are the same as for Option A, above.

3.3.12.12.5 Construction and Water Control Plan

The Construction and Water Control paragraphs for Option H are the same as for Option A, above.

3.3.12.12.6 Project Security

The Project Security paragraphs for Option H are the same as for Option A, above.

3.3.12.12.7 Operation and Maintenance

The Operation and Maintenance paragraphs for Option H are the same as for Option A, above.

3.3.12.12.8 Cost Estimate

The Cost Estimate paragraphs for Option H are the same as for Option A, above.

3.3.12.12.9 Schedule for Design and Construction

The Schedule for Design and Construction paragraphs for Option H are the same as for Option A, above.

3.3.12.13 Cost Estimate Summary

The costs for construction and for operations and maintenance of all options are shown in Tables 3.3.12-2 and 3.3.12-3, below. Estimates are comparative-Level "Parametric Type" and are based on Historical Data, Recent Pricing, and Estimator's Judgment. Quantities listed within the estimates represent Major Elements of the Project Scope and were furnished by the Project Delivery Team. Price Level of Estimate is April 07. Estimates excludes project Escalation and HTRW Cost.

Table 3.3.12-2.
Jackson Co Pascagoula/Moss Point Ring Levee Construction Cost Summary

Option	Total project cost
Option A – Elevation 20 ft NAVD88	$699,000,000
Option B – Elevation 30 ft NAVD88	$916,000,000
Option C – Elevation 20 ft NAVD88	$671,600,000
Option D – Elevation 30 ft NAVD88	$849,900,000
Option E – Elevation 20 ft NAVD88	$874,400,000
Option F – Elevation 30 ft NAVD88	$1,013,200,000
Option G – Elevation 20 ft NAVD88	$921,400,000
Option H – Elevation 30 ft NAVD88	$1,057,700,000

Table 3.3.12-3.
Jackson Co Pascagoula/Moss Point Ring Levee O & M Cost Summary

Option	O&M Costs
Option A – Elevation 20 ft NAVD88	$5,719,000
Option B – Elevation 30 ft NAVD88	$8,309,000
Option C – Elevation 20 ft NAVD88	$4,658,000
Option D – Elevation 30 ft NAVD88	$6,707,000
Option E – Elevation 20 ft NAVD88	$3,761,000
Option F – Elevation 30 ft NAVD88	$5,423,000
Option G – Elevation 20 ft NAVD88	$3,537,000
Option H – Elevation 30 ft NAVD88	$5,197,000

3.3.12.14 References

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3.4 Line of Defense 4 – Inland Barrier and Surge Gates

3.4.1 General

To preserve the shoreline environment as much as possible, a 4th line of defense for very large storms is envisioned that would be inland from the coast. This line of defense would be the highest line and could contain a larger storm surge up to that associated with a "Maximum Possible Intensity" (MPI) hurricane. LOD-4 was be modeled as an infinitely high barrier with the screening storms defining a surge elevation against the barrier. The top elevation could then be defined based on selected protection from a selected screening storm. Storms that will be modeled against this line will vary from a Camille type storm up to the MPI. This alignment would follow the same path as the railway that crosses the state near the coast but not cross either the Pearl River to the west or the Pascagoula River to the east.

In order to protect much of the developed areas around Biloxi and St. Louis Bays, LOD-4 would have to include a structural surge barrier that would also cross the mouth of these bays. These surge barriers, when closed, would prevent storm surge from moving in through the inlets of the bays. The structural barriers across the bays could be similar to designs used in Europe for storm surge protection. While many types of barriers were reviewed, the rising sector design used on the Thames River in London, England was selected. This type of structure would allow the least restriction to natural tidal flow and with gates flush with the natural bottom, provide the least environmental concern.

During initial planning, options were discussed that would provide a LOD-4 line of defense, but not include closing off the bays with surge barriers. Due to the topography and the positions of the bays and river systems, the project team collectively decided that to be effective, LOD-4 had to include a barrier across Biloxi Bay, but that St. Louis Bay could possibly be excluded. The location of Biloxi and Gulfport on a narrow coastal ridge with the Sound to the south and the Back Bay of Biloxi to the north would not allow closure for a levee to higher elevations to the north. This would leave any type of significant defense as a high ring levee or seawall following the shorelines of the sound and the bay, something widely opposed in early public meetings. It would also leave many heavily developed areas around the bay subject to surge from any future storms. Considering this for St. Louis Bay provides a different option. There could be an optional alignment that would extend northward from Long beach to a selected higher elevation. This northern extension would follow the general alignment of Menge Avenue north of the railroad. There are two major drainages that would cross along this alternate path that carry floodwaters from rainfall away from the town of Long Beach. These drainages are canals that extend from the headwaters of Turkey Branch southwestward to drain into St. Louis Bay. These drainages may require large pumping stations to prevent the canals from flooding upstream if they were closed off during hurricanes. This revision of LOD-4 would leave most of the area westward from Long Beach without any type of defense from storm surge including the cities of Pass Christian and Bay St. Louis. The inclusion of a ring levee around Bay St. Louis could be added should planners choose to not close off the bay.

The general alignment of line 4 is envisioned along the path of a railway that crosses the coast of Mississippi. In Harrison County, this pathway is through heavily populated and commercial zones. To the east in Jackson County, a decision was made not to cross the Pascagoula River and associated marshes. To do so would have both technical and environmental concerns. Crossing this major river system would create environmental problems as well as interior flooding. Constructing barriers or levees across the marshes will change the surface water flow, restrict tidal exchange and could alter existing salinity conditions leading to major ecosystem changes. Blocking the rivers with surge gates, even for short periods could cause extensive flooding due to water backing up behind the gates during storms as rain falls inland. This could cause more flooding than the storm surge. The Pascagoula River system is also habitat to the endangered Gulf Sturgeon and any approved construction or modifications in the river would be unlikely.

For these reasons, the first major watershed divide west of the Pascagoula River was selected to turn the barrier north and extend it to a location beyond the extent of the storm surge associated with a MPI event. Similarly to the west in Hancock County, LOD-4 follows the railway to a watershed divide that is located east of the Pearl River where it follows the divide north to the MPI line. Both of these northward extensions will cross the path of Interstate 10 and may dictate some modifications to the highway depending on the selected top elevation of the line.

LOD-4 could also be designed to have roadways, even major highways on top if desired. This line would be the highest defense, but would not protect structures seaward from the larger storms that might overtop Line 3. All facilities seaward of Line 4 would be prone to flooding in a large storm, so flood-proofing would be necessary in this zone. As described prior, this barrier would extend from high ground east of the Pearl River to high ground west of the Pascagoula River for a distance of approximately 57 miles. It would not cross either of these river systems.

Like Line 3, interior drainage behind this barrier must also be considered. The watersheds may be large and large rainfall events would require substantial structures designed to allow the water to drain or be pumped over the structure in a storm.

3.4.1.1 Surge Gates

3.4.1.1.1 Literature Research

As the requirements of the MsCIP project studies were developed it became apparent early on that several massive gate structures would be required to protect the large inlets from tidal surges during larger storm events. Initially it was thought that some adaptation of our customary tainter or vertical lift gate assemblies might serve this purpose, but as the water levels to be resisted and the required length of the structures were developed it became apparent that much more massive construction than we had heretofore experienced would be required. This was further complicated by the need to minimize the visual impact, obstruction to vessel traffic, and normal tidal flow.

Our search for a method of construction that would be efficient and effective while optimizing freedom of tide flow and minimizing visual and physical obstruction under normal conditions, led us to the Netherlands, Italy, Russia, and the River Thames in the United Kingdom, where several very massive and large scale projects of this type have been constructed or are presently in the planning stages.

Oosterscheldt Barrier, Netherlands

The Dutch have fought these coastal flooding battles for centuries and, since the major floods suffered in the middle of the 20th century, have made a concerted effort to protect their land and people from the sea's ravages. As a result of these efforts several large and innovative structures have been constructed by the Dutch, using very specialized construction techniques and involving use of conventional construction materials on a massive scale.

The Eastern Scheldt Barrier (the Oosterscheldt Barrier) completed in 1986/87 effectively enclosed the southwest coastline of Holland and Zeeland protecting some 100,000 people from flooding up to the 1:4000 year storm event. The gate structure is three kilometers long, was constructed in three segments, and consists of 65 reinforced concrete pillars ranging from 30.25 to 38.75 meters high, and weighing approximately 18,000 tons each. The gaps between the piers were filled with massive stones precisely placed to form the lower portion of the cutoff. The cutoff was completed by insertion of massive reinforced concrete upper and lower beams and moveable steel gates. The 62 massive steel gates, each 42 meters wide, are of the vertical lift type, operated by vertical overhead mounted hydraulic rams. In the open (raised) position they are suspended between the piers over the North Sea, and in the closed position they bridge vertically between the upper and lower concrete sill beams. The gates vary in height from 6 to 12 meters. The largest weighs approximately 480 tons and takes 82 minutes to close. These gates were designed for a maximum design head differential of 5 meters. The entire barrier, including the levee and gated portions, was constructed at a total cost to the Dutch Government of approximately $8.7 billion (2005 U.S. price level). The annual cost of operation is approximately 13 million dollars. See Figure 3.4.1.1-1 for a picture of these gates and their intended operation.

(Oostescheldekering, Wikipedia, Internet Encyclopedia; The Delta Project, Ministry of Transport, Public Works, and water Management, The Netherlands)

Figure 3.4.1.1-1. Oosterscheldt Barrier, Netherlands

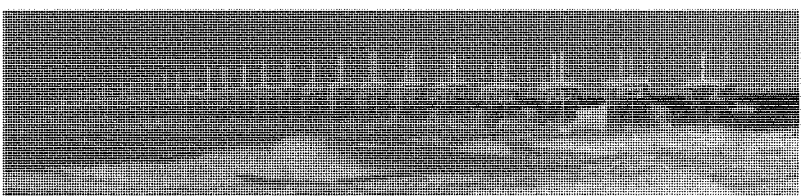
This type design offers several advantages. Under normal conditions the gates are high and dry leaving the structure exposed for ready access for maintenance. The construction method used included prefabricated pier sections constructed in the dry in a series of below sea level construction yards which were eventually flooded allowing the pier sections to be moved into place using specially made ships, then sunk onto previously prepared stone mattress foundations. No foundation pilings were required. The gates can be completely closed/opened in one hour. In considering application of this design for the MsCIP several disadvantages were identified. The gate and pier structures are always in view, extending above the water's surface, an undesirable feature in the locations under consideration. The design head was relatively low when compared to that which might be encountered along the Mississippi Gulf Coast. Because of the water depth at the site the gate sills were constructed to a point well above the sea floor. This has caused definite and identifiable environmental changes in the lakes and inlets inland of the barrier, one of which is marked reduction in salinity resulting in changes in the species of flora and fauna growing in these areas. These changes have adversely affected the commercial fishing industries and other commercial interests.

Maeslant Barrier, Rotterdam, Netherlands

The latest barrier constructed by the Dutch in their long fight against the North Sea tides was the Maeslant Barrier completed in 1997, near the mouth of the Nieuwe Waterweg, the main access to Rotterdam Harbor. This sea port is the second largest in the world, is surrounded by one of the largest industrial areas in Europe, and is home to approximately 1,000,000 people.

This structural marvel consists of two opposing radial sector gates. Each gate is a watertight steel chamber 22 meters high and 210 meters long mounted on two 237-meter long tubular steel space frame radial arms. These arms extend from the protected side of each gate to massive steel ball joints which are embedded in similarly massive concrete foundations in the banks of the Waterweg. These gates move radially, floating from their moorings in concrete lined pocket channels within the opposite banks of the navigation channel to their "closed" position near the canter of the channel. When the gates are within approximately 1.5 meters of each other they are flooded and sink to rest on a concrete sill in the channel bottom. The entire gate operation is controlled by computers and is linked to a highly sophisticated weather monitoring system. The gate closure operation is automatically triggered when the storm surge of 3 meters above normal sea level is predicted for Rotterdam. The entire closing operation, including ship warning and stopping of navigation traffic, takes approximately 5 hours.

The design criteria for this facility dictated that it provide maximum protection against flooding, maintain optimal channel width and depth for navigation, that its operation require a minimum of interruption to navigation traffic, and that it have no overhead obstructions. This structure and its related protection works were designed to protect against the 1:10,000 year flood event. The total construction cost of the barrier was 450-million Euros (about 500 million dollars) and it took approximately six years to build. See Figure 3.4.1.1-2 for picture of these gates in operation.



(Maeslantkering, Wikipedia, Internet Encyclopedia)

Figure 3.4.1.1-2. Maeslant Barrier, Rotterdam, Netherlands

In assessing the adaptation of this design for the MsCIP flood barrier sites the ease and simplicity of operation were noted as plusses. Also the linkage between the barrier operation and the weather monitoring system would be of great value in our area of concern. However, it was also noted that the width of the water opening at both Biloxi and Saint Louis Bays is substantially greater than that required for the Maeslant site. Also, the hydraulic head for which the structure was designed is significantly less than that which would be experienced along the Mississippi Gulf Coast. While the opening width could possibly be restricted using finger dikes and pass-through culverts to maintain the natural ebb and flow of tide water, this would drastically change the appearance of the bay inlets and might greatly restrict the seaward view from the land side. These factors coupled with the requirement that the barrier be designed to withstand considerably greater hydraulic loading than is seen at the Maeslant site, were viewed as great disadvantages to the use of this type of barrier for the MsCIP sites.

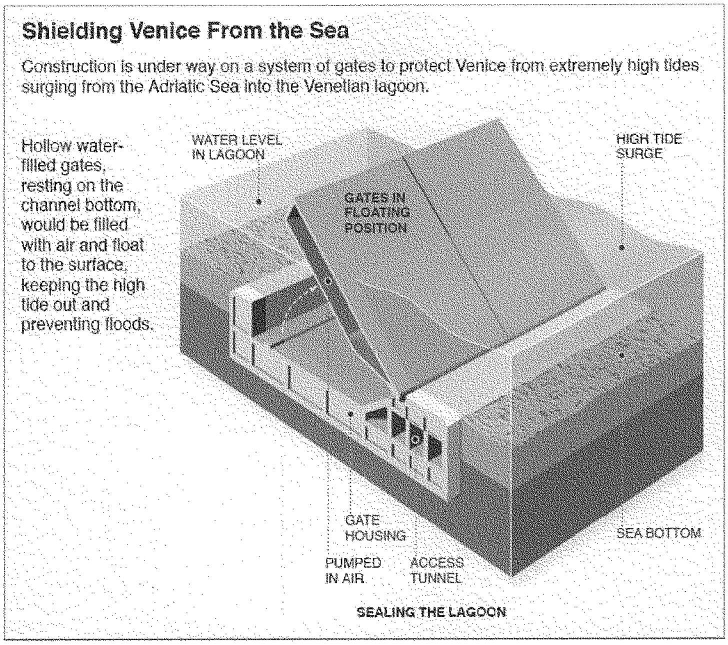
Venice Lagoons

The work done pursuant to addressing flooding problems in Venice, Italy was also cursorily investigated for possible application to the Mississippi Gulf Coast study. This work is still in the investigation and design stages, thus no actual construction details were available. This work would involve the use of "tilt-up" tide gates which would be placed across the lagoon inlets in a string as defense against higher than usual tides. As envisioned for the Venice application these gates would consist of closed hollow chamber gates attached to foundation structures along their seaward edge with hinges. These gates would normally rest filled with water in structure recesses in the sea bottom., They would be raised only when the higher tides are forecast, by injection of air into the hollow gate chambers thus causing the gates to float and hinge upward into their closed position.

The gates designed for the Venice application consisted of 79 separate gate leaves each 20 meters wide providing a total protected length of 1,580 meters configured in three separate groupings. The gates are approximately 30 meters high and were made to retain tides of up to 1.1 meters (approximately 3.6 feet) higher than normal. Further investigation revealed that, as designed, the hinge attachment is the only point of attachment of the gate leaves to the foundation or other structure. The cost estimated for the "Mobile Gates" for the Venice Lagoons in 2004 was approximately $2.7 billion. See Figure 3.4.1.1-3 for graphic depiction of these gates and their intended operation.

(NOVA, Sinking City of Venice, PBS, Internet Transcript; Venice could provide gateway to 21st century flood control method, Denise Brehm, Massachusetts Institute of Technology, 2002, Internet Article)

In order to be functional in a high head situation with gates wide enough to fulfill other project objectives, the gates and structure would have to be designed to resist high lateral loads. The gates would likely need to bear on the structure at the ends of each gate, and the foundations would have to be designed to resist the very large hydraulic loads anticipated. While this design method could possibly be developed to fulfill the needs of our structures, this would have taken considerable work and computation to ascertain the required structure configuration and requirements, much more than the scope of this effort would afford.



Source: Venice turns to the Futureto Rescue its Past, Elisabeth Rosenthal, WITS ARENA

Figure 3.4.1.1-3. Venice Lagoons Flood Barrier, Venice Italy

Thames River Barrier

The Thames River Barrier, Figure 3.4.1.1-4 and 3.4.1.1-5, was constructed during the 1980's to protect portions of historic London and the surrounding area from tidal flooding. At this site there is a naturally wide variation in the "spring tides" resulting in frequent very high tides, the maximum observed to date being +3.2 meters (i.e. 3.2 meters above the normal tide influenced water level). Also at this site storm surges of as much as +3.66 meters have been experienced. In the event that a storm surge equivalent to the maximum experienced to date and a very high spring tide were to occur at the same time, the water level could conceivably reach as much as +6.86 meters at this site. Based on this possibility, the top of the gates at the Thames River barrier was set at +6.9 meters. This elevation is sufficient to fully contain the 100-year flood event which would yield a water elevation of approximately +5.5 meters. The design flood event was estimated as being the 2000-year flood.

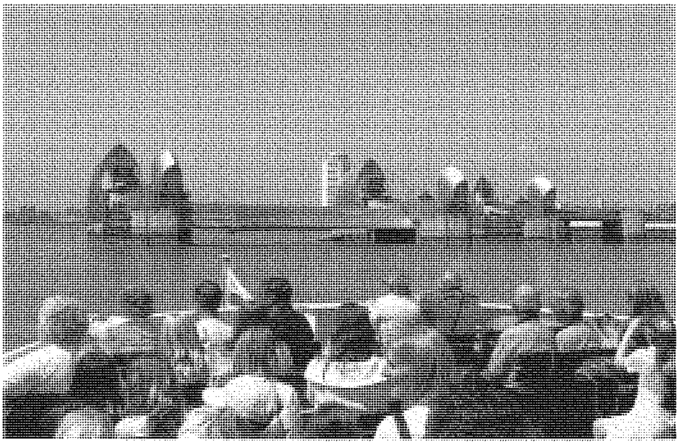


Figure 3.4.1.1-4. Thames River Barrier, Sea Side View

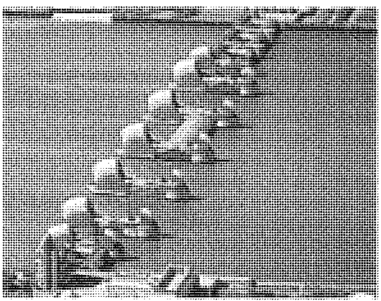


Figure 3.4.1.1-5. Thames River Barrier, Aerial Right Bank View

The Barrier constructed includes a series of reinforced concrete piers and sills, supporting massive steel gates. Each main pier is 11 meters wide and extends to a point slightly above the top of the gates, with the operating machinery and machinery housings mounted atop each pier. Protective and decorative machinery housings were constructed consisting of large curved coverings made of wood and clad with stainless steel. The lowest pier foundations were sunk some 17 meters into the chalk beneath the river bottom.

The barrier includes four main navigation openings measuring 61 meters (approximately 200 feet) in width and two 31.5 meter (approximately 103-foot) openings for passage of smaller vessels. Each of these openings is fitted with a rising sector gate. To allow for free water flow for practically the full width of the river, four more 31.5 meter openings were included each having a falling radial gate, similar to the tainter type gates common to our inland waterway control structures.

The rising sector gates are hollow stainless steel structures with the downriver side curved. Each gate is mounted at either end to large steel disks giving the entire gate structure the appearance of a cut-away cylinder. The gates are supported on trunnion shafts which rotate in bearings mounted in the piers. They are operated by means of reversible hydraulic rams and operating arms mounted on the top of the piers. Under normal conditions the gates lie flat in curved concrete sill recesses in the river bed. Each can be operated upward and stopped at four positions, partially closed (1/8 turn of the disk upward), fully closed (1/4 turn of the disk upward), underspill position (3/8 turn of the disk upward), and maintenance position (1/2 turn of the disk upward). To facilitate operation of the gate the interior of each gate chamber is evacuated of water resulting in a partially buoyant structure.

The sills were set at elevation -9.25 meters and the top of the gates in the fully closed position is +6.9 meters (mean sea level), for an overall protection height of 16.15 meters (approximately 53 feet). The design head for these structures was 6.9 meters (approximately 22.6 feet).

The facilities are operated from a Control Tower located on one bank of the river with a backup control room on the opposite bank. Two service tunnels pass through the foundation of the barrier beneath the river to connect between the two control rooms and to provide power and other utility service access to each pier. In case of extreme emergency each gate can be operated from the individual pier engine rooms. Operating power is provided by three 1.5 MW on-site power generating units, with backup connection to the local electrical grid.

Since its commissioning the Thames River Barrier has been operated 4 to 5 times per year, for a total of 276 times as of 29 April 2002. Each closing cycle takes approximately 15 minutes, though the operation time is greatly extended because of the coordination required with operation of the port facilities.

The Thames River Barrier was constructed between 1972 and 1982 and was formally opened in 1984. The total project construction cost was approximately $760 million. The annual operating and maintenance cost for the Barrier and appurtenant facilities is approximately $13 million.

(Flood London, Thames Barrier: History, Technical Specifications, Why The Barrier is Too Small, Internet articles; Thames Region – Operating the Barrier, Environmental Agency, 2007, Internet Article)

In considering the rising sector gate design for application to the MsCIP barrier structures several points of advantage were identified. Under normal conditions the gates rest out of view at river bottom level. This is appealing in that it would offer a minimum of obstruction to view, to tidal ebb and flow, and to navigation through the structure. The piers, while substantial, are placed wide enough apart that they should be no more obtrusive than the existing bridge structures. The speed of operation would minimize the time the gates would be required to be in place before and after a storm event, and the fact that the gates can be rotated to a full up position for maintenance completely in the dry without installation of unwatering devices or dismantling of the structure is a great maintenance advantage. The maintenance aspect is further enhanced by the fact that the gate surface material is all stainless steel.

Readily observable disadvantages or questionable considerations include the very high construction cost, the relatively small design head required at the Thames River installation as compared to those for the MsCIP sites, the considerably weaker foundation materials existing at the Mississippi Gulf Coast sites, and the relative lengths of the barrier structures required for the MsCIP project sites compared to the Thames River site.

3.4.1.1.2 Design Rationale

The approach to selection of a structural model upon which to base our general design for the MsCIP surge barrier structures was governed by certain basic assumptions and basic criteria:

- The structure must, as completely as possible, block the water surge resulting from the design storm;
- It must be as unobtrusive to view from the sound side or the bay side as possible;
- It must not appreciably alter the natural ebb and flow of water from the Mississippi Sound into/out of the bay areas to be protected;
- It must not appreciably alter the existing navigation of the affected waters by commercial and pleasure craft.

After studying the facilities described above and assessing the features offered by each design approach, along with the associated advantages and disadvantages, it was decided to use the Thames River Barrier model as the basis for the cursory layout and design required for the surge barriers at Biloxi and Saint Louis Bays. A structure layout was made for each bay crossing based on available sounding and water surface information. Uniformity of structure height, gate bay width, and end treatment were used so that one single design might be adapted to each bay crossing.

Preliminary gate designs were made using © STAAD computer modeling, and applying the water pressure and wave action forces based on the prescribed protection levels. Various gate heights were used for each design, as dictated by the protection level under consideration and the configuration of the bay bottom along the route of the surge barrier.

Trial designs were made based on the maximum prescribed protection level and using a 200-foot wide centerline to centerline of pier gate bay and a pier width of 28 feet. The resulting 172-foot wide gates proved to be much too massive, requiring the use of very large structural shapes, very thick covering plate elements, and very closely spaced stiffening frames within the gate proper. The required gate operating disks would have been similarly massive using the 200-foot bay width. This difference form the Thames River gates was primarily caused by the much greater design head possible at the MsCIP sites, amounting to 40 feet at the MsCIP sites, as opposed to approximately 23 feet for the Thames River Site.

The gates were reconfigured using a 160-foot center to center of pier spacing and retaining the 28-foot pier width, resulting in a gate clear width of 132 feet. These gates appeared to be much more reasonable, the framing members required being in the mid range of structural shapes available. It should be noted that these design computations were made purely to obtain rough materials weights upon which to base construction cost estimates. Deflections were not checked, and member connections were not designed. In the event that these facilities were to be designed for construction much more work would be required to bring these gate structures to final design. However, the gate structures arrived at through this effort should provide a good estimate of the materials that would be required to construct such structures.

Once the gate structures were cursorily designed, concrete pier and sill monoliths were laid out and iterative static stability analyses were made to arrive at a structure that would be stable under the applied loading. The foundation bearing pressures resulting from these analyses were above that deemed acceptable for the materials likely to be encountered at these sites. Therefore, as a final design measure, these monoliths were fitted with an array of foundation piles. These piles were battered to resist both vertical and horizontal loading. The resulting materials data are summarized in the tables below, for the various protection levels and resulting monolith configurations.

3.4.1.2 Culverts

As any flood barrier is constructed the natural groundwater runoff would be inhibited. In order to maintain the natural runoff patterns culverts would be inserted through the protection line at appropriate locations. These features would be equipped with gates to provide for closure during extreme storms. The shear number of these structures required throughout the area covered by this study could dictate that some automated system be incorporated whereby the gates could be operated from a series of central locations. From each control point the culverts could be monitored and the sluice gates operated to close off the culverts. Multiple flood protection districts would be set up all along each protection line, each coordinating its efforts with all others.

3.4.1.3 Pumping Stations

The stoppage of normal runoff during storm events would dictate that some means be included by which to evacuate groundwater from behind the protection line during such events. This would be done using pumping stations located at appropriate points along each protection line as described below.

Mechanical. Vertical shaft pumps were used for all of the pumping facilities. Preliminary mechanical design of the required pumping equipment was made by adaptation of manufacturer's stock pumping equipment to approximate hydraulic head and flow data developed for each pumping location. This data was coordinated with a pump manufacturer who supplied a cross check of the pump selections and cost data for use in preparation of project construction cost estimates. In consideration of the primary purpose which this equipment would serve and in light of the widespread unavailability of electric power during and immediately after a major storm it was determined that the pumps should be diesel engine driven. Each engine would be battery started through activation of a float switch and the start-up of the engines would be properly timed to accommodate variations in required pumping volume.

Structural layout of each pumping facility was made in conformance with Corp of Engineers Guidance document EM 1110-2-3105, Mechanical and Electrical Design of Pumping Stations. The basic plant dimensions for each site were set using approximate dimensions derived based on specific pump data (pump impeller diameter, pump bell bottom clearance, etc.). Each facility was roughly fitted to its site using existing ground elevations taken from available mapping and height of levee data. In every case the top of the pump floor was required to be above the 100 year flood elevation. Nominal sidewall and sump and pump floor thicknesses were assumed along with wall and roof thicknesses for the pump room enclosure. Using these basic dimensions and the preliminary number and size of pumping units determined for each site, the overall plant footprint and elevations were set and quantities of basic construction materials computed. The pumping plants were configured, to the greatest extent possible with the data provided, to provide multiple pumps at each site.

Discharge piping for each plant was estimated using over the levee piping with one pipe per pumping unit. For estimating purposes the piping was sized to match the pump diameter. Each pipe was extended approximately 25 feet beyond the toe of the embankment on the discharge end to allow for energy dissipation features to be incorporated into the pipe discharge.

At the discharge end of the piping a heavy mat of grouted riprap was included as protection for the levee slope and immediately adjacent area. In each case the 4-foot deep stone mat was estimated as extending 30 feet up the levee slope and 50 feet out from the levee toe for a total width of 80 feet.

Electrical design for these facilities would consist primarily of providing station power for the facilities. For each of the sites this would include installation of Power Poles, Cable, Power Pole Terminations, miscellaneous electrical appurtenances, and an Electrical 30 kW Diesel Generator Set for backup power.

3.4.1.4 Levee and Roadway/Railway Intersections

Roadways. At each point where a roadway crosses the protection line the decision must be made whether to maintain this artery and adapt the protection line to accommodate it, or to terminate the artery at the protection line and divert traffic to cross the protection line at another location. For this study it was assumed that the majority of roadways and all railways crossing the levee alignment would be retained.

Once the decision has been made to retain a particular roadway, it must then be determined how best to configure the artery to conduct traffic across the protection line. The simplest means of passing roadway traffic is to ramp the roadway over the protection line. This alternative is not always viable because of severe right-of-way restraints caused by extreme levee height, urban congestion, etc. In such instances other methods can be used including partial ramping in combination with low profile roller gates. In more restricted areas full height gates which would leave the roadway virtually unaltered might be preferable, even though this alternative would usually be more costly than ramping. In some extreme circumstances where high levees are required to pass through very congested areas, installation of tunnels with closure gates may be required. See Figures 3.4.1.4-1 and 3.4.1.4-2 for geometric plan representations of typical types of roadway crossing structures. All gates up to and including 9 feet high would be roller gates. All above 9 feet high would be dual leaf swing gates.

Some economy could probably be achieved in this effort by combining smaller arteries and passing traffic through the protection line in fewer locations. However, this would involve detailed traffic routing studies and designs that are beyond the scope of this effort. These studies would be included in the next phase of the development of these options, should such be warranted.

Railways. Because of the extreme gradient restrictions necessarily placed on railway construction, it is practically never acceptable to elevate a railway up and over a levee. Therefore, the available alternatives would include gated pass through structures or much more expensive tunnel structures. Because of the vertical clearance requirements of railroad traffic all railroad pass through structures for this study were configured having vertical walls on either side of the railway with double swing gates extending to the full height of the levee. See Figure 3.4.1.4-3 for geometric plan representation of railroad crossing structures. All railroad gates were assumed to be dual leaf swing gates extending to the full height of levee.

3.4.1.5 Dedicated Flood Barriers

At certain locations there exist properties of vital government interest, extreme historic value, or vital emergency response value in areas where the city congestion would preclude use of levee structures to protect them. As a matter of prudent design these facilities should be removed from the danger zone to a point behind the protection line and where this is possible, this option was followed. However, there are a few instances where removal to a protected area is not desired or expedient. In these instances other structural protection measures would be used as determined by the height of protection required. Generally this protection has been provided using reinforced concrete Tee Walls with sufficient pass through gates to maintain usefulness of the facilities during normal times.

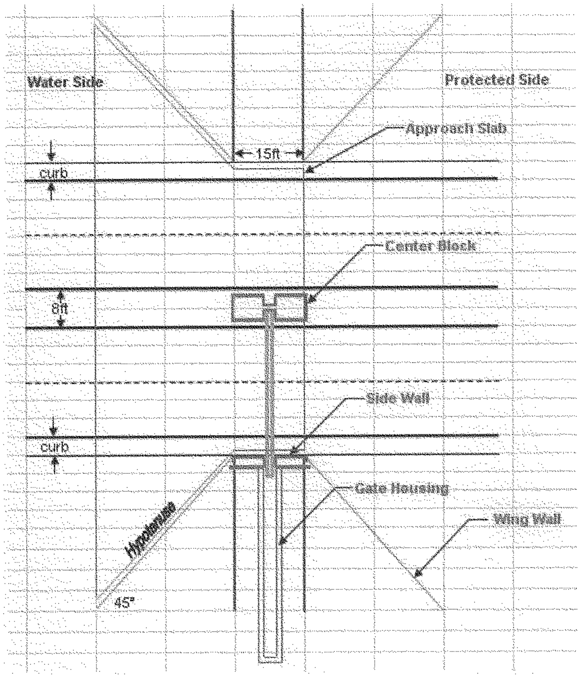


Figure 3.4.1.4-1. Crossings Under 9ft (two lane gate shown; gate and structure would be mirrored to provide for four-lane highway)

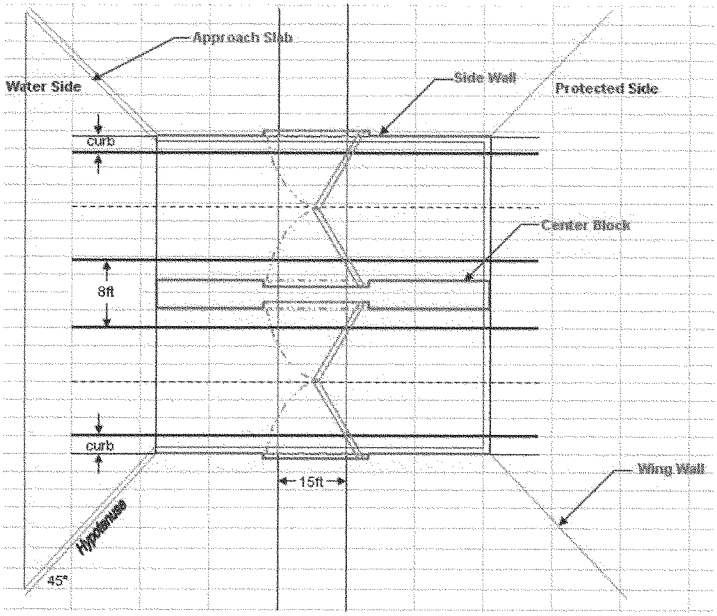


Figure 3.4.1.4-2. Crossing Over 9ft

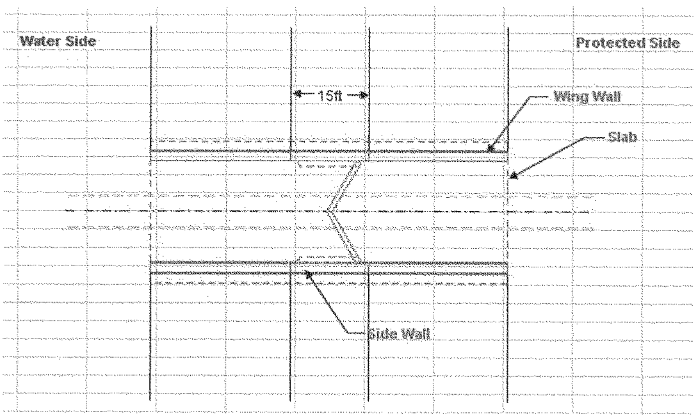


Figure 3.4.1.4-3. Railroad Crossings

3.4.1.6 Operation and Maintenance

3.4.1.6.1 Levee

All levees will require periodic maintenance efforts to include mowing of surface grasses, monitoring of any surface erosion and filling of any resulting cavities. The levees will be periodically monitored for any evidence of subsidence, slope instabilities or seepage.

3.4.1.6.2 Culverts

All culverts penetrating the levee system would have to be periodically and regularly inspected for damage, overgrowth, and sedimentation. The culvert intake and outfall areas would require periodic clearing of vegetation and debris and the surrounding levee slopes and overbanks would have to be kept free of erosion.

The gates and operating mechanisms at each culvert would also require periodic inspection and operation to assure their operability. As planned for this study, all of the culvert gates would be remotely operated. Therefore the periodic maintenance would also cover checks and fine tuning of the remote monitoring and control system. These facilities would require a staff of mechanics and technicians capable of maintaining all mechanical and electrical components in proper working order.

3.4.1.6.3 Pumping Stations

Maintenance of the pumping facilities would require all of the normal civil maintenance activities including clearing of impoundment and outfall areas and general housekeeping activities designed to maintain a workable plant. In addition, the pumps themselves would require periodic inspection and maintenance in keeping with the pump and pump driver manufacturers' warranty requirements. Such requirements would also dictate that each pumping unit be exercised for a minimum duration and a certain number of times during each year. This may pose some degree of difficulty for some of the plants since some were designed almost totally to respond to flood situations. During normal times there may be insufficient inflow to support operation of the pumps, even with the adjacent culverts closed and the normal runoffs collected at the pumps. This difficulty would be addressed in detail in any future study and design work that might be undertaken to refine this system.

3.4.1.6.4 Levee and Roadway/Railway Intersections

These features would require all of the civil maintenance required at the other structures but would in general be more accessible being located along traveled ways. A possible exception to this would be the railway crossings, however these are relatively few and would likely be maintained by railroad personnel. At each of these sites the gates would require lubrication and operation and the gate seals would require periodic inspection and renewal. The gates would be manually operated and would require close coordination with local traffic authorities when any gate movement might be planned.

3.4.1.7 Physical Security

The Protocol for security measures for this study has been performed in general accordance with the Risk Assessment Methodology for Dams (RAM-D) developed by the Interagency Forum for Infrastructure Protection (IFIP). This methodology has been used for physical security for the critical infrastructure throughout the Corps of Engineers. The determination of the level of physical security provided for each facility is based on the following critical elements: 1) threat assessment of the likelihood that an adversary will attack a critical asset, 2) consequence assessment should an adversary be successful in disrupting, disabling or destroying the asset and 3) effectiveness to prevent a successful attack against an operational component.

Three levels of physical security were selected for use in this study.

Level 1 Security provides no improved security for the selected asset. This security level would be applied to the barrier islands and the sand dunes. These features present a very low threat level of attack and basically no consequence if an attack occurred.

Level 2 Security applies standard security measures such as road barricades, perimeter fencing, and intrusion detection systems for unoccupied building and vertical structures and security lighting. The intrusion detection systems will be connected to the local law enforcement office for response during an emergency. Facilities requiring this level of security would possess a higher threat level than those in Level 1 and would include assets such as levees, access roads and pumping stations.

Level 3 Security includes all of the features of Level 2 plus enhanced security measures such as the use of video cameras for real-time monitoring of the facility, monitors, motion detectors and alarm sound system in the occupied control buildings. Facilities requiring this level of security would possess the highest threat level of all the critical assets. The surge barriers located in the bays, manned control buildings, and power plants would require this level of security.

3.4.1.8 References

(Oosteschedekering, Wikipedia, Internet Encyclopedia; The Delta Project, Ministry of Transport, Public Works, and water Management, The Netherlands)

(Maeslantkering, Wikipedia, Internet Encyclopedia)

(NOVA, Sinking City of Venice, PBS, Internet Transcript; Venice could provide gateway to 21st century flood control method, Denise Brehm, Massachusetts Institute of Technology, 2002, Internet Article)

(Flood London, Thames Barrier: History, Technical Specifications, Why The Barrier is Too Small, Internet articles; Thames Region – Operating the Barrier, Environmental Agency, 2007, Internet Article)

EM 1110-2-3105, Mechanical and Electrical Design of Pumping Stations

3.4.2 Hancock County Inland Barrier

3.4.2.1 General

Several high density residential and business areas are located in Hancock County. These are subject to damage from storm surges associated with hurricanes. Earthen levees were evaluated for protection of these areas. The levees were evaluated at elevations 20 ft NAVD88 and 30 ft NAVD88 and 40 ft NAVD88. The top width was assumed 15 ft with side-slopes of 1 vertical to 3 horizontal. Each of the levees is presented separately in this report. Storm surge gates across St Louis are also included to prevent flooding from hurricanes. Additional options not evaluated in detail are described elsewhere in this report.

Evaluation of this option was done by comparing benefits computed by Hydrologic Engineering Center's (HEC) Flood Damage Analysis (FDA) computer application HEC-FDA and costs computed. HEC-FDA modeling was done comparing the study reaches using variations in expected sea-level rise and development. Details regarding the methodology are presented elsewhere in this report.

3.4.2.2 Location

The location of the levee in Hancock County is shown in Figures 3.4.2-1 through 3.4.2-4 parallel to the CSX Railroad and the coast and turning northward across I-10 to tie into the corresponding elevation.

3.4.2.3 Existing Conditions

Hancock County is located on the west side of the Mississippi coast of Mississippi Sound. The main residential and business area is at Bay St Louis and Waveland. Ground elevations over the areas behind the levee vary between elevations 10-20 ft NAVD88 at low areas to as low as 5 ft NAVD88 in the Shoreline Park area. The drains to the south along the coast to Mississippi Sound, to the north and east to St Louis Bay, and on the far west to Pearl River. The 4-ft(blue), 8-ft(Dark green), 12-ft(light green), 16-ft(brown), 20-ft(pink), and 24-ft(purple) ground contour lines are shown in Figure 3.4.2-5.

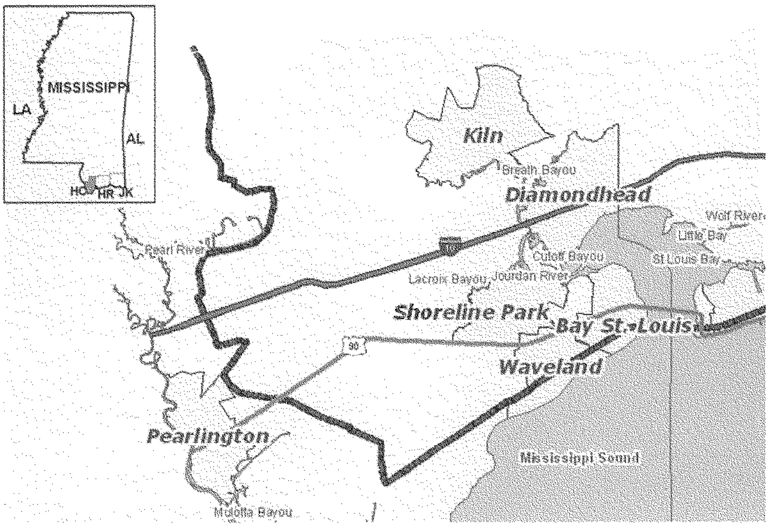


Figure 3.4.2-1. Vicinity Map Hancock County, MS

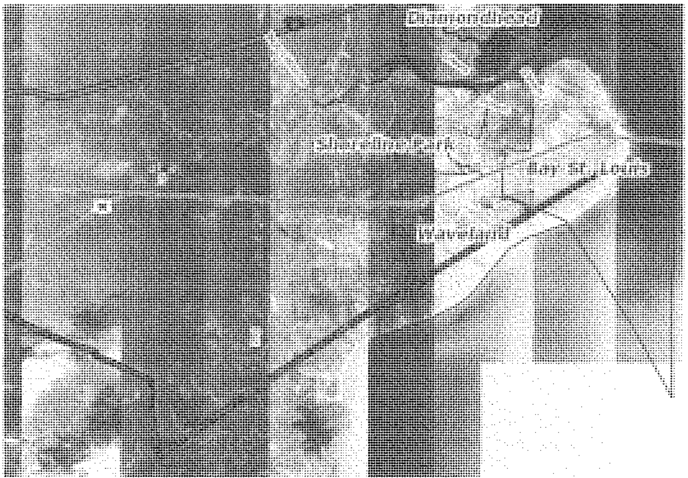


Figure 3.4.2-2. Hancock County Inland Barrier

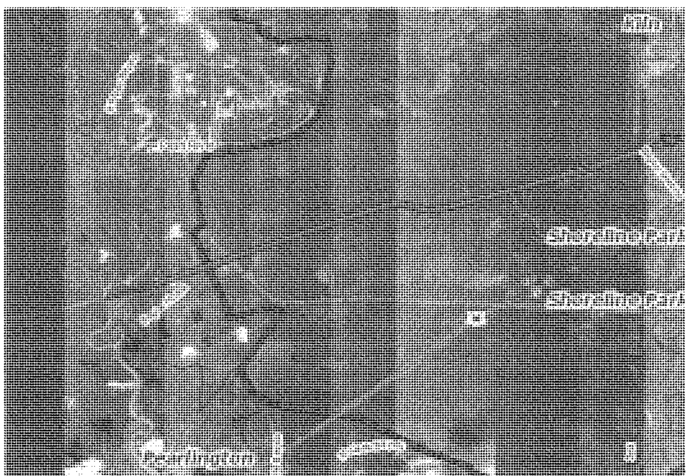


Figure 3.4.2-3. Hancock County Inland Barrier

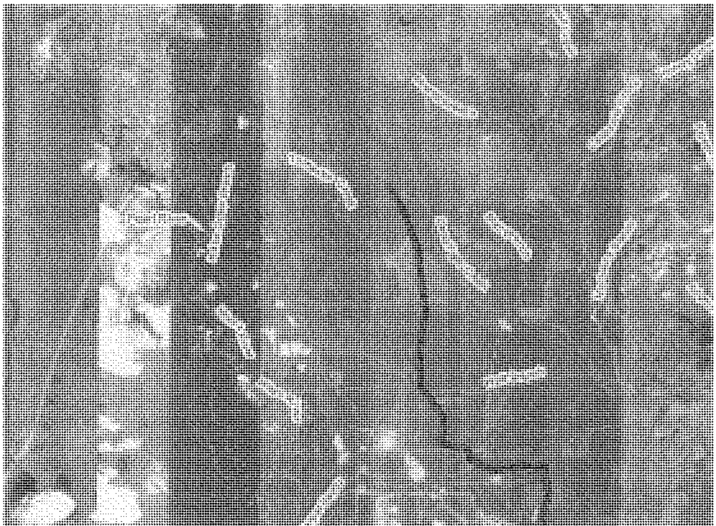


Figure 3.4.2-4. Hancock County Inland Barrier

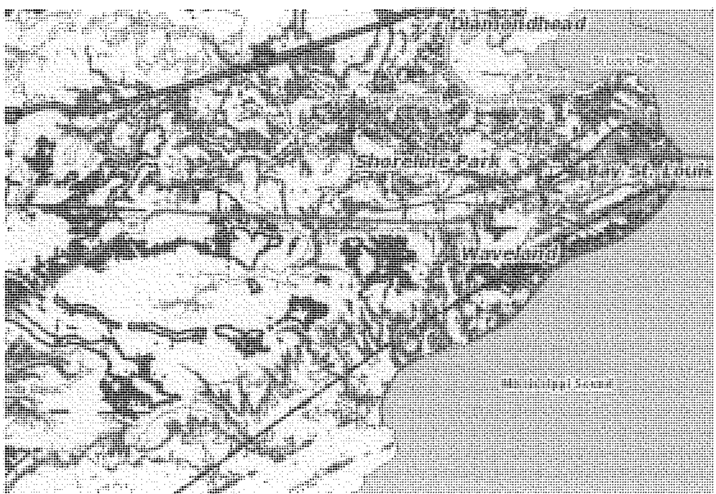
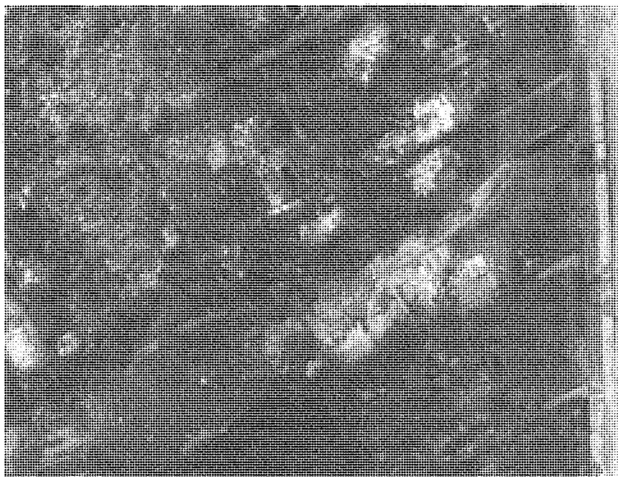


Figure 3.4.2-5. Existing Conditions Hancock County, MS

Drainage from ordinary rainfall is hindered on occasions when either of the rivers or the gulf is high, but impacts from hurricanes are devastating. Damage from Hurricane Katrina in August, 2005 in the Waveland area are shown in Figure 3.4.2-6 and 3.4.2-7.



Source: http://ngs.woc.noaa.gov/storms/katrina/24334552.jpg

Figure 3.4.2-6. Hurricane Katrina Damage Hancock Co, MS

Source: G.J. Charlet III, http://www.flickr.com/photo_zoom.gne?id=46937047&size=m

Figure 3.4.2-7. Hurricane Katrina Damage Hancock Co, MS

3.4.2.4 Coastal and Hydraulic Data

Historic coastal data is shown in Paragraph 1.4, elsewhere in this report. High water marks taken by FEMA after Hurricane Katrina in 2005 as well as the 4-ft(blue), 8-ft(Dark green), 12-ft(light green), 16-ft(brown), 20-ft(pink), and 24-ft(purple) ground contour lines are shown below in Figures 3.4.2-8 and 3.4.2-9. The data indicates the Katrina high water was as high as 26 ft NAVD88 in the Waveland/Bay St Louis area.

Stage-Frequency data for a suite of severe storms using Joint Probability Method (JPM) and hydrodynamic modeling were developed by the Engineer Research and Development Center (ERDC) for 80 locations along the study area. These data were combined with historical gage frequencies for smaller storms to establish stage-frequency curves at 54 economic reaches in the study area which were entered into Hydrologic Engineering Center's (HEC) Flood Damage Analysis (HEC-FDA) application to evaluate benefits. An expanded description of the procedure is shown elsewhere in this report. Points near Waveland/Bay St Louis at which data from hydrodynamic modeling was saved are shown in Figures 3.4.2-10 and 3.4.2-11.

Figure 3.4.2-8. Ground Contours and Katrina High Water Elevations

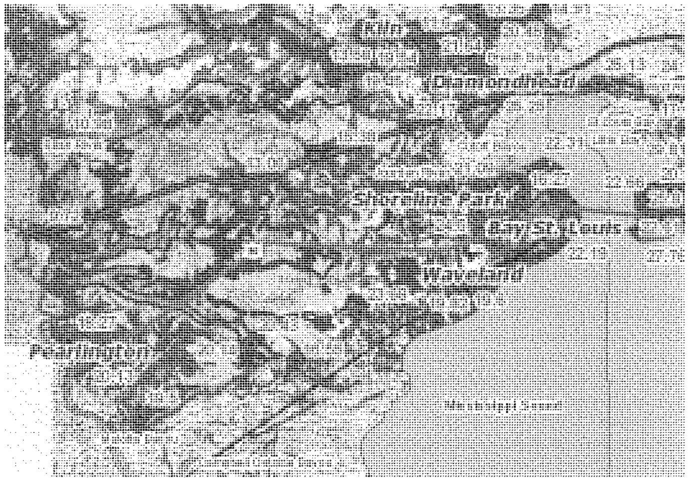


Figure 3.4.2-9. Ground Contours and Katrina High Water Elevations

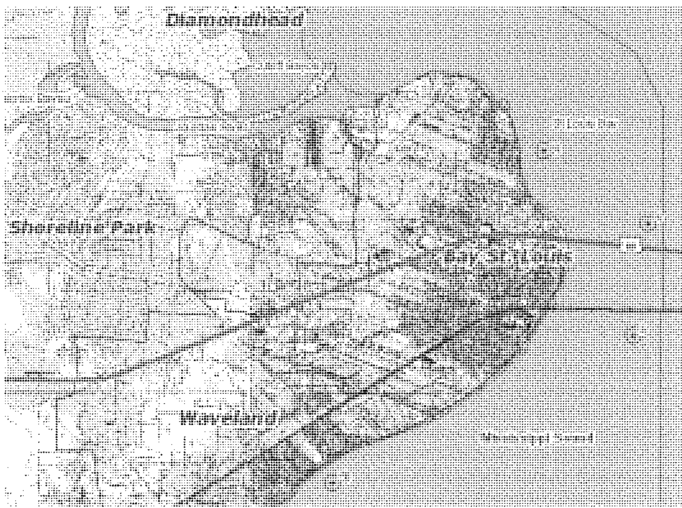


Figure 3.4.2-10. Hydrodynamic Modeling Save Points near Waveland/Bay St Louis

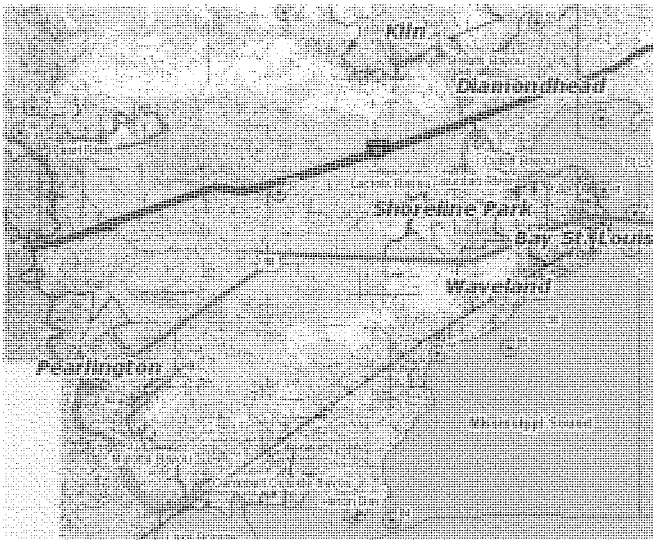


Figure 3.4.2-11. Hydrodynamic Modeling Save Points near Waveland/Bay St Louis

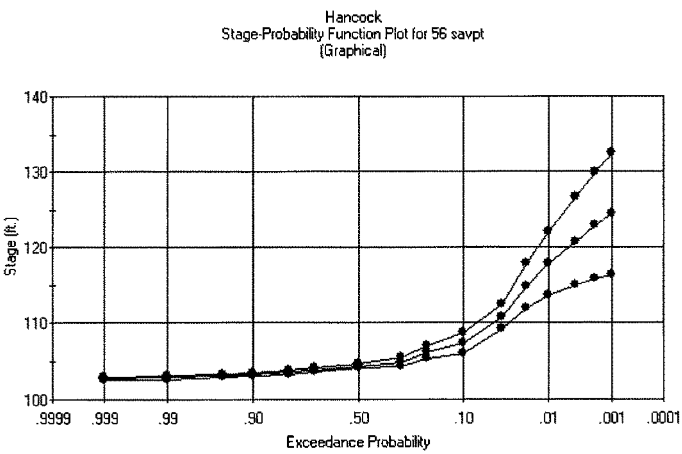


Figure 3.4.2-12. Existing Conditions at Save Point 56, near Waveland, MS

3.4.2.5 *Option A – Elevation 20 ft NAVD88*

This option consists of an earthen dike across the high ground of the county as shown on Figures 3.4.2-13 through 3.4.2-15, along with the internal sub-basins and levee culvert/pump locations. The levee would have a top width of 15 ft and slopes of 1 vertical to 3 horizontal. The levee is located mostly along high ground so ponding at the levee would be minimal. Some ditching would be required on the outside of the levee which is shown in dark blue below. Small boat access structures are also shown at the basin 2. Rising sector gates will be provided at these sites allowing shallow draft traffic most of the time. The gates will be closed prior to hurricane storm surge. A drawing of a typical boat access gate is shown in Figure 3.3.12-5.

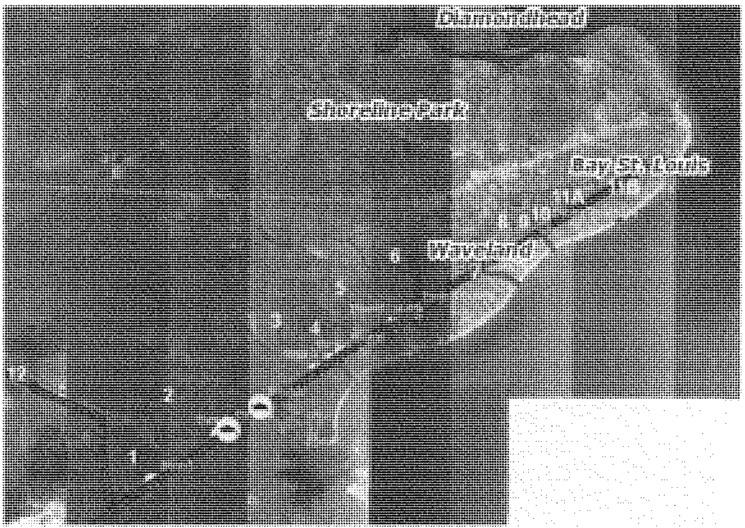


Figure 3.4.2-13. Pump/Culvert/Sub-basins/Boat Access Site Locations

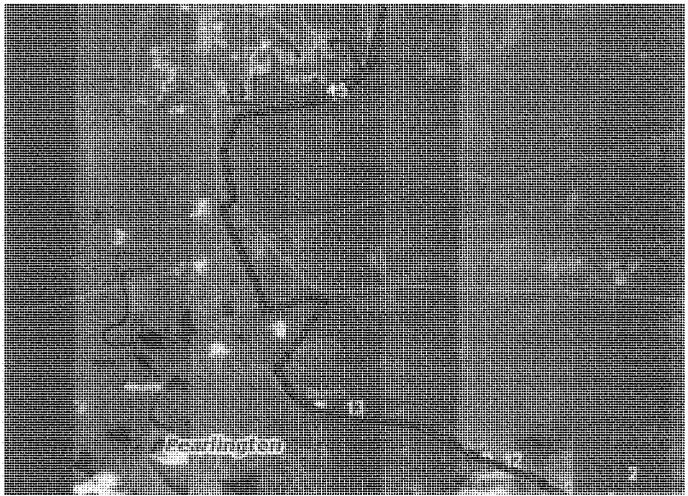


Figure 3.4.2-14. Pump/Culvert/Sub-basins/Boat Access Site Locations

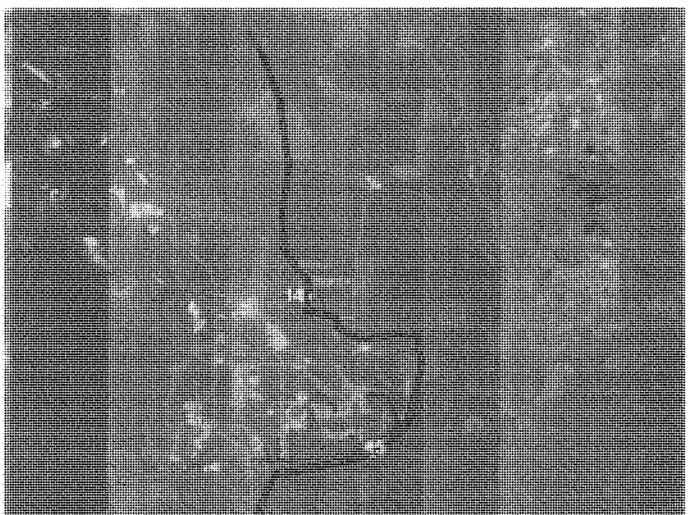
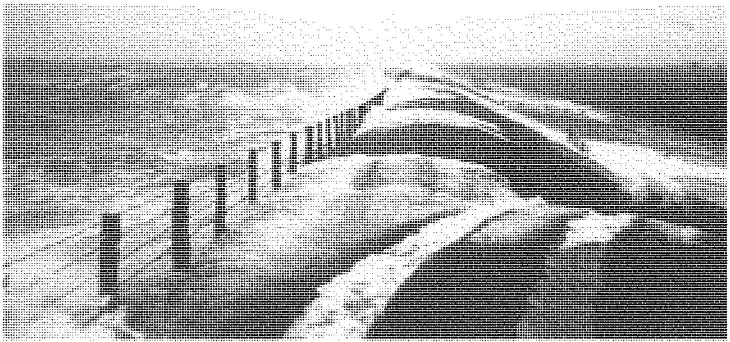


Figure 3.4.2-15. Pump/Culvert/Sub-basins/Boat Access Site Locations

Damage and failure by overtopping of levees could be caused by storms surges greater than the levee crest as depicted in Figure 3.4.2-16.



Source: Wave Overtopping Flow on Seadikes, Experimental and Theoretical Investigations, Holger Schüttrumpf, (Photo: Leichtweiss-Institute) http://kfki.baw.de/fileadmin/projects/E_35_134_Lit.pdf

Figure 3.4.2-16. North Sea, Germany, March 1976

Overtopping failures are caused by the high velocity of flow on the back side of the levee. Although significant wave attack on the seaward side of some of the New Orleans levees occurred during Hurricane Katrina, the duration of the wave attack was for such a short time that major damage did not occur from wave action. The erosion shown in Figure 3.4.2-17 was caused by approximately 1-2 ft of overtopping crest depth.

Source: ERDC, Steven Hughes

Figure 3.4.2-17. Crown Scour from Hurricane Katrina at Mississippi River Gulf Outlet (MRGO) Levee in St. Bernard Parish, New Orleans, LA

Revetment will be included in the levee design to prevent overtopping failure.

The levee would be protected by gabions on filter cloth as shown in Figure 3.4.2-18, extending across a drainage ditch which carries water to nearby culverts and which would also serve to dissipate some of the supercritical flow energy during overtopping conditions.

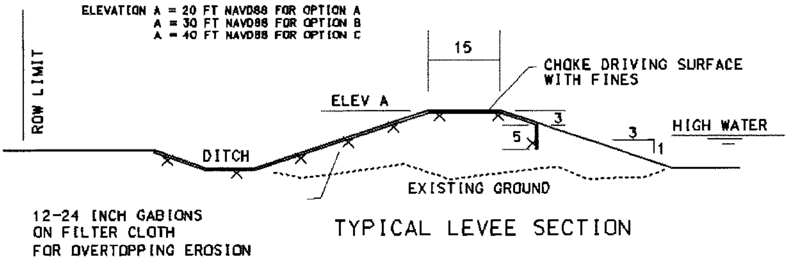


Figure 3.4.2-18. Typical Section at Inland barrier

3.4.2.5.1 Interior Drainage

For smaller drainage areas, drainage on the interior of the inland barrier would be collected at the levee and channeled to culverts placed in the levee at the locations shown in Figures 3.4.2-13 through 3.4.2-15. The culverts would have tidal 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 the upstream end at every culvert in the levee for manual control in the event the tidal gate malfunctions. A typical section is shown is shown in Figure 3.4.2-19.

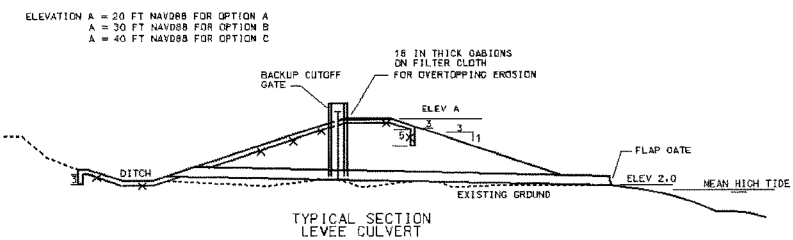


Figure 3.4.2-19. Typical Section at Culvert

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 inland barrier into major sub-basins as shown in Figure 3.4.2-13 through 3.4.2-15 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.

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. For the culvert design, headwater elevations at the culverts were maintained at an elevation no greater than 5 ft NAVD88 with a tailwater elevation of 2.0 ft NAVD88 assumed. Drainage ditches along the toe of the levee will be required to assure that smaller basins can be drained to a culvert/pump site. These ditches were sized using a normal depth flow computation. Curve numbers, pump, and culvert capacity tables are not included in the report beyond that necessary to obtain a cost estimate. The data is considered beyond the level of detail required for this report.

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. This decision was based on an evaluation of rainfall observed during hurricane and tropical storm events as presented in two sources. The first is "Frequency and Aerial 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. However, in some of the areas, existing storage could be adequate to pond water without causing damage, even without pumps. In other areas that do have pumps, some rise in interior water during interior events greater than the 10-yr rain could occur, but may not cause damage. Designing the pumps for the peak 10-yr flow provides a significant pumping capacity. Further studies will detail the requirement for the appropriate ponding areas, pump sizes, or buyouts in the affected areas.

During non-hurricane periods of low water in the sound, when rainfall greater than the 25-yr event occurs, the pumps could also be used to augment the flow capacity of the levee culverts.

In addition to the local drainage outlets at the levee described above, in the event of an imminent hurricane, barrier gates across the St Louis Bay would be closed, and flow from the Jourdan and Wolf Rivers, as well as local runoff would pond behind the gates. The location of the barrier is shown in Figure 3.4.2-20.

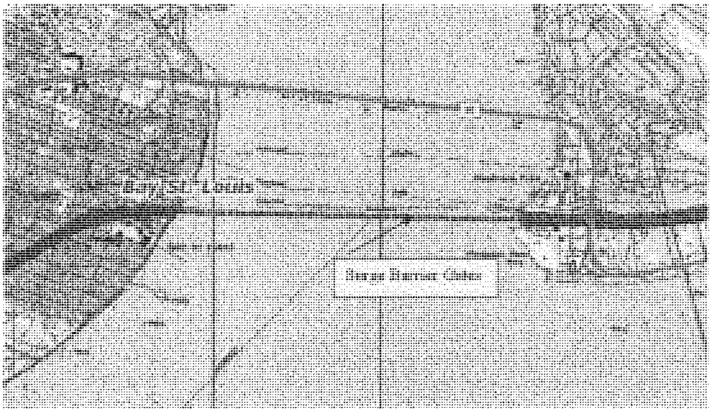


Figure 3.4.2-20. St Louis Bay Surge Barrier Location

The gates would be similar to the gates across the Thames River in London, England, shown in Figure 3.4.2-21.

Figure 3.4.2-21. Thames River Barrier Gates

The Hydrologic Engineering Center's Hydrologic Modeling System (HEC-HMS) was used to model the St Louis Bay watershed in order to predict the maximum water elevation behind the gates in the bay under several different scenarios.

The St. Louis Bay watershed covers approximately 654 square miles and is comprised of six sub-basins that stretch across the Mississippi counties of Harrison, Hancock, Stone, and Pearl River. There is one United States Geological Survey (USGS) discharge stream gage (#2481510) located in the watershed along the Wolf River, near Landon, Mississippi. There are three significant National

Oceanic and Atmospheric Administration (NOAA) hourly precipitation gages located nearby to the watershed: #109617 White Sand located to the west, #87720 Purvis 2 N to the north, and #109617, 87720, and 107840 Saucier Experimental Forest to the east of the basin. Data from these gages, along with soils data from the National Cooperative Soil Survey and Technical Paper 40 (TP-40) synthetic rainfall events were used to determine the peak discharge and total run-off volume entering St. Louis Bay from the St. Louis Bay watershed for the 2 year, 5 year, 10 year, 25 year, 50 year and 100 year rainfall events. The St. Louis Bay watershed is shown in Figure 3.4.2-22.

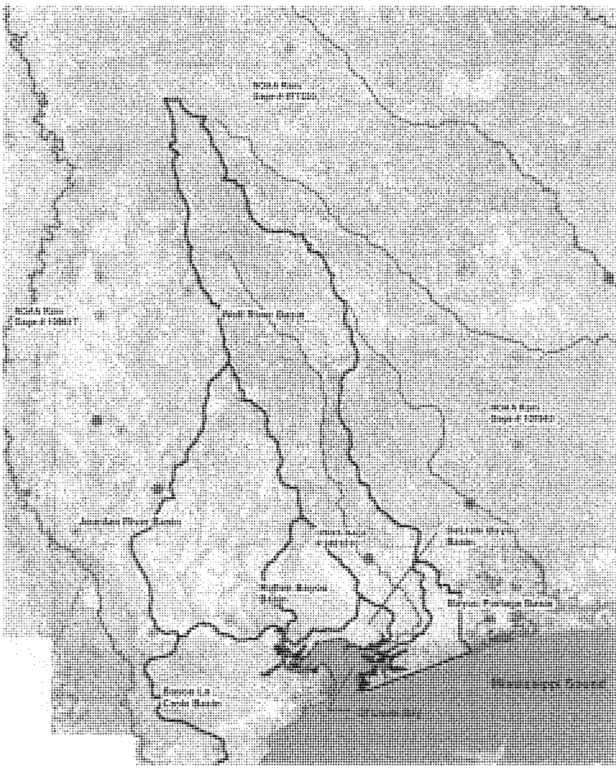


Figure 3.4.2-22. St Louis Bay Watershed

The Hydrologic Engineering Center's Hydrologic Modeling System (HEC-HMS) was used for the modeling effort. The components of the model include the precipitation specification, the loss model, the direct runoff model, and observed discharge data. Precipitation data used in the modeling process included hourly precipitation from NOAA gages 109617, 87720, and 109617, 87720, and 107840 and the 2-100 year 24-hour TP-40 rainfall events. The initial and constant loss rate method was used for the loss model while the Snyder's unit hydrograph (UH) method was used for the direct runoff model. The model was calibrated to observed hourly discharge data for one event at USGS gage 2481510. Several other events were analyzed but not used because the observed hourly precipitation for those events did not match the TP-40 rainfall.

The HEC-HMS St. Louis Bay watershed model was calibrated to the September 24-30, 2002 storm events. The model was calibrated at the Upper Wolf River sub-basin using observed precipitation data from NOAA gages 109617, 87720, and 107840 and observed discharge data from USGS gage 2481510. This event had a total rainfall of 13.75 inches and peak discharge of 17,854 cfs. This event was chosen due to the availability of both the hourly precipitation and discharge data. The observed and computed hydrographs are shown in Figure 3.4.2-23.

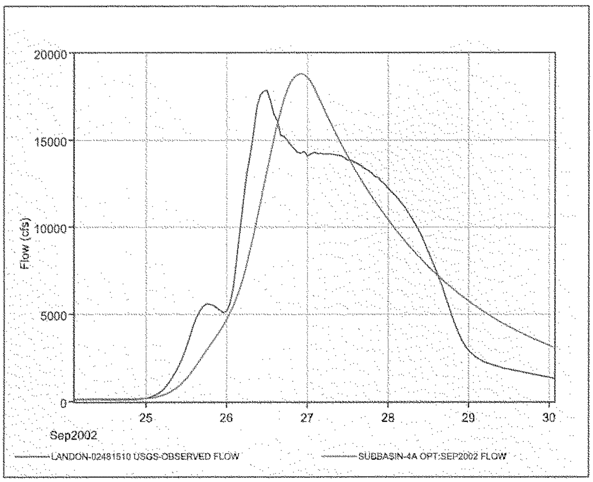


Figure 3.4.2-23. St. Louis Bay Watershed Calibration

Ponding from the interior rivers behind the gates will depend partially on the elevation of the gulf when the gates are closed. Several historical stage hydrographs of hurricanes were reviewed to determine the duration of various stages along the gulf. From this review, it was determined that storms generally reach 4 ft NAVD88 and recede to that elevation within 24 hours. Using this information, various theoretical coincident rainfall events taken from T.P 40 were modeled to determine the resulting water surface elevations behind the barrier during the 24-hour period the gates are to be closed. A 10-yr rain was selected for the design condition, in accordance with studies cited above. The highest inflow period of the inflow hydrograph was used to compute changes in bay elevations in the 24-hour gate closure period.

Based on this method of analysis, the resulting elevations for the various storms are shown in Table 3.4.2-1, with the 10-yr elevation of 6.8 ft NAVD88 the design condition.

This ponded water area in Hancock County above the surge barrier gates is approximated by the 8-ft ground contour line shown in Figure 3.4.2-24.

Table 3.4.2-1.
St. Louis Bay Ponding

St. Louis Bay 4 ft. Base Elevations	
Strom Event	**Bay Elevation (ft NAVD88)**
2-year	5.5
5-year	6.3
10-year	6.8
25-year	7.5
50-year	7.9
100-year	8.4

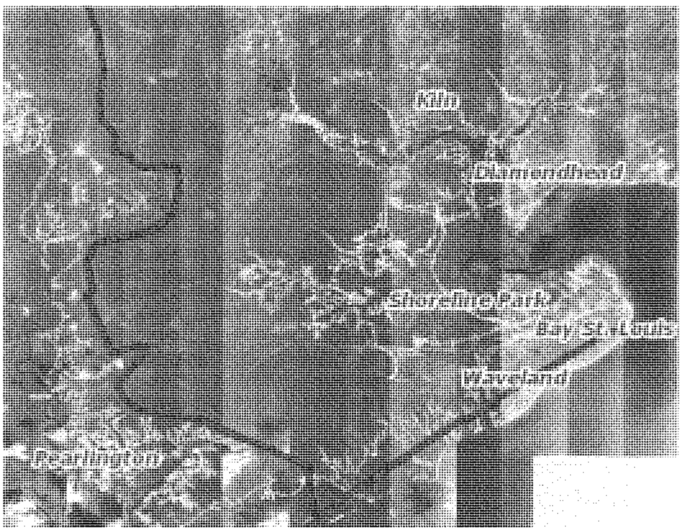


Figure 3.4.2-24. St Louis Bay 10-yr Ponding to Elev. 6.8 ft NAVD88

3.4.2.5.2 Geotechnical Data

Geology: The Citronelle formation extends north of Interstate 10 and is a relatively thin unit of fluvial deposits of Plio-Pleistocene age consisting of gravelly sand and silty sand layers. Typically the formation is 30 to 80 feet thick, except where it has filled eroded channels in the underlying formations. The sand in the formation has a variety of colors, often associated with the presence of iron oxides in the form of hematite or goethite. Thin discontinuous clay layers are found in some areas. The iron oxide has occasionally cemented the sand into somewhat friable sandstone, usually occurring only as a localized layer. Within the study area, this formation outcrops north of Interstate 10 and will not be encountered at project sites other than any levees that might extend northward to higher ground elevations.

The Prairie formation is found southward of the Citronelle formation and is of Pleistocene age. This formation consists of fluvial and floodplain sediments that extend southward from the outcrop of the Citronelle formation to or near the mainland coastline. Sand found within this formation has an economic value as beach fill due to its color and quality. Southward from its outcrop area, the formation extends under the overlying Holocene deposits out into the Mississippi Sound.

The Gulfport Formation is found along the coastline in most of Harrison County and western Jackson County at Belle Fontaine Beach. This formation of Pleistocene age overlies the Prairie formation and is present as well sorted sands that mark the edge of the coastline during the last high sea level stage of the Sangamonian Interglacial period. It does not extend under the Mississippi Sound.

Geotechnical: The inland barrier earthen levee section will have one vertical to three horizontal side slopes with a fifteen foot crest width. All work areas to receive the fill shall be cleared and grubbed of all trees and surface organics and all existing foundations, streets, utilities, etc. will be removed and the subsequent cavities backfilled and compacted. The levee will be constructed of sand clay materials obtained from off site commercial sources, trucked to the work area, placed in thin lifts and compacted to 95 percent of the maximum modified density. The final surface will be armored by the placement of 24 inch thick gabion mattress filled with small stone for erosion protection during an event that overtops the levee. The armoring will be anchored on the front face by trenching and extend across the downstream slope and the 25 foot easement area beyond the toe. The front side of the levee and all non critical surface areas will be subsequently covered by grassing. Road crossings will incorporate small gate structures or ramping over the embankment where the surface elevation is near that of the crest elevation. The elevation relationship of the crest and the adjacent railroad will be a governing factor. The surfaces will be paved with asphalt and the corresponding drainage will be accommodated. Those areas where the subgrade geology primarily consists of clean sands, seepage underneath the levee and the potential for erosion and instability must be considered. Final designs may require the installation of a bentonite concrete cutoff wall deep within the foundation. This condition will be investigated during any design phase and its requirement will be incorporated.

3.4.2.5.3 Structural, Mechanical and Electrical

See sections 3.4.2.5.3.1 through 3.4.2.5.3.3.

3.4.2.5.3.1 Culverts

Drainage features would be required at 16 locations ranging from 20-inch diameter reinforced concrete pipe to reinforced concrete box culverts having 11 water passages, each measuring 12' wide by 4' high. Each of the culverts was configured having nominally sized and reinforced structure walls and top and bottom slabs. Each water passage would be fitted with both a flap gate at the outlet end and a sluice gate placed near the center of the culvert with a vertical operator stem extending through an access shaft to the top of levee elevation.

3.4.2.5.3.2 Pumping Stations

The design hydraulic heads derived for the three pumping facilities included in the Hancock County Inland Barrier for the elevation 20 protection level varied from 15 to 20 feet and the corresponding flows required varied from 59,694 to 390,483 gallons per minute. The facilities thus derived would vary from a plant having two, 42-inch diameter, 300 horsepower pumps, to one having four, 60-inch diameter pumps operating at 560 horsepower.

3.4.2.5.3.3 Levee and Roadway/Railway Intersections

With the installation of protection to elevation 20, 14 roadway intersections would have to be accommodated. For this study it was estimated that 4 roller gate structures and 6 swing gate structures would be required. In addition, 4 railway closures would be required.

3.4.2.5.4 HTRW

Due to the extent and large number of real estate parcels along with the potential for re-alignment of the structural aspects of this project, no preliminary assessment was performed to identify the possibility of hazardous waste on the sites. These studies will be conducted during the next phase of work after the final siting of the various structures. The real estate costs appearing in this report therefore will not reflect any costs for remediation design and/or treatment and/or removal or disposal of these materials in the baseline cost estimate.

3.4.2.5.5 Construction Procedures and Water Control Plan

The construction procedures required for this option are similar to general construction in many respects in that the easement limits must be established and staked in the field, the work area cleared of all structures, pavements, utilities, trees, organics, etc. and the foundation prepared for the new work. Where the levee alignment crosses the existing streams or narrow bays, the alignment base shall be created by displacement with layers of crushed stone pushed ahead and compacted by the placement equipment and repeated until a stable platform is created. The required drainage culverts or other ancillary structures can then be constructed. The control of any surface water will be handled by temporary sheetpile cofferdams and pumping. The control of groundwater will be a series of wellpoints systems designed to keep the excavations dry to a depth and width sufficient to install the new work.

3.4.2.5.6 Project Security

The Protocol for security measures for this study has been performed in general accordance with the Risk Assessment Methodology for Dams (RAM-D) developed by the Interagency Forum for Infrastructure Protection (IFIP). This methodology has been used for physical security for the critical infrastructure throughout the Corps of Engineers. The determination of the level of physical security provided for each facility is based on the following critical elements: 1) threat assessment of the likelihood that an adversary will attack a critical asset, 2) consequence assessment should an adversary be successful in disrupting, disabling or destroying the asset and 3) effectiveness to prevent a successful attack against an operational component.

Three levels of physical security were selected for use in this study:

Level 1 Security provides no improved security for the selected asset. This security level would be applied to the barrier islands and the sand dunes. These features present a very low threat level of attack and basically no consequence if an attack occurred and is not applicable to this option.

Level 2 Security applies standard security measures such as road barricades, perimeter fencing, and intrusion detection systems for unoccupied buildings and vertical structures and security lighting. The intrusion detection systems will be connected to the local law enforcement office for response during an emergency. Facilities requiring this level of security would possess a higher threat level than those in Level 1 and would include assets such as levees, access roads and pumping stations. This level is the most applicable to this option.

Level 3 Security includes all of the features of Level 2 plus enhanced security measures such as the use of video cameras for real-time monitoring of the facility, monitors, motion detectors and alarm sound system in the occupied control buildings. Facilities requiring this level of security would

possess the highest threat level of all the critical assets. The surge barriers located in the bays, manned control buildings, and power plants would require this level of security.

3.4.2.5.7 Operations and Maintenance

The features that require periodic operations will be the exercising of the pumps and emergency generators at the various pump stations, the testing of the gate structures at the various road crossings, grass cutting of the levee slopes and toe areas and the filling of rilled areas within the embankment due to surface erosion. Scheduled maintenance should include periodic greasing of all gears and coupled joints, maintaining any battery backup systems, and replacement of standby fuel supplies.

3.4.2.5.8 Cost Estimate

The costs for the various options included in this measure are presented in Section 3.4.2.8 Cost Summary. Construction costs for the various options are included in Table 3.4.2-2 and costs for the annualized Operation and Maintenance of the options are included in Table 3.3.4.2-3 Estimates are comparative-Level "Parametric Type" and are based on Historical Data, Recent Pricing, and Estimator's Judgment. Quantities listed within the estimates represent Major Elements of the Project Scope and were furnished by the Project Delivery Team. Price Level of Estimate is April 07. Estimates excludes project Escalation and HTRW Cost. The construction costs include real estate, engineering design (E&D), construction management, and contingencies. The E&D cost for preparation of construction contract plans and specifications includes a detailed contract survey, preparation of contract specifications and plan drawings, estimating bid quantities, preparation of bid estimate, preparation of final submittal and contract advertisement package, project engineering and coordination, supervision technical review, computer costs and reproduction. Construction Contingency developed and assigned at 25% to cover the Cost Growth of the project.

3.4.2.5.9 Schedule and Design for Construction

After the authority for the design has been issued and funds have been provided, the design of these structures will require approximately 12 months including comprehensive plans and specifications, independent reviews and subsequent revisions. The construction of this option should require in excess of two years.

3.4.2.6 Option B – Elevation 30.0 NAVD 88

3.4.2.6.1 Interior Drainage

Interior drainage analysis and culverts are the same as those for Option A, above, except that the culvert lengths through the levees would be longer.

3.4.2.6.2 Geotechnical Data

Geology: Citronelle formation extends north of Interstate 10 and is a relatively thin unit of fluvial deposits of Plio-Pleistocene age consisting of gravelly sand and silty sand layers. Typically the formation is 30 to 80 feet thick, except where it has filled eroded channels in the underlying formations. The sand in the formation has a variety of colors, often associated with the presence of iron oxides in the form of hematite or goethite. Thin discontinuous clay layers are found in some areas. The iron oxide has occasionally cemented the sand into a somewhat friable sandstone, usually occurring only as a localized layer. Within the study area, this formation outcrops north of Interstate 10 and will not be encountered at project sites other than any levees that might extend northward to higher ground elevations.

The Prairie formation is found southward of the Citronelle formation and is of Pleistocene age. This formation consists of fluvial and floodplain sediments that extend southward from the outcrop of the Citronelle formation to or near the mainland coastline. Sand found within this formation has an economic value as beach fill due to its color and quality. Southward from its outcrop area, the formation extends under the overlying Holocene deposits out into the Mississippi Sound.

The Gulfport Formation is found along the coastline in most of Harrison County and western Jackson County at Belle Fontaine Beach. This formation of Pleistocene age overlies the Prairie formation and is present as well sorted sands that mark the edge of the coastline during the last high sea level stage of the Sangamonian Interglacial period. It does not extend under the Mississippi Sound.

Geotechnical: The inland barrier earthen levee section will have one vertical to three horizontal side slopes with a fifteen foot crest width. All work areas to receive the fill shall be cleared and grubbed of all trees and surface organics and all existing foundations, streets, utilities, etc. will be removed and the subsequent cavities backfilled and compacted. The levee will be constructed of sand clay materials obtained from off site commercial sources, trucked to the work area, placed in thin lifts and compacted to 95 percent of the maximum modified density. The final surface will be armored by the placement of 12 inch thick gabion mattress filled with small stone for erosion protection during an event that overtops the levee. The armoring will be anchored on the front face by trenching and extend across the downstream slope and the 25 foot easement area beyond the toe. The front side of the levee and all non critical surface areas will be subsequently covered by grassing. Road crossings will incorporate small gate structures or ramping over the embankment where the surface elevation is near that of the crest elevation. The elevation relationship of the crest and the adjacent railroad will be a governing factor. The surfaces will be paved with asphalt and the corresponding drainage will be accommodated. Those areas where the subgrade geology primarily consists of clean sands, seepage underneath the levee and the potential for erosion and instability must be considered. Final designs may require the installation of a bentonite concrete cutoff wall deep within the foundation. This condition will be investigated during any design phase and its requirement will be incorporated.

3.4.2.6.3 Structural, Mechanical and Electrical

See sections 3.4.2.6.3.1 through 3.4.2.6.3.3.

3.4.2.6.3.1 Culverts

Drainage features would be required at 16 locations ranging from 20-inch diameter reinforced concrete pipe to reinforced concrete box culverts having 11 water passages, each measuring 12' wide by 4' high. Each of the culverts was configured having nominally sized and reinforced structure walls and top and bottom slabs. Each water passage would be fitted with both a flap gate at the outlet end and a sluice gate placed near the center of the culvert with a vertical operator stem extending through an access shaft to the top of levee elevation.

3.4.2.6.3.2 Pumping Stations

Design hydraulic heads derived for the three pumping facilities included in the Hancock County Inland Barrier for the elevation 30 protection level varied from 25 to 30 feet and the corresponding flows required varied from 59,694 to 390,483 gallons per minute, respectively. The facilities thus derived would consist of one plant having two, 42-inch diameter, 500 horsepower pumps to one having four, 60-inch diameter pumps operating at 1000 horsepower.

3.4.2.6.3.3 Levee and Roadway/Railway Intersections

With the installation of protection to elevation 30, 31 roadway/railway intersections would have to be accommodated. For this study it was estimated that 9 roller gate structures and 18 swing gate structures would be required. In addition, 4 railway closure gates would be required.

3.4.2.6.4 HTRW

Due to the extent and large number of real estate parcels along with the potential for re-alignment of the structural aspects of this project, no preliminary assessment was performed to identify the possibility of hazardous waste on the sites. These studies will be conducted during the next phase of work after the final siting of the various structures. The real estate costs appearing in this report therefore will not reflect any costs for remediation design and/or treatment and/or removal or disposal of these materials in the baseline cost estimate.

3.4.2.6.5 Construction Procedures and Water Control Plan

The construction procedures required for this option are similar to general construction in many respects in that the easement limits must be established and staked in the field, the work area cleared of all structures, pavements, utilities, trees, organics, etc. and the foundation prepared for the new work. Where the levee alignment crosses the existing streams or narrow bays, the alignment base shall be created by displacement with layers of crushed stone pushed ahead and compacted by the placement equipment and repeated until a stable platform is created. The required drainage culverts or other ancillary structures can then be constructed. The control of any surface water will be handled by temporary sheetpile cofferdams and pumping. The control of groundwater will be a series of wellpoints systems designed to keep the excavations dry to a depth and width sufficient to install the new work.

3.4.2.6.6 Project Security

The Protocol for security measures for this study has been performed in general accordance with the Risk Assessment Methodology for Dams (RAM-D) developed by the Interagency Forum for Infrastructure Protection (IFIP). This methodology has been used for physical security for the critical infrastructure throughout the Corps of Engineers. The determination of the level of physical security provided for each facility is based on the following critical elements: 1) threat assessment of the likelihood that an adversary will attack a critical asset, 2) consequence assessment should an adversary be successful in disrupting, disabling or destroying the asset and 3) effectiveness to prevent a successful attack against an operational component.

Three levels of physical security were selected for use in this study:

Level 1 Security provides no improved security for the selected asset. This security level would be applied to the barrier islands and the sand dunes. These features present a very low threat level of attack and basically no consequence if an attack occurred and is not applicable to this option.

Level 2 Security applies standard security measures such as road barricades, perimeter fencing, and intrusion detection systems for unoccupied buildings and vertical structures and security lighting. The intrusion detection systems will be connected to the local law enforcement office for response during an emergency. Facilities requiring this level of security would possess a higher threat level than those in Level 1 and would include assets such as levees, access roads and pumping stations. This level of security is the most applicable to this option.

Level 3 Security includes all of the features of Level 2 plus enhanced security measures such as the use of video cameras for real-time monitoring of the facility, monitors, motion detectors and alarm sound system in the occupied control buildings. Facilities requiring this level of security would

possess the highest threat level of all the critical assets. The surge barriers located in the bays, manned control buildings, and power plants would require this level of security.

3.4.2.6.7 Operations and Maintenance

The features that require periodic operations will be the exercising of the pumps and emergency generators at the various pump stations, the testing of the gate structures at the various road crossings, grass cutting of the levee slopes and toe areas and the filling of rilled areas within the embankment due to surface erosion. Scheduled maintenance should include periodic greasing of all gears and coupled joints, maintaining any battery backup systems, and replacement of standby fuel supplies.

3.4.2.6.8 Cost Estimate

The costs for the various options included in this measure are presented in Section 3.4.2.8 Cost Summary. Construction costs for the various options are included in Table 3.4.2-2 and costs for the annualized Operation and Maintenance of the options are included in Table 3.3.4.2-3. Estimates are comparative-Level "Parametric Type" and are based on Historical Data, Recent Pricing, and Estimator's Judgment. Quantities listed within the estimates represent Major Elements of the Project Scope and were furnished by the Project Delivery Team. Price Level of Estimate is April 07. Estimates excludes project Escalation and HTRW Cost. The construction costs include real estate, engineering design (E&D), construction management, and contingencies. The E&D cost for preparation of construction contract plans and specifications includes a detailed contract survey, preparation of contract specifications and plan drawings, estimating bid quantities, preparation of bid estimate, preparation of final submittal and contract advertisement package, project engineering and coordination, supervision technical review, computer costs and reproduction. Construction Contingency developed and assigned at 25% to cover the Cost Growth of the project.

3.4.2.6.9 Schedule and Design for Construction

After the authority for the design has been issued and funds have been provided, the design of these structures will require approximately 12 months including comprehensive plans and specifications, independent reviews and subsequent revisions. The construction of this option should require in excess of two years.

3.4.2.7 Option C – Elevation 40.0 NAVD 88

3.4.2.7.1 Interior Drainage

Interior drainage analysis and culverts are the same as those for Option A, above, except that the culvert lengths through the levees would be longer.

3.4.2.7.2 Geotechnical Data

Geology: Citronelle formation extends north of Interstate 10 and is a relatively thin unit of fluvial deposits of Plio-Pleistocene age consisting of gravelly sand and silty sand layers. Typically the formation is 30 to 80 feet thick, except where it has filled eroded channels in the underlying formations. The sand in the formation has a variety of colors, often associated with the presence of iron oxides in the form of hematite or goethite. Thin discontinuous clay layers are found in some areas. The iron oxide has occasionally cemented the sand into somewhat friable sandstone, usually occurring only as a localized layer. Within the study area, this formation outcrops north of Interstate 10 and will not be encountered at project sites other than any levees that might extend northward to higher ground elevations.

The Prairie formation is found southward of the Citronelle formation and is of Pleistocene age. This formation consists of fluvial and floodplain sediments that extend southward from the outcrop of the Citronelle formation to or near the mainland coastline. Sand found within this formation has an economic value as beach fill due to its color and quality. Southward from its outcrop area, the formation extends under the overlying Holocene deposits out into the Mississippi Sound.

The Gulfport Formation is found along the coastline in most of Harrison County and western Jackson County at Belle Fontaine Beach. This formation of Pleistocene age overlies the Prairie formation and is present as well sorted sands that mark the edge of the coastline during the last high sea level stage of the Sangamonian Interglacial period. It does not extend under the Mississippi Sound.

Geotechnical: The inland barrier earthen levee section will have one vertical to three horizontal side slopes with a fifteen foot crest width. All work areas to receive the fill shall be cleared and grubbed of all trees and surface organics and all existing foundations, streets, utilities, etc. will be removed and the subsequent cavities backfilled and compacted. The levee will be constructed of sand clay materials obtained from off site commercial sources, trucked to the work area, placed in thin lifts and compacted to 95 percent of the maximum modified density. The final surface will not be armored since the elevation will not allow overtopping. All surfaces of the levee and all non critical surface areas will be subsequently covered by grassing. Road crossings will incorporate small gate structures or ramping over the embankment where the surface elevation is near that of the crest elevation. The elevation relationship of the crest and the adjacent railroad will be a governing factor. The surfaces will be paved with asphalt and the corresponding drainage will be accommodated. Those areas where the subgrade geology primarily consists of clean sands, seepage underneath the levee and the potential for erosion and instability must be considered. Final designs may require the installation of a bentonite concrete cutoff wall deep within the foundation. This condition will be investigated during any design phase and its requirement will be incorporated.

3.4.2.7.3 Structural, Mechanical and Electrical

See sections 3.4.2.7.3.1 through 3.4.2.7.3.3.

3.4.2.7.3.1 Culverts

Drainage features would be required at 16 locations ranging from 20-inch diameter reinforced concrete pipe to reinforced concrete box culverts having 11 water passages, each measuring 12' wide by 4' high. Each of the culverts was configured having nominally sized and reinforced structure walls and top and bottom slabs. Each water passage would be fitted with both a flap gate at the outlet end and a sluice gate placed near the center of the culvert with a vertical operator stem extending through an access shaft to the top of levee elevation.

3.4.2.7.3.2 Pumping Stations

Design hydraulic heads derived for the three pumping facilities included in the Hancock County Inland Barrier for the elevation 40 protection level varied from 30 to 35 feet and the corresponding flows required varied from 59,694 to 390,483 gallons per minute, respectively. The facilities thus derived would consist of one plant having two, 42-inch diameter, 500 horsepower pumps to one having six, 54-inch diameter pumps operating at 1000 horsepower.

3.4.2.7.3.3 Levee and Roadway/Railway Intersections

With the installation of protection to elevation 40, 40 roadway/railway intersections would have to be accommodated. For this study it was estimated that all 36 of the highway crossings would require swing gates. In addition, 4 railway closure gates would be required.

3.4.2.7.4 HTRW

Due to the extent and large number of real estate parcels along with the potential for re-alignment of the structural aspects of this project, no preliminary assessment was performed to identify the possibility of hazardous waste on the sites. These studies will be conducted during the next phase of work after the final siting of the various structures. The real estate costs appearing in this report therefore will not reflect any costs for remediation design and/or treatment and/or removal or disposal of these materials in the baseline cost estimate.

3.4.2.7.5 Construction Procedures and Water Control Plan

The construction procedures required for this option are similar to general construction in many respects in that the easement limits must be established and staked in the field, the work area cleared of all structures, pavements, utilities, trees, organics, etc. and the foundation prepared for the new work. Where the levee alignment crosses the existing streams or narrow bays, the alignment base shall be created by displacement with layers of crushed stone pushed ahead and compacted by the placement equipment and repeated until a stable platform is created. The required drainage culverts or other ancillary structures can then be constructed. The control of any surface water will be handled by temporary sheetpile cofferdams and pumping. The control of groundwater will be a series of wellpoints systems designed to keep the excavations dry to a depth and width sufficient to install the new work.

3.4.2.7.6 Project Security

The Protocol for security measures for this study has been performed in general accordance with the Risk Assessment Methodology for Dams (RAM-D) developed by the Interagency Forum for Infrastructure Protection (IFIP). This methodology has been used for physical security for the critical infrastructure throughout the Corps of Engineers. The determination of the level of physical security provided for each facility is based on the following critical elements: 1) threat assessment of the likelihood that an adversary will attack a critical asset, 2) consequence assessment should an adversary be successful in disrupting, disabling or destroying the asset and 3) effectiveness to prevent a successful attack against an operational component.

Three levels of physical security were selected for use in this study:

Level 1 Security provides no improved security for the selected asset. This security level would be applied to the barrier islands and the sand dunes. These features present a very low threat level of attack and basically no consequence if an attack occurred and is not applicable to this option.

Level 2 Security applies standard security measures such as road barricades, perimeter fencing, and intrusion detection systems for unoccupied buildings and vertical structures and security lighting. The intrusion detection systems will be connected to the local law enforcement office for response during an emergency. Facilities requiring this level of security would possess a higher threat level than those in Level 1 and would include assets such as levees, access roads and pumping stations. This level of security is the most applicable to this option.

Level 3 Security includes all of the features of Level 2 plus enhanced security measures such as the use of video cameras for real-time monitoring of the facility, monitors, motion detectors and alarm sound system in the occupied control buildings. Facilities requiring this level of security would possess the highest threat level of all the critical assets. The surge barriers located in the bays, manned control buildings, and power plants would require this level of security.

3.4.2.7.7 Operations and Maintenance

The features that require periodic operations will be the exercising of the pumps and emergency generators at the various pump stations, the testing of the gate structures at the various road crossings, grass cutting of the levee slopes and toe areas and the filling of rilled areas within the embankment due to surface erosion. Scheduled maintenance should include periodic greasing of all gears and coupled joints, maintaining any battery backup systems, and replacement of standby fuel supplies.

3.4.2.7.8 Cost Estimate

The costs for the various options included in this measure are presented in Section 3.4.2.8 Cost Summary. Construction costs for the various options are included in Table 3.4.2-2 and costs for the annualized Operation and Maintenance of the options are included in Table 3.4.2-3. Estimates are comparative-Level "Parametric Type" and are based on Historical Data, Recent Pricing, and

Estimator's Judgment. Quantities listed within the estimates represent Major Elements of the Project Scope and were furnished by the Project Delivery Team. Price Level of Estimate is April 07. Estimates excludes project Escalation and HTRW Cost. The construction costs include real estate, engineering design (E&D), construction management, and contingencies. The E&D cost for preparation of construction contract plans and specifications includes a detailed contract survey, preparation of contract specifications and plan drawings, estimating bid quantities, preparation of bid estimate, preparation of final submittal and contract advertisement package, project engineering and coordination, supervision technical review, computer costs and reproduction. Construction Contingency developed and assigned at 25% to cover the Cost Growth of the project.

3.4.2.7.9 Schedule and Design for Construction

After the authority for the design has been issued and funds have been provided, the design of these structures will require approximately 12 months including comprehensive plans and specifications, independent reviews and subsequent revisions. The construction of this option should require in excess of two years.

3.4.2.8 Cost Estimate Summary

The costs for construction and for operations and maintenance of all options are shown below. Estimates are comparative-Level "Parametric Type" and are based on Historical Data, Recent Pricing, and Estimator's Judgment. Quantities listed within the estimates represent Major Elements of the Project Scope and were furnished by the Project Delivery Team. Price Level of Estimate is April 07. Estimates excludes project Escalation and HTRW Cost.

Table 3.4.2-2.
Hancock Co Inland Barrier Construction Cost Summary

Option	Total project cost
Option A – Elevation 20 ft NAVD88	$379,400,000
Option B – Elevation 30 ft NAVD88	$852,200,000
Option C – Elevation 40 ft NAVD88	$790,800,000

Table 3.4.2-3.
Hancock Co Inland Barrier O & M Cost Summary

Option	O&M Costs
Option A – Elevation 20 ft NAVD88	$3,390,000
Option B – Elevation 30 ft NAVD88	$8,934,000
Option C – Elevation 40 ft NAVD88	$7,562,000

3.4.2.9 References

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Weather Bureau and USACE. 1956. 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.

3.4.3 St. Louis Bay Surge Barrier

3.4.3.1 General

In order to protect the properties surrounding Saint Louis Bay and along the lower portions of the various rivers and streams flowing into the bay, a barrier would be required at some point to block storm waters during major storm events. A proposed alignment for the surge barrier is shown in Figure 3.4.3.1-1. As outlined above, a search of other similar facilities constructed world wide revealed that the structure model best satisfying both the engineering and socio-ecological necessities of this site was that used for the Thames River Barrier in London, UK. The structure tentatively investigated for incorporation into this work was thus, patterned after the Thames River Barrier with certain minor modifications to adapt to the site and environment specific conditions enumerated previously.

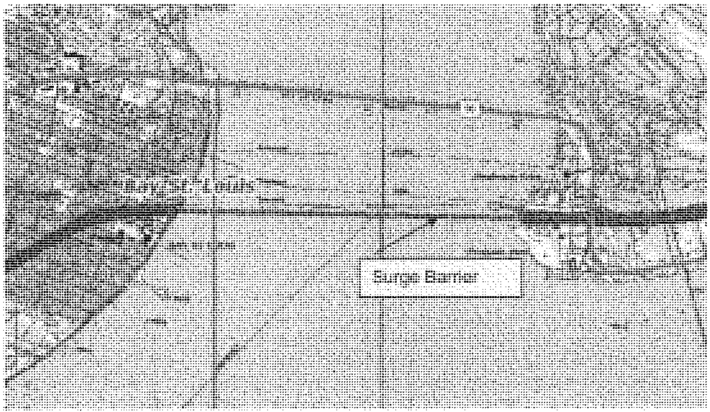


Figure 3.4.3.1-1. St. Louis Bay Surge Barrier Location

3.4.3.1.1 Interior Drainage

In the event of an imminent hurricane, the gates St Louis Bay would be closed, and flow from the rivers feeding these bays, as well as local runoff would pond behind the gates. The tentative location of the barrier chosen for this study is shown below.

The St. Louis Bay watershed, Figure 3.4.3.1-2, covers approximately 654 square miles and is comprised of six sub-basins that stretch across the Mississippi counties of Harrison, Hancock, Stone, and Pearl River. There is one United States Geological Survey (USGS) discharge stream gage (#2481510) located in the watershed along the Wolf River, near Landon, Mississippi. There are three significant National Oceanic and Atmospheric Administration (NOAA) hourly precipitation gages located nearby to the watershed: #109617 White Sand located to the west, #87720 Purvis 2 N to the north, and #109617, 87720, and 107840 Saucier Experimental Forest to the east of the basin. Data from these gages, along with soils data from the National Cooperative Soil Survey and Technical Paper 40 (TP-40) synthetic rainfall events were used to determine the peak discharge and total run-off volume entering St. Louis Bay from the St. Louis Bay watershed for the 2 year, 5 year, 10 year, 25 year, 50 year and 100 year rainfall events.

The Hydrologic Engineering Center's Hydrologic Modeling System (HEC-HMS) was used for the modeling effort. The components of the model include the precipitation specification, the loss model, the direct runoff model, and observed discharge data. Precipitation data used in the modeling process included hourly precipitation from NOAA gages 109617, 87720, and 109617, 87720, and 107840 and the 2-100 year 24-hour TP-40 rainfall events. The initial and constant loss rate method was used for the loss model while the Snyder's unit hydrograph (UH) method was used for the direct runoff model. The model was calibrated to observed hourly discharge data for one event at USGS gage 2481510. Several other events were analyzed but not used because the observed hourly precipitation for those events did not match the TP-40 rainfall.

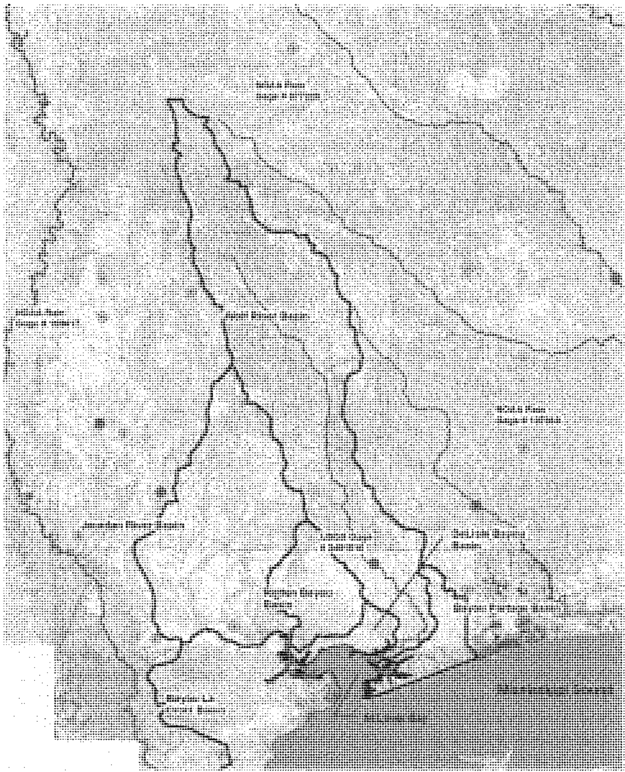


Figure 3.4.3.1-2. St. Louis Bay Watershed

Calibration results agree reasonably well with observed data as shown in Figure 3.4.3.1-3.

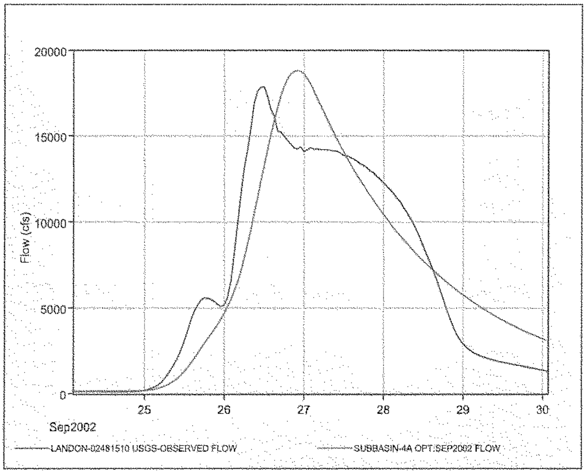


Figure 3.4.3.1-3. St. Louis Bay Watershed Calibration

Ponding from the interior rivers behind the gates will depend partially on the elevation of the gulf when the gates are closed. Several historical stage hydrographs of hurricanes were reviewed to determine the duration of various stages along the gulf. From this review, it was determined that storms generally reach 4 ft NAVD88 and recede to that elevation within 24 hours. Using this information, various theoretical coincident rainfall events taken from T.P 40 were modeled to determine the resulting water surface elevations behind the barrier during the 24-hour period the gates are to be closed. A 10-yr rain was selected for the design condition. This decision was 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, U.S. Army Corps of Engineers.

The 24-hour period of highest inflow from the flow hydrograph was used to compute changes in bay elevations in the 24-hour gate closure period.

Based on this method of analysis, the resulting elevations for the various storms are shown in Table 3.4.3.1-1, with the 10-yr elevation of 6.8 ft NAVD88 the design condition.

Table 3.4.3.1-1.
St. Louis Bay Ponding

St. Louis Bay 4 ft. Base Elevations	
Strom Event	**Bay Elevation (ft NAVD88)**
2-year	5.5
5-year	6.3
10-year	6.8
25-year	7.5
50-year	7.9
100-year	8.4

The ponded water area in above the surge barrier gates is approximated by the 8-ft ground contour line shown in Figure 3.4.3.1-4.

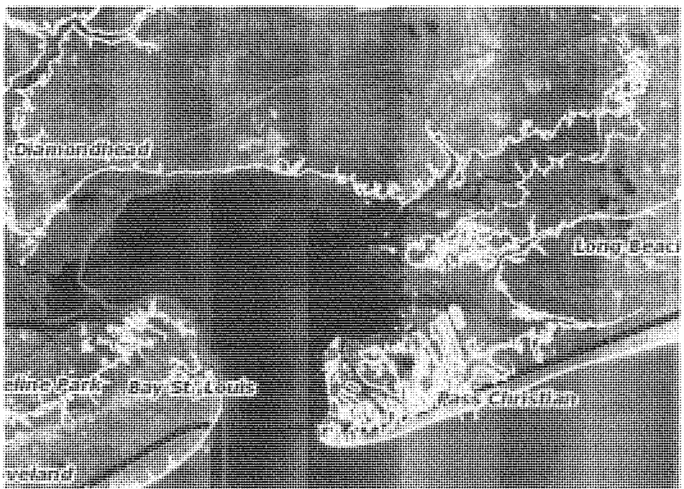


Figure 3.4.3.1-4. St. Louis Bay 10-yr Ponding to Elev 6.8 ft NAVD88

3.4.3.1.2 Geotechnical Data

The available mapping covering the bay bottom is very sketchy consisting mostly of quad maps. This data indicates that the existing bay bottom elevation along the study alignment would be fairly uniform at approximate (-)7 to (-) 8 feet across much of the bay width. The water depth naturally tapers from full depth to the water's edge over some distance out from each bank. Information gathered from the Mississippi Department of Transportation indicates that the bay bottom materials are very loose and unstable to a significant depth below the bay bottom indicating that a significant amount of undercutting would be required for any structure that might be installed, and that structures of the magnitude under consideration would require very deep pile foundations.

3.4.3.1.3 Structural, Mechanical and Electrical

See sections 3.4.3.1.3.1 through 3.4.3.1.3.3.

3.4.3.1.3.1 Structural

Structurally, the Barrier as configured for this study would consist of a series of 38 large stainless steel clad, structural steel framed gates called rising sector gates. Each of these would be supported on reinforced concrete piers resting on large continuous concrete sills with pile foundations. The tentative layout used to estimate the scope of the structure was configured having gates 132 feet long mounted on 28-foot wide piers. The number of gates was determined by the extent of water having depth sufficient to support their operation. To facilitate as nearly as possible the normal ebb and flow of tide waters through the barrier, the concrete connector wall and rock fill portions of the barrier either side of the gated structure would be fitted with a series of closely spaced low level gated culverts. The gate and pier heights were varied to accommodate the "level of protection" under consideration. The three elevations selected for this study were 20, 30, and 40 NAVD88. In each instance the gate heights were set to match the protection level elevations with pier heights set approximately 3 feet higher to provide minor wave clearance for protection of operating equipment. Atop each pier an operating machinery block would be mounted to house the operating equipment. No lateral access over the tops of the piers was envisioned because of the long spans and the desire to keep the vista across the structure as clear as possible. Operating and utility access would be provided through two continuous tunnels passing through the sill section and the rock fill, to operating facilities located on each bank.

3.4.3.1.3.2 Mechanical

The mechanical equipment and appurtenances required for operation of these facilities would include very large steel gate linkages and hydraulic rams and pivot pins for operation of each gate. Each gate would rotate on large bearings and pivot hubs at each end of the gate. Various operating hydraulic and lubrication oil systems would also be required. Each gate would have an opening/closing time of approximately 15 minutes.

3.4.3.1.3.3 Electrical

Primary electrical power for operating the gates would be provided using dedicated, standard transformers with emergency back-up generators. The size of the generators would be greatly reduced by minimizing the wattage output through reduction of the demand on the facility. The demand would be minimized by phasing the operation of the gates to the greatest extent possible. For this study it was determined that this could possibly be done by operating a maximum of eight gates at a time, with the last eight gates being left open until the storm threat was definite and eminent. The operation would require that a maximum of four gates be started at one time, with the remaining four gates sequenced to start 1 minute later. It was determined that this would allow the entire closure and subsequent opening operations to be done over a period of 4 to 6 hours. The supplemental generation aspect was considered to be a vital component of the design because of the very high cost of Commercial standby power and because commercial electric power would almost certainly be unavailable during and immediately following a storm event.

3.4.3.1.4 HTRW

Due to the extent and large number of real estate parcels along with the potential for re-alignment of the structural aspects of this project, no preliminary assessment was performed to identify the possibility of hazardous waste on the sites. These studies will be conducted during the next phase of work after the final siting of the various structures. The real estate costs appearing in this report

therefore will not reflect any costs for remediation design and/or treatment and/or removal or disposal of these materials in the baseline cost estimate.

3.4.3.1.5 Construction Procedures and Water Control Plan

Following is a very tentative description of a sequence of construction by which the barrier structure and embankments might be built. There are admittedly myriad other means by which this could be accomplished as demonstrated by the construction methods used in construction of the Thames River Barrier and various structures in The Netherlands and elsewhere, any one of which might result in more economical and expeditious construction of the barrier. However, at this juncture, in the interest of clarity and brevity, it was considered expedient to describe this work using customary construction techniques common to most of our large civil works projects constructed to date.

3.4.3.1.5.1 Construction Procedure

As configured for this study, the physical construction of the barrier would begin with installation of the first of what would likely be a three stage cellular cofferdam. The arrangement assumed for this study consisted of a series of circular sheet pile cells and connecting arcs measuring approximately 60 feet in diameter and extending 100 feet from the top of the cell to the pile tip elevation. These cells would encompass either the east side or west side transition monoliths and approximately one-third of the gated portion of the structure. It was assumed that for structures designed to provide the highest protection level (Elevation 40 NAVD88) the top of cells could be placed at elevation 35 with reasonable degree of safety. This would provide cell embedment of approximately 30 feet below the lowest structure foundation elevation. This configuration was, naturally, modified to fit the lower levels of protection, but in each case the configuration was made to provide the same relative of protection during construction. With the cofferdam in place the interior would be dewatered using hydraulic pumps, and excavation for the concrete structures would begin. Once the excavation in a given area is brought to the required grade work would continue in this area with the installation of foundation piles. Prior to completion of this phase of the work, installation would begin on the next phase of the cofferdam.

Once the first phase of the concrete structure is completed and the first phase cofferdam removed, installation of the gates and operating machinery would begin. Fabrication of the gates would have been done on land in an outfitting yard and the gates transported by water to the proper installation site. Note that this would likely require dredging of a temporary construction channel parallel to the barrier for a portion of its length.

Construction of the rock fill embankments would require surcharging and pre-consolidation of the bay bottom materials. (See section 3.4.3.1.2 above for discussion of the Geotechnical aspects of this site.)

3.4.3.1.5.2 Water Control Plan

As this work progresses the flow into and out of Saint Louis Bay would be somewhat restricted for practically the entire construction time. This restriction could be minimized by removal of the cofferdams immediately upon completion of the concrete piers to some point above the normal high tide level thus allowing flow over the completed sill sections as construction continues on the piers and as the gates are being installed. It is estimated the maximum flow restriction at any time would be approximately 30% of the inlet width and that this restriction could endure for as much as four to seven years using the methods and approximate sequence of construction indicated above.

3.4.3.1.6 Physical Security

As described in 3.4.1.7, the construction of the project the contractor would be responsible for maintaining security of all his work sites. This would be done in accordance with latest AT/FP guidance for projects of this type and scope in addition to the normal site security requirements.

Upon completion of the project the facilities security responsibilities would pass to the U.S. Army Corps of Engineers and the state, county and municipal law enforcement entities, all of whom would coordinate a program of oversight under which the facilities would be operated and maintained and under which specific security responsibilities would be defined and allocated. These agreements would also be required to meet AT/FP requirements in addition to normal security criteria.

3.4.3.1.7 Operations and Maintenance

In order to assure proper functioning of the facilities once they are placed in service a program of Operations and Maintenance would be developed by the U.S. Army Corps of Engineers, in conjunction and cooperation with the affected state and local entities. This O & M Plan would address specific responsibilities as to daily operation of the facilities, the periodic testing and maintenance of the operating machinery, maintenance of specified stocks of replacement parts, security of the facilities, and maintenance of any buildings and grounds associated with the operation and maintenance of the facilities. As presently envisioned, this O & M responsibility would remain under control of the U.S. Army Corps of Engineers and would be administered under its Operations mission.

3.4.3.1.8 Cost Estimate

The costs for the various options included in this measure are presented in Section 3.4.3.8 Cost Summary. Construction costs for the various options are included in Table 3.4.3.8-1 and costs for the annualized Operation and Maintenance of the options are included in Table 3.4.3.8-2. Estimates are comparative-Level "Parametric Type" and are based on Historical Data, Recent Pricing, and Estimator's Judgment. Quantities listed within the estimates represent Major Elements of the Project Scope and were furnished by the Project Delivery Team. Price Level of Estimate is April 07. Estimates exclude project Escalation and HTRW Cost. The construction costs include real estate, engineering design (E&D), construction management, and contingencies. The E&D cost for preparation of construction contract plans and specifications includes a detailed contract survey, preparation of contract specifications and plan drawings, estimating bid quantities, preparation of bid estimate, preparation of final submittal and contract advertisement package, project engineering and coordination, supervision technical review, computer costs and reproduction. Construction Contingency developed and assigned at 25% to cover the Cost Growth of the project.

3.4.3.1.9 Schedule and Design for Construction

The scheduling for events following this conceptual study would of necessity include further study to ascertain in greater detail the specific requirements of the project and the most feasible means by which to fulfill these requirements. The Sequence of events would include but not be limited to the following:

a. The alignment and extent of the proposed barrier should be subjected to detailed study to determine the most feasible routing. This study should address, among other factors, the exact location of utilities features crossing the bay inlet, the present and projected future needs of boat traffic passing through the barrier, and how best to minimize the effects that the barrier could have on the existing marine environment.

b. Detailed deep geotechnical investigation should be made to determine as accurately as possible the engineering capabilities of the soils making up the bay bottom along the alignment (or alignments) under consideration.

c. A more thorough and painstaking investigation of various types of gate structures should be undertaken to confirm the choice of the rising sector gate for this application, or to replace this type gate with another perhaps more appropriate to the circumstances.

d. Once exhaustive search and investigations and analyses have been completed a thorough design of the structures to be included in the final facility would be undertaken addressing the full range of hydraulic events that the structure might see, and making certain that all pertinent design considerations are accounted for.

e. A thorough analysis of the power required to operate the gates in a timely manner in time of storm must be made and the very best, most dependable means of providing this power determined.

f. The link between the operation of the gates and the best available storm forecasting system(s) would be designed and its operating features and equipment detailed.

3.4.3.2 Location

The alignment suggested herein for the barrier structure would run parallel with and south of the Railroad Bridge crossing Saint Louis Bay. This would approximate the shortest route across the inlet leading form the Mississippi Sound into the bay. As the layout of the barrier was developed it became apparent that, because of the excavation required, a significant amount of separation would be required between the railroad bridge and the ultimate location of the structures included in the barrier. For this study the centerline of the barrier was positioned approximately 260 feet from the center of the railroad bridge. This was left unaltered for all protection levels. The entire barrier would be approximately 10,320 feet in length from water's edge to water's edge, and would consist of rock fill levees extending from the overland levee at each bank for some distance into the bay and enveloping the mass concrete non-overflow wall sections leading to each end of the gated structure.

3.4.3.3 Existing Conditions

The points at which the barrier would come ashore in Jackson County on the east and Harrison County on the west, are in urban areas with extensive residential and commercial development. Several structures would need to be relocated and it is uncertain the extent to which existing utilities might have to be relocated to clear the way for this facility.

3.4.3.4 Coastal and Hydraulic Data

Historic coastal data is shown in Paragraph 1.4, elsewhere in this report. High water marks taken by FEMA after Hurricane Katrina in 2005 as well as the 8-ft(dark green), 12-ft(light green), 16-ft(brown), and 20-ft(pink) ground contour lines are shown in Figure 3.4.3.4-1. The data indicates the Katrina high water was as high as 22 ft NAVD88 at the mouth of the bay.

Stage-Frequency data for a suite of severe storms using Joint Probability Method (JPM) and hydrodynamic modeling were developed by the Engineer Research and Development Center (ERDC) for 80 locations along the study area. These data were combined with historical gage frequencies for smaller storms to establish stage-frequency curves at 54 economic reaches in the study area which were entered into Hydrologic Engineering Center's (HEC) Flood Damage Analysis (HEC-FDA) application to evaluate benefits. An expanded description of the procedure is shown elsewhere in this report. Points near the mouth of the bay at which data from hydrodynamic modeling was saved are shown in Figure 3.4.3.4-2.

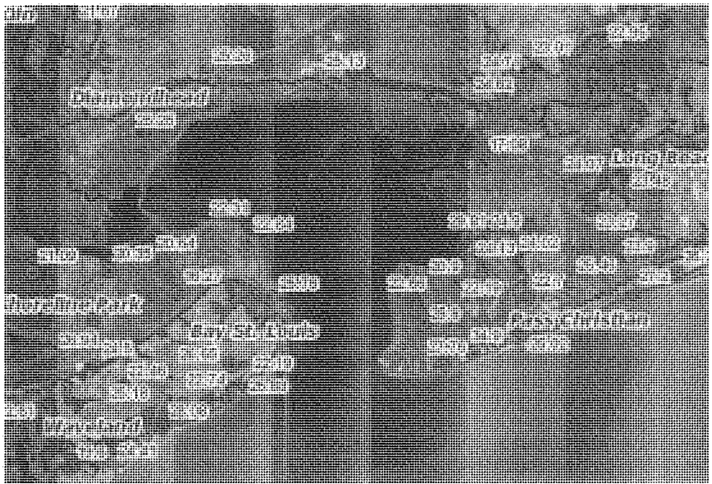


Figure 3.4.3.4-1. Ground Contours and Katrina High Water

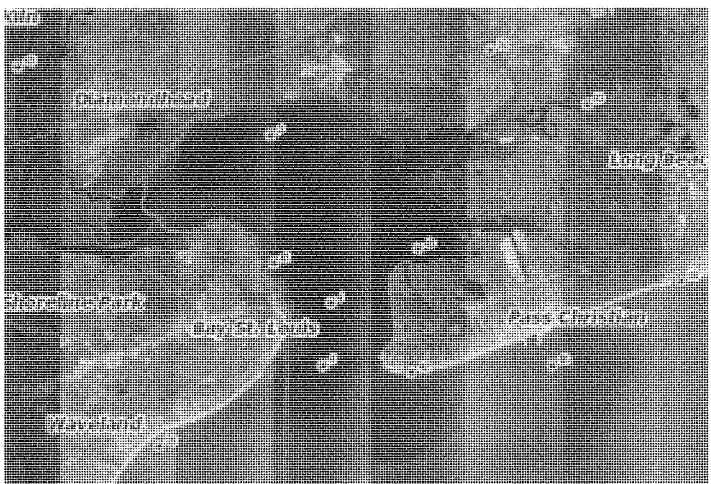


Figure 3.4.3.4-2. Hydrodynamic Modeling Save Points near St Louis Bay

Existing Condition Stage –Frequency data for Save Point 61, near the mouth of the bay, is shown in Figure 3.4.3.4-3. The 95% confidence limits, approximately equally to plus and minus two standard deviations, are shown bounding the median curve. The elevations are presented at 100 ft higher than actual to facilitate HEC-FDA computations.

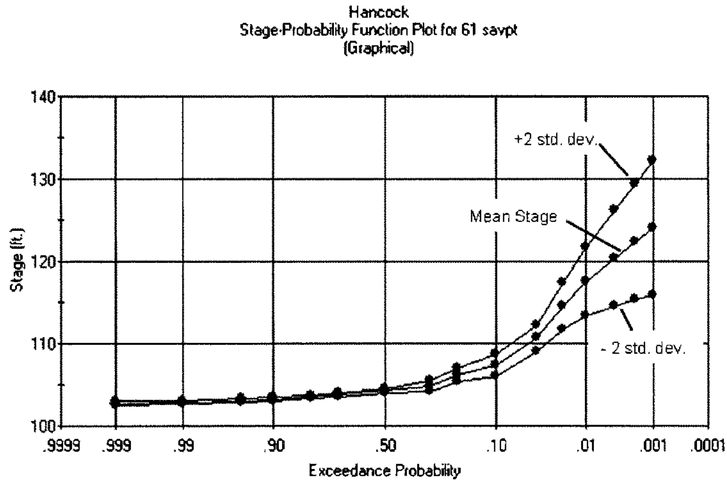


Figure 3.4.3.4-3. Existing Conditions at Save Point 61, near the Mouth of St. Louis Bay

3.4.3.5 Option A – Elevation 20.0

In order to reasonably accurately approximate the scope of the structures required to form a moveable barrier to elevation 20 a very preliminary rising sector gate design was made for the gate and its operating disks, and the piers and foundations were approximated on a proportional basis. A system of foundation piles was then estimated from a stability analysis made for the most stringent hydraulic situation, water with wave impact to the top of the gates on the flood side and at elevation "Zero" on the protected side of the gate. Uplift for the situation described was assumed to vary from full static water head at the flood side edge of the sill to static water pressure equivalent to the embedment of the sill below elevation "zero" at the protected side edge of the sill. Static lateral water forces were derived for static water pressure to elevation 20 on the flooded side of the structure and to elevation "zero" on the protected side. Wave impact data from model testing was not yet available when these analyses were made. Therefore an approximation of the wave impact loading was made by applying 25% of the flooded side static head pressure at the top of the gate and allowing this to taper to zero at the base of the monolith. The force and moment resulting from this inverted triangular load was then added to that derived for the static head situation.

The preliminary design for a gated structure providing protection up to elevation 20 resulted in gross quantities of basic construction materials as indicated in Table 3.4.3.5-1 below.

Table 3.4.3.5-1.
Gross Quantities for Saint Louis Bay Surge Barrier Elevation 20.0 NAVD88

Item	Quantity	Units
Cofferdam Piling	38,008	Tons
Foundation Piling	20,540	Each
Concrete	493,700	Cubic Yards
Reinforcement	1,210	Tons
Rising Sector Gates (25 Each)	19,750	Tons
Gate Operating Machinery (Steel, 25 sets)	10,100	Tons

Note: Quantities taken from preliminary stability and other design computations.

3.4.3.6 Option B – Elevation 30.0

In order to reasonably accurately approximate the scope of the structures required to form a moveable barrier to elevation 30, a very preliminary rising sector gate design was made for the gate and its operating disks, and the piers and foundations were approximated on a proportional basis. The foundation piles were then estimated from a stability analysis made for the most stringent hydraulic situation, water with wave impact to the top of the gates on the flood side and at elevation "Zero" on the protected side of the gate. Uplift for the situation described was assumed to vary from full static water head at the flood side edge of the sill to static water pressure equivalent to the embedment of the sill below elevation "zero" at the protected side edge of the sill. Static lateral water forces were derived for static water pressure to elevation 30 on the flooded side of the structure and to elevation "zero" on the protected side. Wave impact data from model testing was not yet available when these analyses were made. Therefore an approximation of the wave impact loading was made by applying 25% of the flooded side static head pressure at the top of the gate and allowing this to taper to zero at the base of the monolith. The force and moment resulting from this inverted triangular load was then added to that derived for the static head situation.

The preliminary design for a gated structure providing protection up to elevation 30 resulted in gross quantities of basic construction materials as indicated in Table 3.4.3.6-1 below.

Table 3.4.3.6-1.
Gross Quantities for Saint Louis Bay Surge Barrier Elevation 30.0 NAVD88

Item	Quantity	Units
Cofferdam Piling	47,511	Tons
Foundation Piling	14,538	Each
Concrete	552,800	Cubic Yards
Reinforcement	1,083	Tons
Rising Sector Gates (25 Each)	24,260	Tons
Gate Operating Machinery (Steel, 25 sets)	10,100	Tons

Note: Quantities taken from preliminary stability and other design computations.

3.4.3.7 Option C – Elevation 40.0

In order to reasonably accurately approximate the scope of The structures required to form a moveable barrier to elevation 40, a very preliminary rising sector gate design was made for the gate and its operating disks, and the piers and foundations were approximated on a proportional basis. The foundation piles were then estimated from a stability analysis made for the most stringent hydraulic situation, water with wave impact to the top of the gates on the flood side and at elevation

"Zero" on the protected side of the gate. Uplift for the situation described was assumed to vary from full static water head at the flood side edge of the sill to static water pressure equivalent to the embedment of the sill below elevation "zero" at the protected side edge of the sill. Static lateral water forces were derived for static water pressure to elevation 40 on the flooded side of the structure and to elevation "zero" on the protected side. Wave impact data from model testing was not yet available when these analyses were made. Therefore an approximation of the wave impact loading was made by applying 25% of the flooded side static head pressure at the top of the gate and allowing this to taper to zero at the base of the monolith. The force and moment resulting from this inverted triangular load was then added to that derived for the static head situation.

The preliminary design for a gated structure providing protection up to elevation 40 resulted in gross quantities of basic construction materials as indicated in Table 3.4.3.7-1 below.

Table 3.4.3.7-1.
Gross Quantities for Saint Louis Bay Surge Barrier Elevation 40.0 NAVD88

Item	Quantity	Units
Cofferdam Piling	47,511	Tons
Foundation Piling	20,540	Each
Concrete	561,300	Cubic Yards
Reinforcement	1,061	Tons
Rising Sector Gates (25 Each)	40,291	Tons
Gate Operating Machinery (Steel, 25 sets)	10,100	Tons

Note: Quantities taken from preliminary stability and other design computations.

3.4.3.8 Cost Estimate Summary

The costs for construction and for operations and maintenance of all options are shown below. Estimates are comparative-Level "Parametric Type" and are based on Historical Data, Recent Pricing, and Estimator's Judgment. Quantities listed within the estimates represent Major Elements of the Project Scope and were furnished by the Project Delivery Team. Price Level of Estimate is April 07. Estimates excludes project Escalation and HTRW Cost.

Table 3.4.3.8-1.
St Louis Bay Surge Barrier Construction Cost Summary

Option	Total project cost
Option A – Elevation 20 ft NAVD88	$1,628,000,000
Option B – Elevation 30 ft NAVD88	$1,963,600,000
Option C – Elevation 40 ft NAVD88	$2,362,200,000

Table 3.4.3.8-2.
St Louis Bay Surge Barrier O & M Cost Summary

Option	O&M Costs
Option A – Elevation 20 ft NAVD88	$22,674,000
Option B – Elevation 30 ft NAVD88	$27,364,000
Option C – Elevation 40 ft NAVD88	$32,936,000

3.4.3.9 References

See 3.4.3 General discussion above for references.

3.4.4 Harrison County Inland Barrier

3.4.4.1 General

Residential and business areas along the coast in Harrison County are susceptible to storm surge damage. A damage reduction option is to construct an inland barrier to various elevations were evaluated. Additional options not evaluated in detail are described elsewhere in this report.

Evaluation of this option was done by comparing benefits computed by Hydrologic Engineering Center's (HEC) Flood Damage Analysis (FDA) computer application HEC-FDA and costs computed. HEC-FDA modeling was done comparing the study reaches using variations in expected sea-level rise and development. Details regarding the methodology are presented in Section 2.14 of the Engineering Appendix and in the Economic Appendix.

3.4.4.2 Location

The location of the barrier in Harrison County is shown in Figure 3.4.4-1 extending from Biloxi Bay to Pass Christian approximately 1000-3000 ft north of, and parallel to, the shoreline. This alignment is evaluated in Options A through E. For Options F through J, an alternate alignment is evaluated. This alternate alignment extends from Biloxi Bay to Menge Avenue, thence northward along Menge Avenue to high ground. Both alignments are shown on the map. They are also shown in more detail in the Option A section (Figures 3.4.4-12 through 3.4.4-14) and the Option F section (Figures 3.4.4-29 through 3.4.4-31).

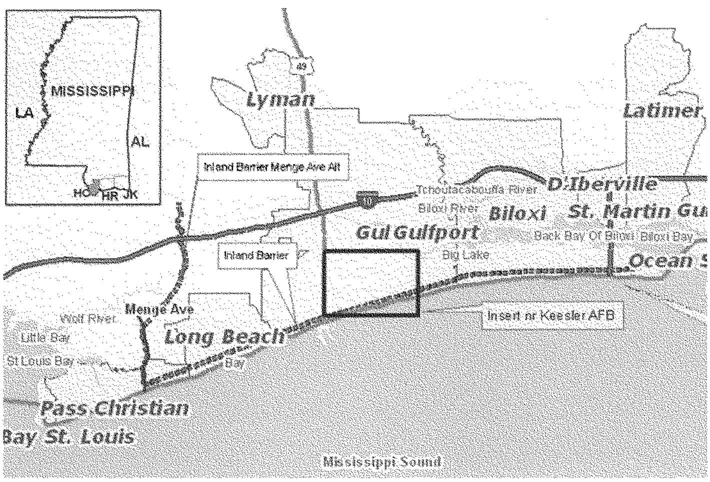


Figure 3.4.4-1. Vicinity Map Harrison County, MS

3.4.4.3 Existing Conditions

In Harrison County, ground elevations over most of the residential and business areas vary between elevation 8-12 ft NAVD88 on the coast and rising within 1000 ft to elevation 30-36 along a ridge parallel to the coast line, then decreasing to the north. The 4-ft (blue), 8-ft (green), 20-ft (pink), 30-ft (dark blue) and 34-ft (gold) ground contours show the pattern at the coastline for the county and are shown in Figure 3.4.4-2.

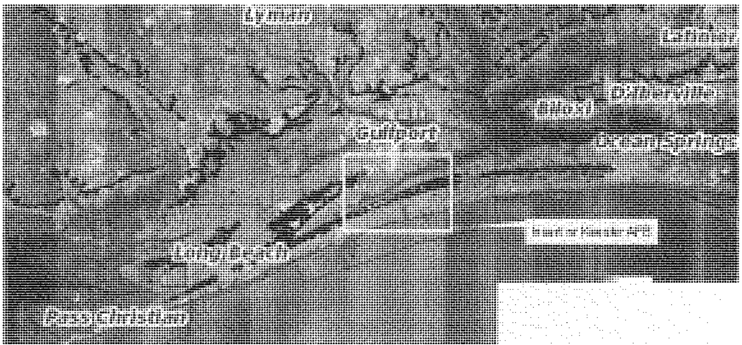


Figure 3.4.4-2. Existing Conditions Harrison County, MS

A close-up near Keesler Air Force Base is shown in Figure 3.4.4-3. The 4-ft(blue), 8-ft(dark green), 12-ft(light green), 16-ft(brown), 20-ft(pink), 24-ft(light purple), 28-ft (teal), and 32-ft (gold) ground contour lines are shown.

The area is drained by natural and some improved channels. Above the ridge water drains o the north, thence to either the Back Bay of Biloxi on the east side of the county, or to the west to the St Louis Bay. South of the ridge, the water drains to Mississippi Sound.

Drainage from ordinary rainfall is hindered on occasions when either of the rivers in the area or the gulf is high, but impacts from hurricanes are devastating.

Damage from Hurricane Katrina in August, 2005 in the Pascagoula area are shown in Figures 3.4.4-4 and 3.4.4-5. Many homes are still un-repaired, pending settlement of insurance claims.

Figure 3.4.4-3. Existing Conditions Harrison County near Keesler AFB

Source: http://ngs.woc.noaa.gov/storms/katrina/24330924.jpg

Figure 3.4.4-4. Hurricane Katrina Damage Harrison County, MS

Source: danakay, http://www.flickr.com/photo_zoom.gne?id=45235550&size=m

Figure 3.4.4-5. Hurricane Katrina Damage Harrison County, MS

3.4.4.4 Coastal and Hydraulic Data

Typical coastal data is shown in Section 1.4, of this report. High water marks taken by FEMA after Hurricane Katrina in 2005 as well as the Katrina inundation limits are shown in Figures 3.4.4-6 and 3.4.4-7. The data indicates the Katrina high water was as high as 21 ft NAVD88 Biloxi, and 28 ft NAVD88 at Pass Christian.

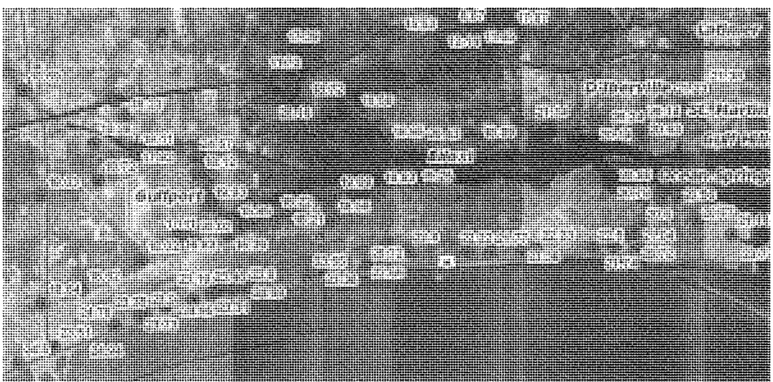


Figure 3.4.4-6. Hurricane Katrina High Water Elevations

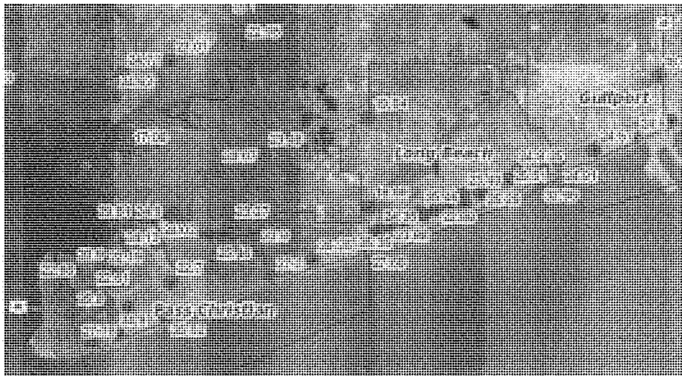


Figure 3.4.4-7. Hurricane Katrina High Water Elevations

A closer view at the intersection of Hwy 90 and US Hwy 49 in Gulfport of existing flooding potential along Harrison County is shown in Figure 3.4.4-8. Ground contours shown are 4-ft (blue), 8-ft (dark green), 12-ft (light green), 16-ft (brown), 20-ft (pink), 24-ft (light purple), 28-ft (teal), and 32-ft (gold).

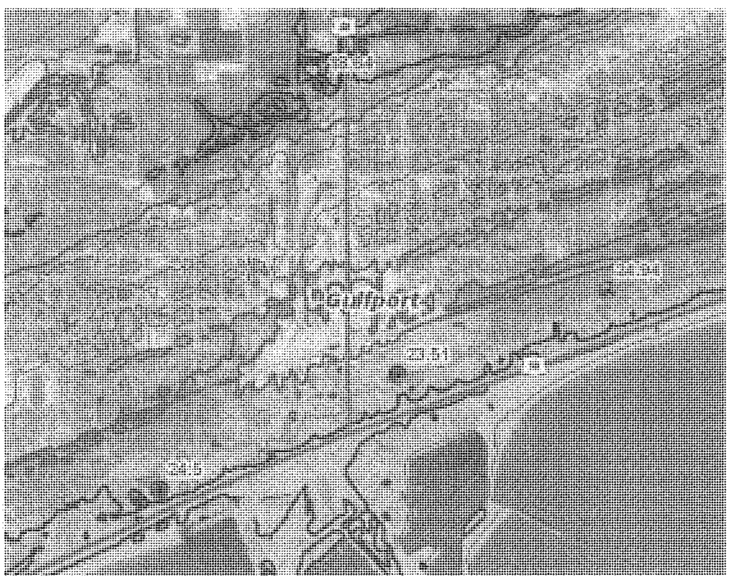


Figure 3.4.4-8. Ground Contours and Katrina High Water Elevations near Hwy 49

Stage-Frequency data for a suite of severe storms using Joint Probability Method (JPM) and hydrodynamic modeling were developed by the Engineer Research and Development Center (ERDC) for 80 locations along the study area. These data were combined with historical gage frequencies for smaller storms to establish stage-frequency curves at 54 economic reaches in the study area which were entered into Hydrologic Engineering Center's (HEC) Flood Damage Analysis (HEC-FDA) application to evaluate benefits. An expanded description of the procedure is shown in Section 2.14 of the Engineering Appendix and in the Economic Appendix. Points near the coast in Harrison County at which data from hydrodynamic modeling was saved are shown in Figures 3.4.4-9 and 3.4.4-10.

Existing Condition Stage –Frequency data for Save Point 50, just off the coast of Harrison County, is shown in Figure 3.4.4-11. The 95% confidence limits, approximately equally to plus and minus two standard deviations, are shown bounding the median curve. The elevations are presented at 100 ft higher than actual to facilitate HEC-FDA computations.

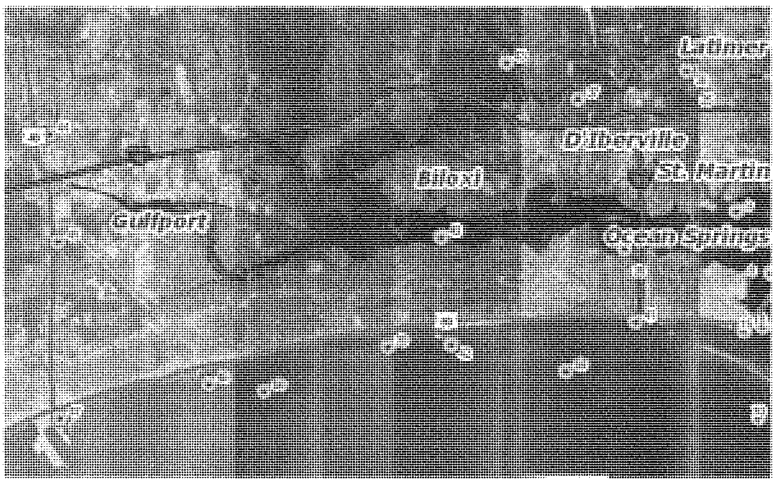


Figure 3.4.4-9. Hydrodynamic Modeling Save Points in Harrison County

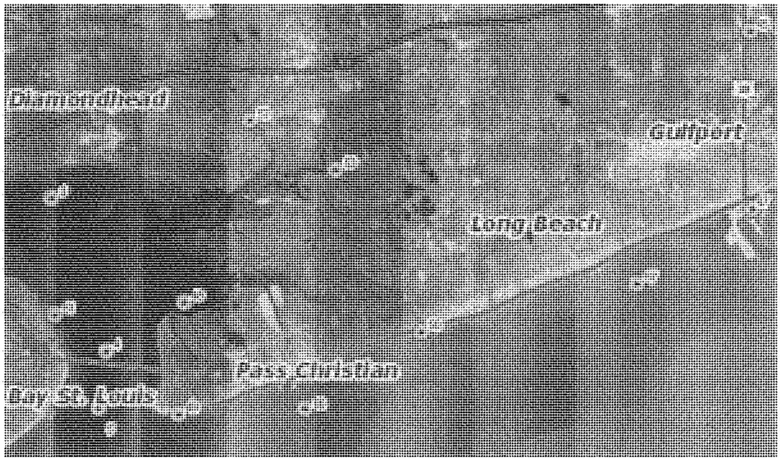


Figure 3.4.4-10. Hydrodynamic Modeling Save Points in Harrison County

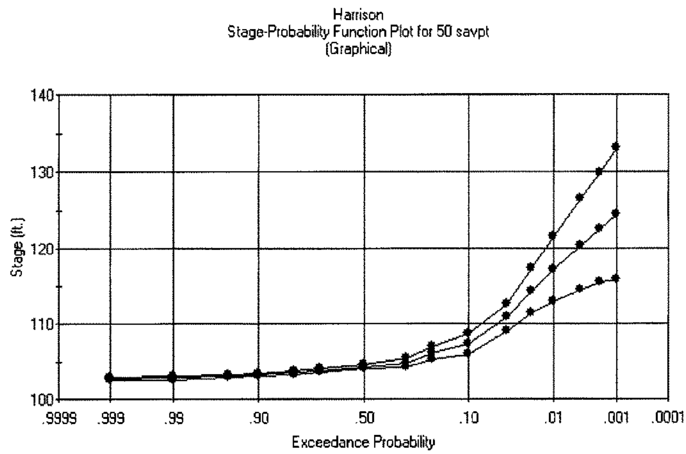


Figure 3.4.4-11. Existing Conditions at Save Point 50, near Pass Christian, MS

3.4.4.5 Option A – Elevation 20 ft NAVD88

This option consists of constructing a levee to elevation 20 ft NAVD88 along the coast of Harrison County as shown on Figures 3.4.4-12 through 3.4.4-14, along with the internal sub-basins and levee culvert/pump locations. Drainage basins 24 and 25 drain north against the levee. These sites will be ditched along the levee to St. Louis Bay.

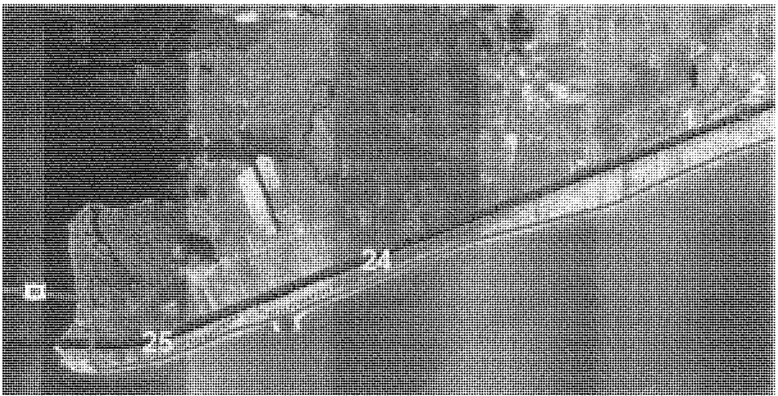


Figure 3.4.4-12. Pump/Culvert/Sub-basin Site Locations

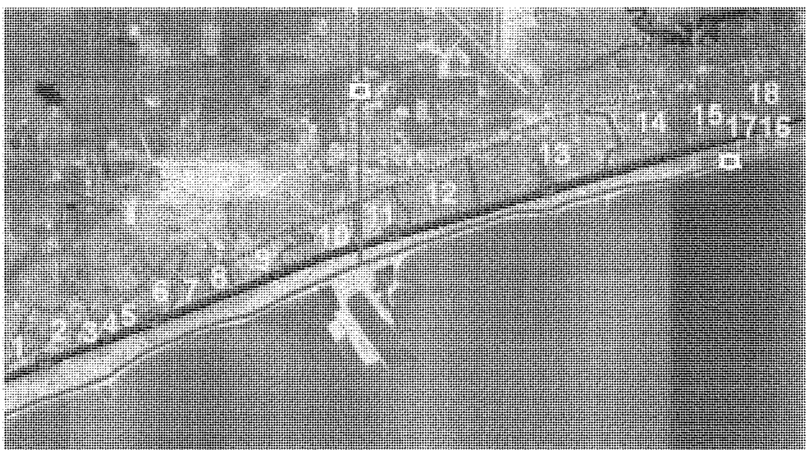


Figure 3.4.4-13. Pump/Culvert/Sub-basin Site Locations

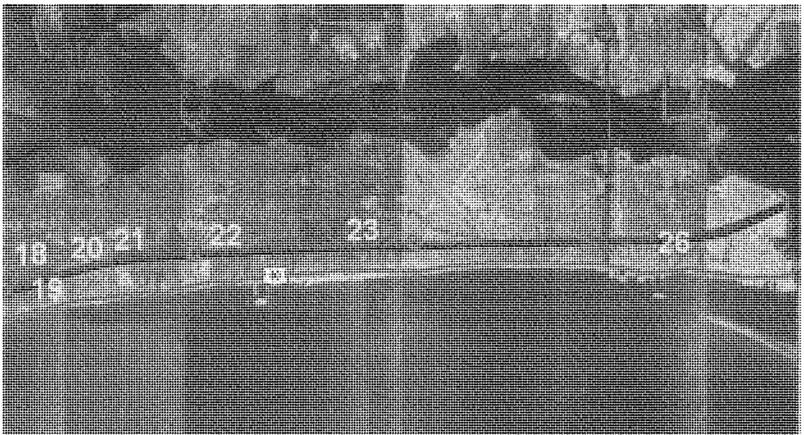
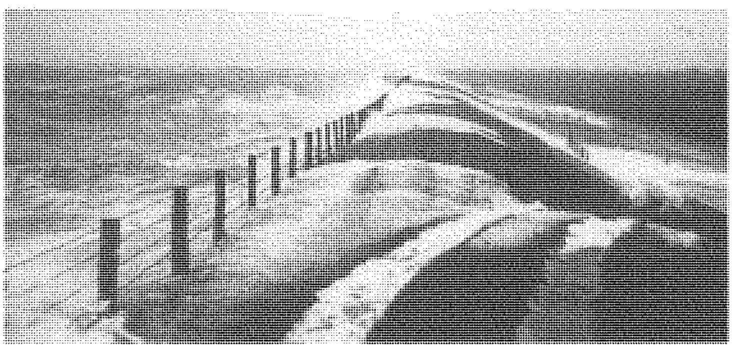


Figure 3.4.4-14. Pump/Culvert/Sub-basin Site Locations

Drainage basin 26 drains north against the levee. This site will be ditched along the levee to Biloxi Bay.

Damage and failure by overtopping of levees could be caused by storms surges greater than the levee crest as shown in the Figure 3.4.4-15.



Source: Wave Overtopping Flow on Seadikes, Experimental and Theoretical Investigations, Holger Schüttrumpf, (Photo: Leichtweiss-Institute) http://kfki.baw.de/fileadmin/projects/E_35_134_Lit.pdf

Figure 3.4.4-15. North Sea, Germany, March 1976

Overtopping failures are caused by the high velocity of flow on the top and back side of the levee. Although significant wave attack on the seaward side of some of the New Orleans levees occurred during Hurricane Katrina, the duration of the wave attack was for such a short time that major damage did not occur from wave action. The erosion shown in Figure 3.4.4-16 was caused by approximately 1-2 ft of overtopping crest depth.

Source: ERDC, Steven Hughes

Figure 3.4.4-16. Crown Scour from Hurricane Katrina at Mississippi River Gulf Outlet (MRGO) Levee in St. Bernard Parish, New Orleans, LA

Revetment will be included in the levee design to prevent overtopping failure.

The levee will be protected by gabions on filter cloth as shown in Figure 3.4.4-17, extending across a drainage ditch which carries water to nearby culverts and which would also serve to dissipate some of the supercritical flow energy during overtopping conditions.

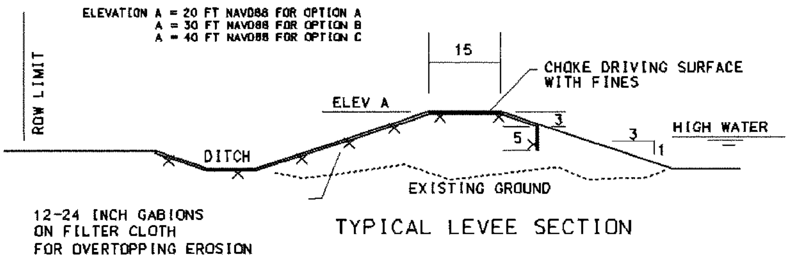


Figure 3.4.4-17. Typical Section at Levee

3.4.4.5.1 Interior Drainage

Drainage on the interior of the raised highway would be collected at the highway and channeled to culverts placed at 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 for control in the event the flap gate malfunctions. A typical section is shown in Figure 3.4.4-18.

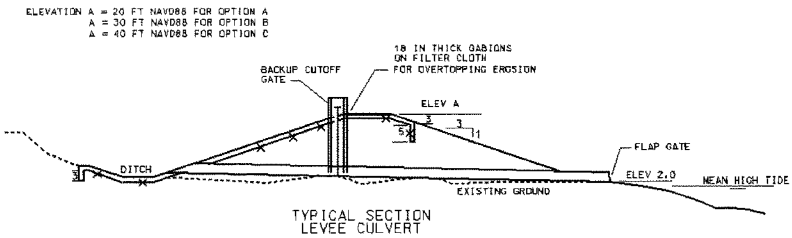


Figure 3.4.4-18. Typical Section at Culvert

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 drainage basin 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.

Peak flows for the 1-yr to 100-yr storms were computed. 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. For the culvert design, headwater/tailwater elevation difference was maintained at 3.0 ft or less. Drainage ditches along the toe of the highway will be required to assure that smaller basins can be drained to a culvert/pump site. These ditches were sized using a normal depth flow computation. Curve numbers, pump, and culvert capacity tables are not included in the report beyond that necessary to obtain a cost estimate. The data is considered beyond the level of detail required for this report.

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. This decision was 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. However, in some of the areas, existing storage could be adequate to pond water without causing damage, even without pumps. In other areas that do have pumps, some rise in interior water during interior events greater than the 10-yr rain could occur, but may not cause damage. Designing the pumps for the peak 10-yr flow provides a significant pumping capacity. Further studies will detail the requirement for the appropriate ponding areas, pump sizes, or buyouts in the affected areas.

During non-hurricane periods of low water in the sound, when rainfall greater than the 25-yr event occurs, the pumps could also be used to augment the flow capacity of the levee culverts.

3.4.4.5.1.1 Surge Barrier

In order to prevent hurricane surges from circumventing the levee, surge barrier gates would be constructed across both Biloxi Bay and St. Louis Bay. In the event of an imminent hurricane, the gates across the Back Bay of Biloxi and St. Louis Bay would be closed, and flow from the rivers feeding these bays, as well as local runoff would pond behind the gates. The location of the barriers are shown in Figure 3.4.4-19 and 3.4.4-20.

The gates would be similar to the rising sector gates across the Thames River in London, England, shown in Figure 3.4.4-21.

The gates are described in more detail elsewhere in this report.

The Hydrologic Engineering Center's Hydrologic Modeling System (HEC-HMS) was used to model both the Biloxi Bay watershed and the St Louis Bay watershed in order to predict the maximum water elevation behind the gates in the bays under several different storm scenarios. These two basins will be described separately.

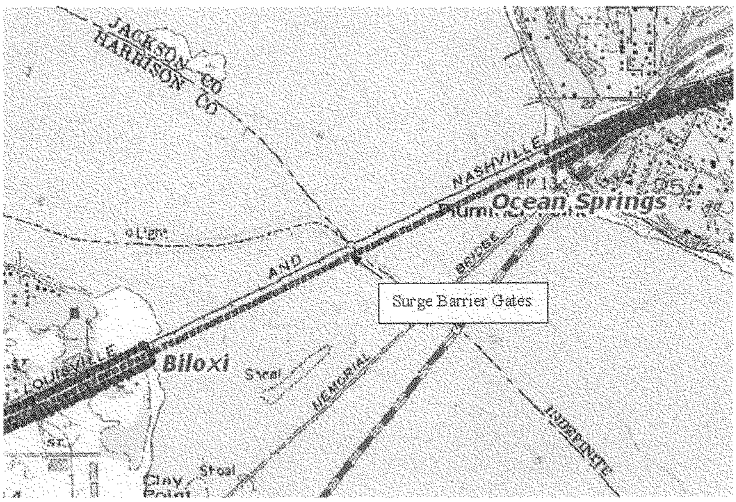


Figure 3.4.4-19. Biloxi Bay Surge Barrier Location

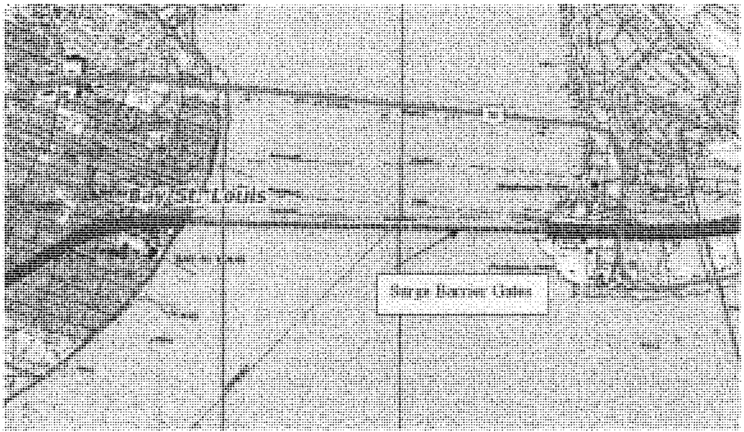


Figure 3.4.4-20. St Louis Bay Surge Barrier Location

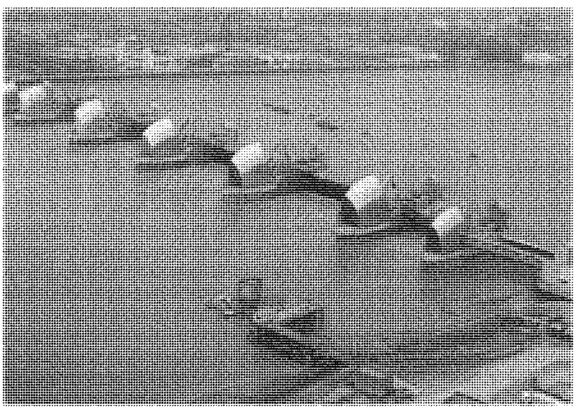


Figure 3.4.4-21. Thames River Barrier Gates

3.4.4.5.1.2 Biloxi Bay Modeling

The Biloxi Bay watershed is an approximately 640 square mile watershed comprised of six subbasins that stretch across Harrison, Stone, and Jackson County, MS. There is one United States Geological Survey (USGS) discharge gage located in the watershed along the Biloxi River and one National Oceanic and Atmospheric Administration (NOAA) hourly precipitation gage located on the east side of the watershed. The discharge gage is USGS gage 2481000 at Wortham, MS and the precipitation gage is NOAA gage 107840 (Saucier Experimental Forest). Data from these gages, along with soils data from the National Cooperative Soil Survey and Technical Paper 40 (TP-40) synthetic rainfall events were used to determine the peak discharge and total run-off volume entering Biloxi Bay from the Biloxi Bay watershed for the 2-100 year rainfall events. The Hydrologic Engineering Center's Hydrologic Modeling System (HEC-HMS) was used for the modeling effort. The Biloxi Bay watershed is shown in Figure 3.4.4-22.

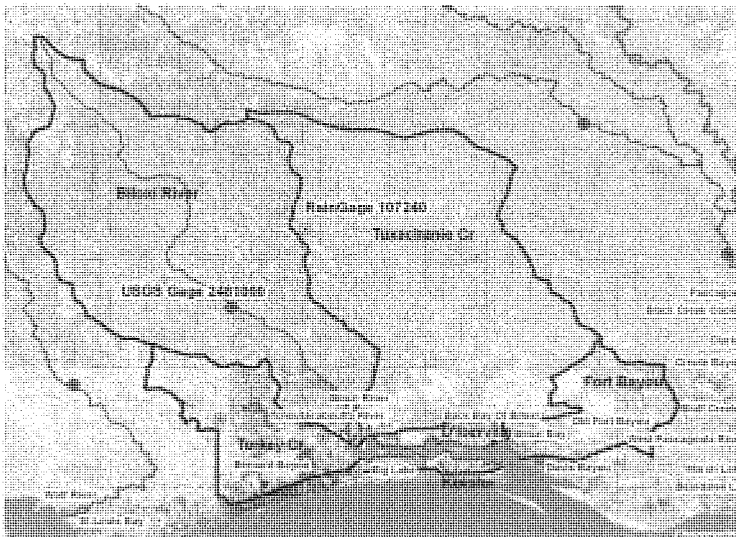


Figure 3.4.4-22. Biloxi Bay Watershed

The components of the model include the precipitation specification, the loss model, the direct runoff model, and observed discharge data. Precipitation data used in the modeling process included hourly precipitation from NOAA gage 107840 and the 2-100 year 24-hour TP-40 rainfall events. For the loss model some basins used the initial and constant loss model and others (D'Iberville and Keesler) used SCS curve number method. For the direct runoff model, all the basins used the Snyder's unit hydrograph (UH) model. The model was calibrated to observed hourly discharge data for two events at USGS gage 2481000. The basin models used in the calibration used the initial constant loss model and Snyder's method for the direct runoff. The two calibration events (May 1991 and Jan 1993) had rainfall of about 6.4 inches and 7.6 inches each, corresponding to approximately 2-yr to 5-yr theoretical rainfall frequency.

Calibration results agree reasonable well with observed data as shown in Figures 3.4.4-23 and 3.4.4-24.

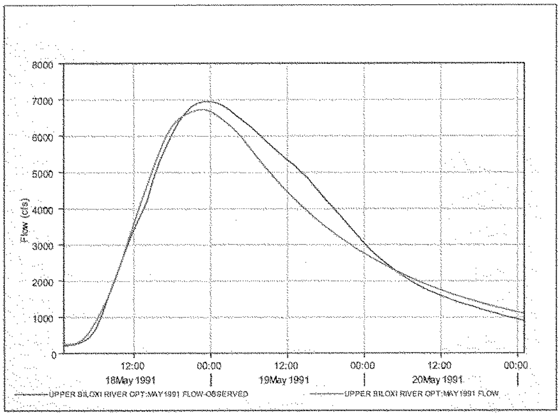


Figure 3.4.4-23. Biloxi Bay Watershed Calibration, May 18, 1991

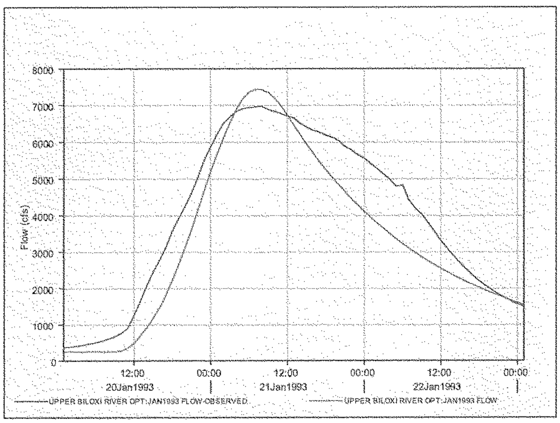


Figure 3.4.4-24. Biloxi Bay Watershed Calibration, Jan 21, 1993

Ponding from the interior rivers behind the gates will depend partially on the elevation of the gulf when the gates are closed. Several historical stage hydrographs of hurricanes were reviewed to determine the duration of various stages along the gulf. From this review, it was determined that storms generally reach 4 ft NAVD88 and recede to that elevation within 24 hours. Using this information, various theoretical coincident rainfall events taken from T.P 40 were modeled to determine the resulting water surface elevations behind the barrier during the 24-hour period the gates are to be closed. A 10-yr rain was selected for the design condition, in accordance with studies cited above. The highest inflow period of the inflow hydrograph was used to compute changes in bay elevations in the 24-hour gate closure period.

Based on this method of analysis, the resulting elevations for the various storms are shown in Table 3.4.4-1, with the 10-yr elevation of 8.4 ft NAVD88 the design condition.

Table 3.4.4-1.
Biloxi Bay Ponding

Biloxi Bay 4 ft. Base Elevations	
Strom Event	**Bay Elevation (ft NAVD88)**
2-year	6.0
5-year	7.6
10-year	8.4
25-year	9.4
50-year	10.0
100-year	10.8

This ponded water area in Harrison County above the surge barrier gates at the 10-yr flood is at 8.4 ft NAVD88 and is approximated by the 8-ft ground contour line shown in Figure 3.4.4-25.

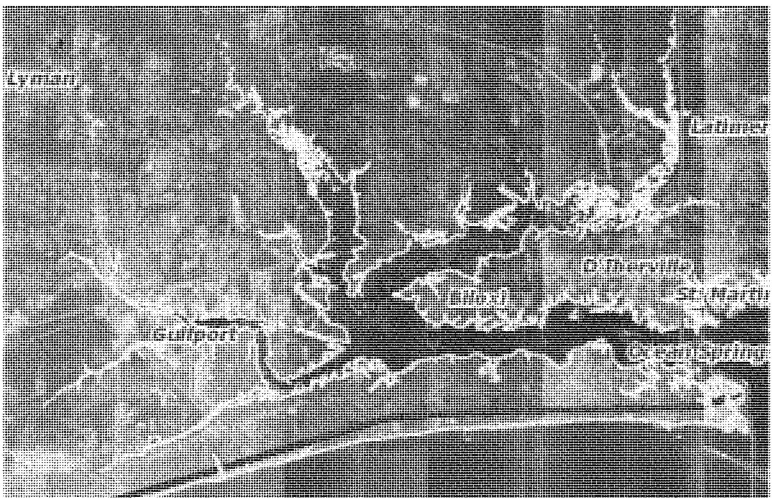


Figure 3.4.4-25. Biloxi Bay 10-yr Ponding to Elev. 8.4 ft NAVD88

3.4.4.5.1.3 St. Louis Bay Modeling

The St. Louis Bay watershed covers approximately 654 square miles and is comprised of six sub-basins that stretch across the Mississippi counties of Harrison, Hancock, Stone, and Pearl River.

There is one United States Geological Survey (USGS) discharge stream gage (#2481510) located in the watershed along the Wolf River, near Landon, Mississippi. There are three significant National Oceanic and Atmospheric Administration (NOAA) hourly precipitation gages located nearby to the watershed: #109617 White Sand located to the west, #87720 Purvis 2 N to the north, and #109617, 87720, and 107840 Saucier Experimental Forest to the east of the basin. Data from these gages, along with soils data from the National Cooperative Soil Survey and Technical Paper 40 (TP-40) synthetic rainfall events were used to determine the peak discharge and total run-off volume entering St. Louis Bay from the St. Louis Bay watershed for the 2 year, 5 year, 10 year, 25 year, 50 year and 100 year rainfall events. The St. Louis Bay watershed is shown in Figure 3.4.4-26.

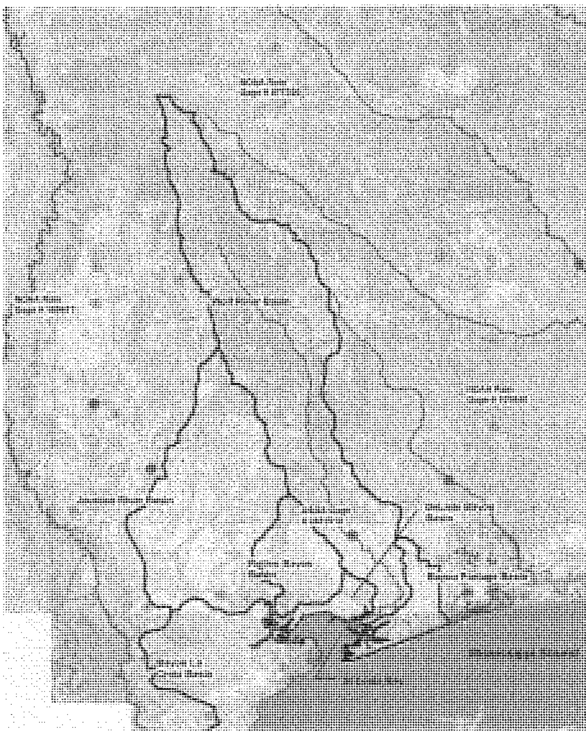


Figure 3.4.4-26. St Louis Bay Watershed

The Hydrologic Engineering Center's Hydrologic Modeling System (HEC-HMS) was used for the modeling effort. The components of the model include the precipitation specification, the loss model, the direct runoff model, and observed discharge data. Precipitation data used in the modeling process included hourly precipitation from NOAA gages 109617, 87720, and 109617, 87720, and 107840 and the 2-100 year 24-hour TP-40 rainfall events. The initial and constant loss rate method was used for the loss model while the Snyder's unit hydrograph (UH) method was used for the direct runoff model. The model was calibrated to observed hourly discharge data for one event at USGS gage 2481510. Several other events were analyzed but not used because the observed hourly precipitation for those events did not match the TP-40 rainfall.

The HEC-HMS St. Louis Bay watershed model was calibrated to the September 24-30, 2002 storm events. The model was calibrated at the Upper Wolf River sub-basin using observed precipitation data from NOAA gages 109617, 87720, and 107840 and observed discharge data from USGS gage 2481510. This event had a total rainfall of 13.75 inches and peak discharge of 17,854 cfs. This event was chosen due to the availability of both the hourly precipitation and discharge data. The observed and computed hydrographs are shown in Figure 3.4.4-27.

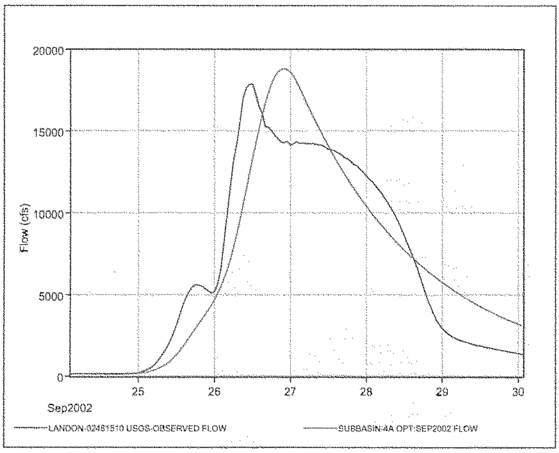


Figure 3.4.4-27. St. Louis Bay Watershed Calibration

Ponding from the interior rivers behind the gates will depend partially on the elevation of the gulf when the gates are closed. Several historical stage hydrographs of hurricanes were reviewed to determine the duration of various stages along the gulf. From this review, it was determined that storms generally reach 4 ft NAVD88 and recede to that elevation within 24 hours. Using this information, various theoretical coincident rainfall events taken from T.P 40 were modeled to determine the resulting water surface elevations behind the barrier during the 24-hour period the gates are to be closed. A 10-yr rain was selected for the design condition, in accordance with studies cited above. The highest inflow period of the inflow hydrograph was used to compute changes in bay elevations in the 24-hour gate closure period.

Based on this method of analysis, the resulting elevations for the various storms are shown in Table 3.4.4-2, with the 10-yr elevation of 6.8 ft NAVD88 the design condition.

Table 3.4.4-2.
St. Louis Bay Ponding

St. Louis Bay 4 ft. Base Elevations	
Storm Event	**Bay Elevation (ft NAVD88)**
2-year	5.5
5-year	6.3
10-year	6.8
25-year	7.5
50-year	7.9
100-year	8.4

This ponded water area in Harrison County above the surge barrier gates is at the 10-yr flood elevation of 6.8 ft NAVD88, but is approximated by the 8-ft ground contour line shown in Figure 3.4.4-28.

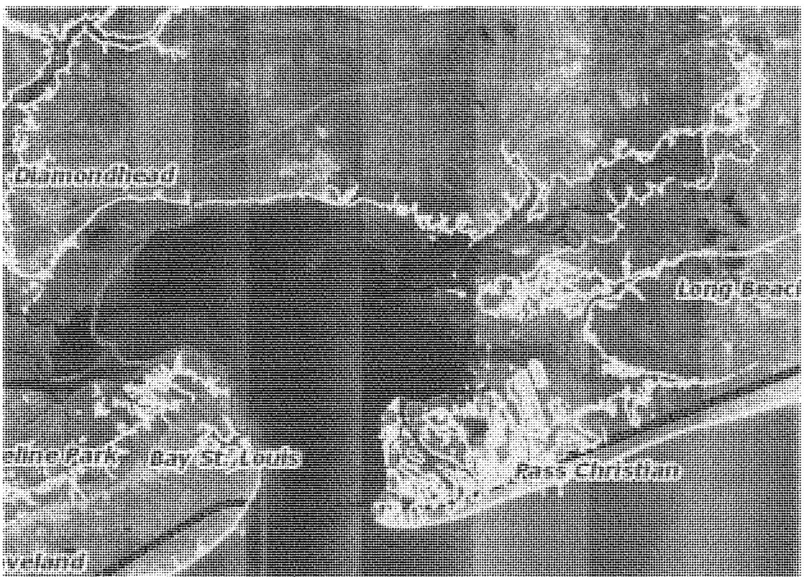


Figure 3.4.4-28. St Louis Bay 10-yr Ponding to Elev. 8.4 ft NAVD88

3.4.4.5.2 Geotechnical Data

Geology: The Prairie formation is found southward of Interstate 10 and is of Pleistocene age. This formation consists of fluvial and floodplain sediments that extend southward from the outcrop of the Citronelle formation to or near the mainland coastline. Sand found within this formation has an economic value as beach fill due to its color and quality. Southward from its outcrop area, the formation extends under the overlying Holocene deposits out into the Mississippi Sound.

The Gulfport Formation is found along the coastline in most of Harrison County. This formation of Pleistocene age overlies the Prairie formation and is present as well sorted sands that mark the edge of the coastline during the last high sea level stage of the Sangamonian Interglacial period. It does not extend under the Mississippi Sound.

Geotechnical: The inland barrier earthen levee section will have one vertical to three horizontal side slopes with a fifteen foot crest width. All work areas to receive the fill shall be cleared and grubbed of all trees and surface organics and all existing foundations, streets, utilities, etc. will be removed and the subsequent cavities backfilled and compacted. The levee will be constructed of sand clay materials obtained from off site commercial sources, trucked to the work area, placed in thin lifts and compacted to 95 percent of the maximum modified density. The final surface will be armored by the placement of 24 inch thick gabion mattress filled with small stone for erosion protection during an event that overtops the levee. The armoring will be anchored on the front face by trenching and extend across the downstream slope and the 25 foot easement area beyond the toe. The front side of the levee and all non critical surface areas will be subsequently covered by grassing. Road crossings will incorporate small gate structures or ramping over the embankment where the surface elevation is near that of the crest elevation. The elevation relationship of the crest and the adjacent railroad will be a governing factor. The surfaces will be paved with asphalt and the corresponding drainage will be accommodated. Those areas where the subgrade geology primarily consists of clean sands, seepage underneath the levee and the potential for erosion and instability must be considered. Final designs may require the installation of a bentonite concrete cutoff wall deep within the foundation. This condition will be investigated during any design phase and its requirement will be incorporated.

3.4.4.5.3 Option A – Elevation 20 ft.NAVD88. Structural, Mechanical and Electrical

See sections 3.4.4.5.3.1 and 3.4.2.5.3.2.

3.4.4.5.3.1 Pumping Stations

Design hydraulic head derived for the one pumping facility included in the Harrison County Inland Barrier for the elevation 20 protection level was 15 feet and the corresponding flow required was 294,882 gallons per minute. The facility thus derived would consist of one plant having four, 60-inch diameter and 560 horsepower pumps.

3.4.2.5.3.2 Levee and Roadway/Railway Intersections

With the installation of protection to elevation 20, 45 roadway intersections would have to be accommodated. For this study it was estimated that 18 roller gate structures and 27 swing gate structures would be required.

3.4.4.5.4 HTRW

Due to the extent and large number of real estate parcels along with the potential for re-alignment of the structural aspects of this project, no preliminary assessment was performed to identify the possibility of hazardous waste on the sites. These studies will be conducted during the next phase of work after the final siting of the various structures. The real estate costs appearing in this report therefore will not reflect any costs for remediation design and/or treatment and/or removal or disposal of these materials in the baseline cost estimate.

3.4.4.5.5 Construction Procedures and Water Control Plan

The construction procedures required for this option are similar to general construction in many respects in that the easement limits must be established and staked in the field, the work area cleared of all structures, pavements, utilities, trees, organics, etc. and the foundation prepared for the new work. Where the levee alignment crosses the existing streams or narrow bays, the alignment base shall be created by displacement with layers of crushed stone pushed ahead and compacted by the placement equipment and repeated until a stable platform is created. The required drainage culverts or other ancillary structures can then be constructed. The control of any surface water will be handled by temporary sheetpile cofferdams and pumping. The control of groundwater will be a series of wellpoints systems designed to keep the excavations dry to a depth and width sufficient to install the new work.

3.4.4.5.6 Project Security

The Protocol for security measures for this study has been performed in general accordance with the Risk Assessment Methodology for Dams (RAM-D) developed by the Interagency Forum for Infrastructure Protection (IFIP). This methodology has been used for physical security for the critical infrastructure throughout the Corps of Engineers. The determination of the level of physical security provided for each facility is based on the following critical elements: 1) threat assessment of the likelihood that an adversary will attack a critical asset, 2) consequence assessment should an adversary be successful in disrupting, disabling or destroying the asset and 3) effectiveness to prevent a successful attack against an operational component.

Three levels of physical security were selected for use in this study:

Level 1 Security provides no improved security for the selected asset. This security level would be applied to the barrier islands and the sand dunes. These features present a very low threat level of attack and basically no consequence if an attack occurred and is not applicable to this option.

Level 2 Security applies standard security measures such as road barricades, perimeter fencing, and intrusion detection systems for unoccupied buildings and vertical structures and security lighting. The intrusion detection systems will be connected to the local law enforcement office for response during an emergency. Facilities requiring this level of security would possess a higher threat level than those in Level 1 and would include assets such as levees, access roads and pumping stations. This security level will be applicable to this option.

Level 3 Security includes all of the features of Level 2 plus enhanced security measures such as the use of video cameras for real-time monitoring of the facility, monitors, motion detectors and alarm sound system in the occupied control buildings. Facilities requiring this level of security would possess the highest threat level of all the critical assets. The surge barriers located in the bays, manned control buildings, and power plants would require this level of security.

3.4.4.5.7 Operation and Maintenance

The features that require periodic operations will be the exercising of the pumps and emergency generators at the various pump stations, the testing of the gate structures at the various road crossings, grass cutting of the levee slopes and toe areas and the filling of rilled areas within the embankment due to surface erosion. Scheduled maintenance should include periodic greasing of all gears and coupled joints, maintaining any battery backup systems, and replacement of standby fuel supplies.

3.4.4.5.8 Cost Estimate

The costs for the various options included in this measure are presented in Section 3.4.4.15, Cost Summary. Construction costs for the various options are included in Table 3.4.4-3 and costs for the annualized Operation and Maintenance of the options are included in Table 3.4.4-4. Estimates are comparative-Level "Parametric Type" and are based on Historical Data, Recent Pricing, and Estimator's Judgment. Quantities listed within the estimates represent Major Elements of the Project Scope and were furnished by the Project Delivery Team. Price Level of Estimate is April 07. Estimates excludes project Escalation and HTRW Cost. The construction costs include real estate, engineering design (E&D), construction management, and contingencies. The E&D cost for preparation of construction contract plans and specifications includes a detailed contract survey, preparation of contract specifications and plan drawings, estimating bid quantities, preparation of bid estimate, preparation of final submittal and contract advertisement package, project engineering and coordination, supervision technical review, computer costs and reproduction. Construction Contingency developed and assigned at 25% to cover the Cost Growth of the project.

3.4.4.5.9 Schedule for Design and Construction

Because of the size and scope of the possible options, feasibility study level of detail could not be attained in this report. A significant additional detailed design effort will be required prior to attaining feasibility level, and construction would normally not proceed until that level is completed and an appropriate plan selected. After feasibility level design is complete and the authority for the design has been issued and funds have been provided, the design of these structures will require approximately 12 months including comprehensive plans and specifications, independent reviews and subsequent revisions. The construction of this option should require in excess of two years.

3.4.4.6 Option B – Elevation 30 ft NAVD88

Option B is similar to option A except for the following items.

3.4.4.6.1 Option B – Elevation 30 ft.NAVD88. Interior Drainage

The alignment of the levee is the same as Option A, above, and is not reproduced here. Differences between the description of this option and preceding description of Option A include the height of the levee, pumping facilities (because of the increased head), and the length of the levee culverts. The methods of analysis for interior drainage and computed flows are the same as for Option A.

3.4.4.6.2 Option B – Elevation 30 ft.NAVD88. Geotechnical Data

The Geology and Geotechnical paragraphs for Option B are the same as for Option A, above.

3.4.4.6.3 Option B – Elevation 30 ft.NAVD88. Structural, Mechanical and Electrical

See sections 3.4.4.6.3.1 and 3.4.4.6.3.2.

3.4.4.6.3.1 Pumping Stations

Design hydraulic heads derived for the 7 pumping facilities included in the Harrison County Inland Barrier for the elevation 30 protection level varied from 5 and 20 feet and the corresponding flows required varied from 172,800 to 294,882 gallons per minute respectively. The facilities thus derived would consist of one plant having three, 54-inch diameter, 175 horsepower pumps and one having four, 60-inch diameter pumps each running at 750 horsepower.

3.4.4.6.3.2 Levee and Roadway/Railway Intersections

With the installation of protection to elevation 30, 158 roadway/railway intersections would have to be accommodated. For this study it was estimated that 78 roller gate structures and 78 swing gate structures would be required at the roadway crossings. In addition, two railway closure gates would be required.

3.4.4.6.4 Option B – Elevation 30 ft.NAVD88. HTRW

The HTRW paragraphs for Option B are the same as for Option A, above.

3.4.4.6.5 Option B – Elevation 30 ft.NAVD88. Construction Procedures and Water Control Plan

The Construction Procedures and Water Control Plan paragraphs for Option B are the same as for Option A, above.

3.4.4.6.6 Option B – Elevation 30 ft.NAVD88. Project Security

The Project Security paragraphs for Option B are the same as for Option A, above

3.4.4.6.7 Option B – Elevation 30 ft.NAVD88. Operations and Maintenance

The Operation and Maintenance paragraphs for Option B are the same as for Option A, above.

3.4.4.6.8 Option B – Elevation 30 ft.NAVD88. Cost Estimate

The Cost Estimate paragraphs for Option B are the same as for Option A, above.

3.4.4.6.9 Option B – Elevation 30 ft.NAVD88. Schedule and Design for Construction

The Schedule for Design and Construction paragraphs for Option B are the same as for Option A, above.

3.4.4.7 Option C – Elevation 40 ft NAVD88

Option C is similar to option A except for the following items.

3.4.4.7.1 Interior Drainage

The alignment of the levee is the same as Option A, above, and is not reproduced here. Differences between the description of this option and preceding description of Option A include the height of the levee, pumping facilities (because of the increased head), and the length of the levee culverts. The methods of analysis for interior drainage and computed flows are the same as for Option A.

3.4.4.7.2 Geotechnical Data

The Geology and Geotechnical paragraphs for Option B are the same as for Option A, above.

3.4.4.7.3 Structural, Mechanical and Electrical

See sections 3.4.4.7.3.1 and 3.4.2.7.3.2.

3.4.4.7.3.1 Pumping Stations

Design hydraulic heads derived for the 7 pumping facilities included in the Harrison County Inland Barrier for the elevation 40 protection level varied from 15 and 30 feet and the corresponding flows required varied from 172,800 to 294,882 gallons per minute respectively. The facilities thus derived would consist of one plant having three, 54-inch diameter, 420 horsepower pumps and one having four, 60-inch diameter pumps each running at 1150 horsepower.

3.4.2.7.3.2 Levee and Roadway/Railway Intersections

With the installation of protection to elevation 40, 161 roadway/railway intersections would have to be accommodated. For this study it was estimated that 1 roller gate structure and 158 swing gate structures would be required at the roadway crossings. In addition, two railway closure gates would be required.

3.4.4.7.4 HTRW

The HTRW paragraphs for Option C are the same as for Option A, above.

3.4.4.7.5 Construction Procedures and Water Control Plan

The Construction Procedures and Water Control Planl paragraphs for Option C are the same as for Option A, above.

3.4.4.7.6 Project Security

The Project Security paragraphs for Option C are the same as for Option A, above.

3.4.4.7.7 Operations and Maintenance

The Operations and Maintenance paragraphs for Option C are the same as for Option A, above.

3.4.4.7.8 Cost Estimate

The Cost Estimate paragraphs for Option C are the same as for Option A, above.

3.4.4.7.9 Schedule and Design for Construction

The Schedule for Design and Construction paragraphs for Option C are the same as for Option A, above.

3.4.4.8 Option D – Levee for Roadway, Elevation 20 ft NAVD88

Option D is similar to option A except for the following items.

3.4.4.8.1 Interior Drainage

The alignment of the levee is the same as Option A, above, and is not reproduced here. The difference between this option and Option A is that the width of the top of the levee in Harrison County is 75 ft for Option D and 15 ft for Option A. This will allow Hwy 90 to be relocated along the top of the levee. The methods of analysis for interior drainage and computed flows are the same as for Option A.

3.4.4.8.2 Geotechnical Data

The Geology and Geotechnical paragraphs for Option D are the same as for Option A, above.

3.4.4.8.3 Structural, Mechanical and Electrical

See sections 3.4.4.8.3.1 and 3.4.4.8.3.2.

3.4.4.8.3.1 Pumping Stations

Design hydraulic head derived for the one pumping facility included in the Harrison County Inland Barrier for the elevation 20 protection level was 15 feet and the corresponding flow required was 294,882 gallons per minute. The facility thus derived would consist of one plant having four, 60-inch diameter and 560 horsepower pumps.

3.4.4.8.3.2 Levee and Roadway/Railway Intersections

With the installation of protection to elevation 20, 42 roadway/railway intersections would have to be accommodated. For this study it was estimated that 18 roller gate structures and 48 swing gate structures would be required at the roadway crossings.

3.4.4.8.4 HTRW

The HTRW paragraphs for Option D are the same as for Option A, above.

3.4.4.8.5 Construction Procedures and Water Control Plan

The Construction Procedures and Water Control Plan paragraphs for Option D are the same as for Option A, above.

3.4.4.8.6 Project Security

The Project Security paragraphs for Option D are the same as for Option A, above

3.4.4.8.7 Operations and Maintenance

The Operation and Maintenance paragraphs for Option D are the same as for Option A, above.

3.4.4.8.8 Cost Estimate

The Cost Estimate paragraphs for Option D are the same as for Option A, above.

3.4.4.8.9 Schedule and Design for Construction

The Schedule for Design and Construction paragraphs for Option D are the same as for Option A, above.

3.4.4.9 Option E – Levee for Roadway, Elevation 30 ft NAVD88

Option E is similar to option A except for the following items.

3.4.4.9.1 Interior Drainage

The alignment of the levee is the same as Option A, above, and is not reproduced here. The difference between this option and Option A is that the width of the top of the levee in Harrison County is 75 ft for Option E and 15 ft for Option A. In addition, the height of the levee is at 30 ft NAVD88 for Option E and 20 ft NAVD88 for Option A. The added width will allow Hwy 90 to be relocated along the top of the levee. The methods of analysis for interior drainage and computed flows are the same as for Option A.

3.4.4.9.2 Option E – Levee for Roadway, Elevation 30 ft.NAVD88. Geotechnical Data

The Geology and Geotechnical paragraphs for Option E are the same as for Option A, above.

3.4.4.9.3 Structural, Mechanical and Electrical

See setions 3.4.4.9.3.1 through 3.4.4.9.3.2.

3.4.4.9.3.1 Pumping Stations

Design hydraulic heads derived for the 7 pumping facilities included in the Harrison County Inland Barrier for the elevation 30 protection level varied from 5 and 20 feet and the corresponding flows required varied from 172,800 to 294,882 gallons per minute respectively. The facilities thus derived would consist of one plant having three, 54-inch diameter, 175 horsepower pumps and one having four, 60-inch diameter pumps each running at 750 horsepower.

3.4.4.9.3.2 Levee and Roadway/Railway Intersections

With the installation of protection to elevation 30, 140 roadway/railway intersections would have to be accommodated. For this study it was estimated that 82 roller gate structures and 112 swing gate structures would be required at the roadway crossings. In addition, two railway closure gates would be required.

3.4.4.9.4 HTRW

The HTRW paragraphs for Option E are the same as for Option A, above.

3.4.4.9.5 Construction Procedures and Water Control Plan

The Construction Procedures and Water Control Plan paragraphs for Option E are the same as for Option A, above.

3.4.4.9.6 Project Security

The Project Security paragraphs for Option E are the same as for Option A, above

3.4.4.9.7 Operations and Maintenance

The Operation and Maintenance paragraphs for Option E are the same as for Option A, above.

3.4.4.9.8 Cost Estimate

The Cost Estimate paragraphs for Option E are the same as for Option A, above.

3.4.4.9.9 Schedule and Design for Construction

The Schedule for Design and Construction paragraphs for Option E are the same as for Option A, above.

3.4.4.10 Option F – Menge Avenue Alternate Route, Elevation 20 ft NAVD88

Option F is similar to Option A except for the following items.

3.4.4.10.1 Interior Drainage

The alignment of the levee is the same as Option A on the east side of Harrison County but extends to the north along Menge Avenue as shown on Figures 3.4.4-29 through 3.4.4-31 instead of continuing westward. These figures also show the pump/culvert locations and the sub-basins. For Option F, culverts are required at all sub-basins, but no pumps are required for sub-basins M3 – M8. The methods of analysis for interior drainage and computed flows are the same as for Option A, except that no surge barrier was included or evaluated for St Louis Bay.

3.4.4.10.2 Geotechnical Data

The Geology and Geotechnical paragraphs for Option F are the same as for Option A, above.

3.4.4.10.3 Structural, Mechanical and Electrical

See sections 3.4.4.10.3.1 and 3.4.4.10.3.2.

3.4.4.10.3.1 Pumping Stations

Design hydraulic head derived for the two pumping facilities included in the Harrison County Inland Barrier for the elevation 20 protection level was 16 feet, and the corresponding flow required varied from 555,626 and 772,358 gallons per minute. The facilities thus derived would consist of one plant having eleven, 42-inch diameter, 290 horsepower pumps, and one having thirteen, 48-inch diameter, 340 horsepower pumps.

Figure 3.4.4-29. Menge Avenue Alternate Route, Pump/Culvert, Sub-basin Site Locations

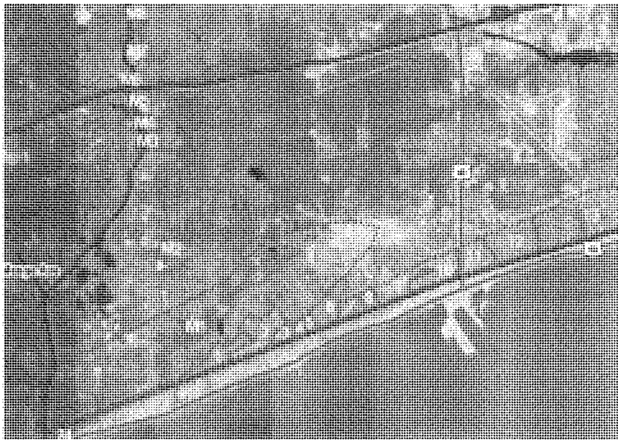


Figure 3.4.4-30. Menge Avenue Alternate Route, Pump/Culvert, Sub-basin Site Locations

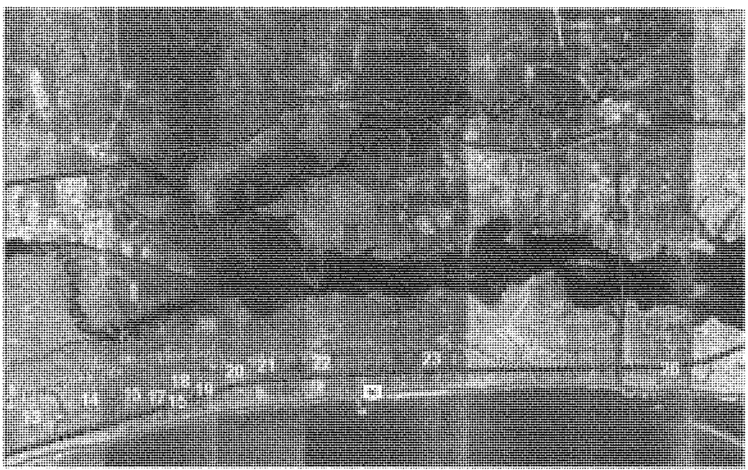


Figure 3.4.4-31. Menge Avenue Alternate Route, Pump/Culvert, Sub-basin Site Locations

3.4.4.10.3.2 Levee and Roadway/Railway Intersections

With the installation of protection to elevation 20, 21 roadway/railway intersections would have to be accommodated. For this study it was estimated that 17 roller gate structures and 4 swing gate structures would be required at the roadway crossings.

3.4.4.10.4 HTRW

The HTRW paragraphs for Option F are the same as for Option A, above.

3.4.4.10.5 Construction Procedures and Water Control Plan

The Construction Procedures and Water Control Plan paragraphs for Option F are the same as for Option A, above.

3.4.4.10.6 Project Security

The Project Security paragraphs for Option F are the same as for Option A, above

3.4.4.10.7 Operations and Maintenance

The Operation and Maintenance paragraphs for Option F are the same as for Option A, above.

3.4.4.10.8 Cost Estimate

The Cost Estimate paragraphs for Option F are the same as for Option A, above.

3.4.4.10.9 Schedule and Design for Construction

The Schedule for Design and Construction paragraphs for Option F are the same as for Option A, above.

3.4.4.11 Option G – Menge Avenue Alternate Route, Elevation 30 ft NAVD88

Option G is similar to option A except for the following items.

3.4.4.11.1 Interior Drainage

The alignment of the levee is the same as Option F, shown above in Figures 3.4.4-29 through 3.4.4-31 and is not repeated here. The primary difference between this option and Option F is the height of the levee. Option F levee height is elevation 20 ft NAVD88 and Option G levee height is elevation 30 ft NAVD88. For this option, culverts are required at all sub-basins, but no pumps are required for sub-basins M3 – M8. The methods of analysis for interior drainage and computed flows are the same as for Option A, except that no surge barrier was included or evaluated for St Louis Bay.

3.4.4.11.2 Geotechnical Data

The Geology and Geotechnical paragraphs for Option G are the same as for Option A, above.

3.4.4.11.3 Structural, Mechanical and Electrical

See sections 3.4.4.11.3.1 and 3.4.4.11.3.2.

3.4.4.11.3.1 Pumping Stations

Design hydraulic head derived for the two pumping facilities included in the Harrison County Inland Barrier for the elevation 30 protection level was 26 feet, and the corresponding flow required varied from 555,626 and 772,358 gallons per minute. The facilities thus derived would consist of one plant having eleven, 42-inch diameter, 475 horsepower pumps, and one having thirteen, 48-inch diameter, 600 horsepower pumps.

3.4.4.11.3.2 Levee and Roadway/Railway Intersections

With the installation of protection to elevation 30, 125 roadway/railway intersections would have to be accommodated. For this study it was estimated that 86 roller gate structures and 37 swing gate structures would be required at the roadway crossings. In addition, two railway closure gates would be required.

3.4.4.11.4 HTRW

The HTRW paragraphs for Option G are the same as for Option A, above.

3.4.4.11.5 Construction Procedures and Water Control Plan

The Construction Procedures and Water Control Plan paragraphs for Option G are the same as for Option A, above.

3.4.4.11.6 Project Security

The Project Security paragraphs for Option G are the same as for Option A, above

3.4.4.11.7 Operations and Maintenance

The Operation and Maintenance paragraphs for Option G are the same as for Option A, above.

3.4.4.11.8 Cost Estimate

The Cost Estimate paragraphs for Option G are the same as for Option A, above.

3.4.4.11.9 Schedule and Design for Construction

The Schedule for Design and Construction paragraphs for Option G are the same as for Option A, above.

3.4.4.12 Option H – Menge Avenue Alternate Route, Elevation 40 ft NAVD88

Option H is similar to option A except for the following items.

3.4.4.12.1 Interior Drainage

The alignment of the levee is the same as Option F, shown above in Figures 3.4.4-29 through 3.4.4-31 and is not repeated here. The primary difference between this option and Option F is the height of the levee. Option F levee height is elevation 20 ft NAVD88 and Option H levee height is Elevation 40 ft NAVD88. For this option, culverts are required at all sub-basins, but no pump is required for sub-basin M8. The methods of analysis for interior drainage and computed flows are the same as for Option A, except that no surge barrier was included or evaluated for St Louis Bay.

3.4.4.12.2 Geotechnical Data

The Geology and Geotechnical paragraphs for Option H are the same as for Option A, above.

3.4.4.12.3 Structural, Mechanical and Electrical

See sections 3.4.4.12.3.1 and 3.4.4.12.3.2.

3.4.4.12.3.1 Pumping Stations

Design hydraulic head derived for the 7 pumping facilities included in the Harrison County Inland Barrier for the elevation 40 protection level varied from 10 to 36 feet, and the corresponding flow required varied from 46,225 to 772,358 gallons per minute. The facilities thus derived would consist of one plant having two, 36-inch diameter, 125 horsepower pumps, and one having thirteen, 48-inch diameter, 800 horsepower pumps.

3.4.4.12.3.2 Levee and Roadway/Railway Intersections

With the installation of protection to elevation 40, 157 roadway/railway intersections would have to be accommodated. For this study it was estimated that 3 roller gate structures and 152 swing gate structures would be required at the roadway crossings. In addition, two railway closure gates would be required.

3.4.4.12.4 HTRW

The HTRW paragraphs for Option H are the same as for Option A, above.

3.4.4.12.5 Construction Procedures and Water Control Plan

The Construction Procedures and Water Control Plan paragraphs for Option H are the same as for Option A, above.

3.4.4.12.6 Project Security

The Project Security paragraphs for Option H are the same as for Option A, above

3.4.4.12.7 Operations and Maintenance

The Operation and Maintenance paragraphs for Option H are the same as for Option A, above.

3.4.4.12.8 Cost Estimate

The Cost Estimate paragraphs for Option H are the same as for Option A, above.

3.4.4.12.9 Schedule and Design for Construction

The Schedule for Design and Construction paragraphs for Option H are the same as for Option A, above.

3.4.4.13 Option I – Levee for Roadway with Menge Avenue Alternate Route, Elevation 20 ft NAVD88

Option I is similar to option A except for the following items.

3.4.4.13.1 Interior Drainage

The alignment of the levee is the same as Option F, shown above in Figures 3.4.4-29 through 3.4.4-31 and is not repeated here. The primary difference between this option and Option F is the top width of the east-west leg of the levee (Biloxi Bay to Menge Avenue). The east-west leg of Option F barrier top width is 15 ft and the east-west leg of Option I barrier top width is 75 ft. This will allow Hwy 90 to be relocated along the top of the levee. For this option, culverts are required at all sub-basins, but no pumps are required for sub-basins M3 - M8. The methods of analysis for interior drainage and computed flows are the same as for Option A, except that no surge barrier was included or evaluated for St Louis Bay.

3.4.4.13.2 Geotechnical Data

The Geology and Geotechnical paragraphs for Option I are the same as for Option A, above.

3.4.4.13.3 Structural, Mechanical and Electrical

See section 3.4.4.13.3.1 and 3.4.4.13.3.2.

3.4.4.13.3.1 Pumping Stations

Design hydraulic head derived for the fourteen pumping facilities included in the Harrison County Inland Barrier for the elevation 20 protection level varied from 8 to 18 feet, and the corresponding flow required varied from 62,388 to 490,083 gallons per minute. The facilities thus derived would consist of one plant having two, 36-inch diameter, 125 horsepower pumps, and one having seven, 54-inch diameter, 290 horsepower pumps.

3.4.4.13.3.2 Levee and Roadway/Railway Intersections

With the installation of protection to elevation 20, 20 roadway/railway intersections would have to be accommodated. For this study it was estimated that 16 roller gate structures and 4 swing gate structures would be required at the roadway crossings.

3.4.4.13.4 HTRW

The HTRW paragraphs for Option I are the same as for Option A, above.

3.4.4.13.5 Construction Procedures and Water Control Plan

The Construction Procedures and Water Control Plan paragraphs for Option I are the same as for Option A, above.

3.4.4.13.6 Project Security

The Project Security paragraphs for Option I are the same as for Option A, above

3.4.4.13.7 Operations and Maintenance

The Operation and Maintenance paragraphs for Option I are the same as for Option A, above.

3.4.4.13.8 Cost Estimate

The Cost Estimate paragraphs for Option I are the same as for Option A, above.

3.4.4.13.9 Schedule and Design for Construction

The Schedule for Design and Construction paragraphs for Option I are the same as for Option A, above.

3.4.4.14 Option J – Levee for Roadway with Menge Avenue Alternate Route, Elevation 30 ft NAVD88

Option J is similar to option A except for the following.

3.4.4.14.1 Interior Drainage

The alignment of the levee is the same as Option F, shown above in Figures 3.4.4-29 through 3.4.4-31 and is not repeated here. The primary difference between this option and Option F is the top width of the east-west leg of the levee (Biloxi Bay to Menge Avenue). The east-west leg of Option F barrier top width is 15 ft and the east-west leg of Option J barrier top width is 75 ft. This will allow Hwy 90 to be relocated along the top of the levee. In addition, the height of this Option J is at elevation 30 ft NAVD88. For this option, culverts are required at all sub-basins, but no pumps are required for sub-basins M3 - M8. The methods of analysis for interior drainage and computed flows are the same as for Option A, except that no surge barrier was included or evaluated for St Louis Bay.

3.4.4.14.2 Geotechnical Data

The Geology and Geotechnical paragraphs for Option J are the same as for Option A, above.

3.4.4.14.3 Structural, Mechanical and Electrical

See sections 3.4.4.14.3.1 and 3.4.4.14.3.2.

3.4.4.14.3.1 Pumping Stations

Design hydraulic head derived for the two pumping facilities included in the Harrison County Inland Barrier for the elevation 30 protection level varied from 15 to 28 feet, and the corresponding flow required varied 62,388 to 490,083 gallons per minute. The facilities thus derived would consist of one plant having two, 36 inch diameter, 250 horsepower pumps, and one having five, 60-inch diameter, 1145 horsepower pumps.

3.4.4.14.3.2 Levee and Roadway/Railway Intersections

With the installation of protection to Elevation 30, 123 roadway/railway intersections would have to be accommodated. For this study it was estimated that 86 roller gate structures and 35 swing gate structures would be required at the roadway crossings. In addition, two railway closure gates would be required.

3.4.4.14.4 HTRW

The HTRW paragraphs for Option J are the same as for Option A, above.

3.4.4.14.5 Construction Procedures and Water Control Plan

The Construction Procedures and Water Control Plan paragraphs for Option J are the same as for Option A, above.

3.4.4.14.6 Project Security

The Project Security paragraphs for Option J are the same as for Option A, above

3.4.4.14.7 Operations and Maintenance

The Operation and Maintenance paragraphs for Option J are the same as for Option A, above.

3.4.4.14.8 Cost Estimate

The Cost Estimate paragraphs for Option J are the same as for Option A, above.

3.4.4.14.9 Schedule and Design for Construction

The Schedule for Design and Construction paragraphs for Option J are the same as for Option A, above.

3.4.4.15 Cost Estimate Summary

The costs for construction and for operations and maintenance of all options are shown below. Estimates are comparative-Level "Parametric Type" and are based on Historical Data, Recent Pricing, and Estimator's Judgment. Quantities listed within the estimates represent Major Elements of the Project Scope and were furnished by the Project Delivery Team. Price Level of Estimate is April 07. Estimates excludes project Escalation and HTRW Cost. Team. Price Level of Estimate is April 07. Estimates excludes project Escalation and HTRW Cost.

Table 3.4.4-3.
Harrison Co Inland Barrier Construction Cost Summary

Option	Total project cost
Option A – Elevation 20 ft NAVD88	$435,800,000
Option B – Elevation 30 ft NAVD88	$731,600,000
Option C – Elevation 40 ft NAVD88	$947,100,000
Option D – Roadway El 20 NAVD88	$205,400,000
Option E – Roadway El 30 NAVD88	$768,300,000
Option F – Menge El 20 NAVD88	$140,400,000
Option G – Menge El 30 NAVD888	$317,100,000
Option H – Menge El 40 NAVD88	$506,300,000
Option I – Road/Menge El 20 ft NAVD88	$178,600,000
Option J – Road/Menge El 30 ft NAVD88	$462,900,000

Table 3.4.4-4.
Harrison Co Inland Barrier O & M Cost Summary

Option	O&M Costs
Option A – Elevation 20 ft NAVD88	$2,007,000
Option B – Elevation 30 ft NAVD88	$5,805,000
Option C – Elevation 40 ft NAVD88	$8,343,000
Option D – Roadway El 20 NAVD88	$1,868,000
Option E – Roadway El 30 NAVD88	$5,871,000
Option F – Menge El 20 NAVD88	$1,800,000
Option G – Menge El 30 NAVD888	$4,052,000
Option H – Menge El 40 NAVD88	$6,564,000
Option I – Road/Menge El 20 ft NAVD88	$2,073,000
Option J – Road/Menge El 30 ft NAVD88	$6,016,000

3.4.4.16 References

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3.4.5 Back Bay of Biloxi Surge Barrier

3.4.5.1 General

In order to protect the properties surrounding Biloxi Bay and along the lower portions of the various rivers and streams flowing into the bay, a barrier would be required at some point to block storm waters during major storm events.

As outlined above, a search of other similar facilities constructed world wide revealed that the structure model best satisfying both the engineering and socio-ecological necessities of this site was that used for the Thames River Barrier in London, UK. The structure tentatively chosen for incorporation into this work was thus, patterned after the Thames River Barrier with certain minor modifications to adapt to the site and environment specific conditions enumerated previously.

3.4.5.1.1 Interior Drainage

In the event of an imminent hurricane, the gates across the Back Bay of Biloxi would be closed, and flow from the rivers feeding these bays, as well as local runoff would pond behind the gates. The tentative location of the barrier chosen for this study is shown Figure 3.4.5.1-1.

The Biloxi Bay watershed is an approximately 640 square mile watershed comprised of six subbasins that stretch across Harrison, Stone, and Jackson County, MS. There is one United States Geological Survey (USGS) discharge gage located in the watershed along the Biloxi River and one National Oceanic and Atmospheric Administration (NOAA) hourly precipitation gage located on the east side of the watershed. The discharge gage is USGS gage 2481000 at Wortham, MS and the precipitation gage is NOAA gage 107840 (Saucier Experimental Forest). Data from these gages, along with soils data from the National Cooperative Soil Survey and Technical Paper 40 (TP-40) synthetic rainfall events were used to determine the peak discharge and total run-off volume entering Biloxi Bay from the Biloxi Bay watershed for the 2-100 year rainfall events. The Hydrologic Engineering Center's Hydrologic Modeling System (HEC-HMS) was used for the modeling effort. The Biloxi Bay watershed is shown in Figure 3.4.5.1-2.

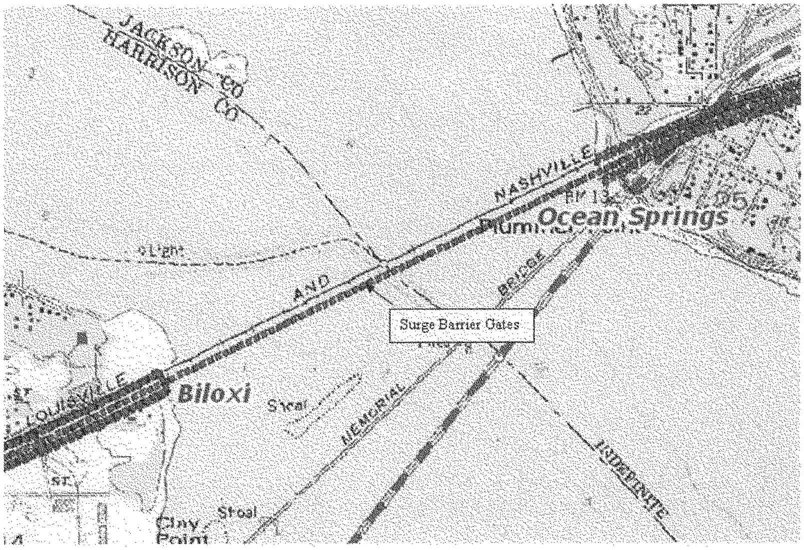


Figure 3.4.5.1-1. Biloxi Bay Surge Barrier Location

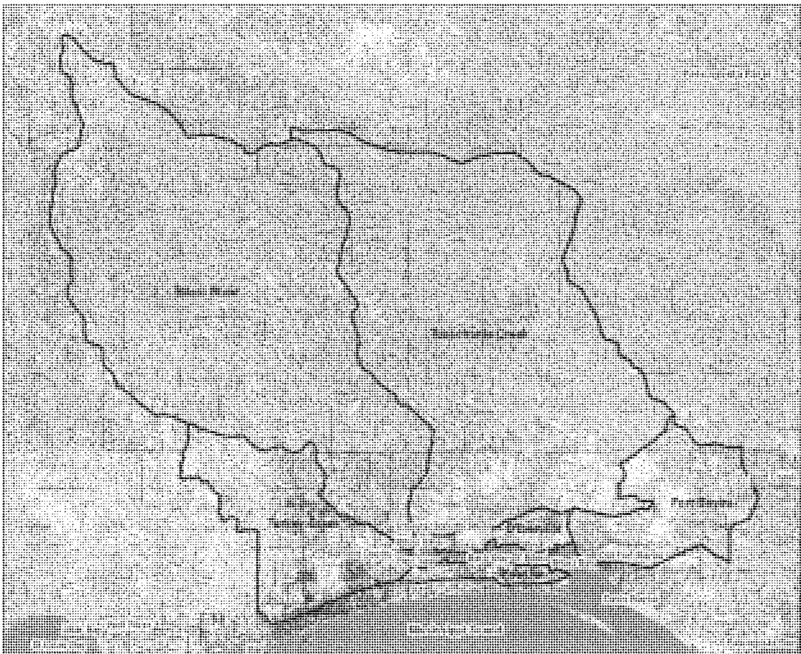


Figure 3.4.5.1-2. Biloxi Bay Watershed

The components of the model include the precipitation specification, the loss model, the direct runoff model, and observed discharge data. Precipitation data used in the modeling process included hourly precipitation from NOAA gage 107840 and the 2-100 year 24-hour TP-40 rainfall events. The initial and constant loss rate and SCS curve number methods were used for the loss model while the Snyder's unit hydrograph (UH) and SCS UH methods were used for the direct runoff model. The model was calibrated to observed hourly discharge data for two events at USGS gage 2481000.

Calibration results agree reasonable well with observed data as shown in Figures 3.4.5.1-3 and 3.4.5.1-4.

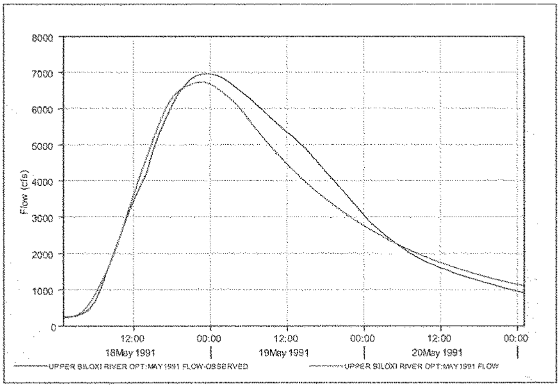


Figure 3.4.5.1-3. Biloxi Bay Watershed Calibration

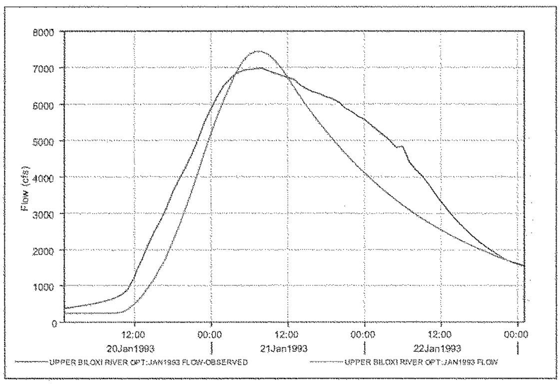


Figure 3.4.5.1-4. Biloxi Bay Watershed Calibration

Ponding from the interior rivers behind the gates will depend partially on the elevation of the gulf when the gates are closed. Several historical stage hydrographs of hurricanes were reviewed to determine the duration of various stages along the gulf. From this review, it was determined that storms generally reach 4 ft NAVD88 and recede to that elevation within 24 hours. Using this information, various theoretical coincident rainfall events taken from T.P 40 were modeled to determine the resulting water surface elevations behind the barrier during the 24-hour period the gates are to be closed. A 10-yr rain was selected for the design condition. This decision was 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, U.S. Army Corps of Engineers.

The 24-hour period of highest inflow from the flow hydrograph was used to compute changes in bay elevations in the 24-hour gate closure period.

Based on this method of analysis, the resulting elevations for the various storms are shown in Figure 3.4.5.1-1, with the 10-yr elevation of 8.4 ft NAVD88 the design condition.

Table 3.4.5.1-1.
Biloxi Bay Ponding

Biloxi Bay 4 ft. Base Elevations	
Strom Event	**Bay Elevation (ft NAVD88)**
2-year	6.0
5-year	7.6
10-year	8.4
25-year	9.4
50-year	10.0
100-year	10.8

This ponded water area in Jackson County above the surge barrier gates at the 10-yr flood is at 8.4 ft NAVD88 and is approximated by the 8-ft ground contour line shown in Figure 3.4.5.1-5.

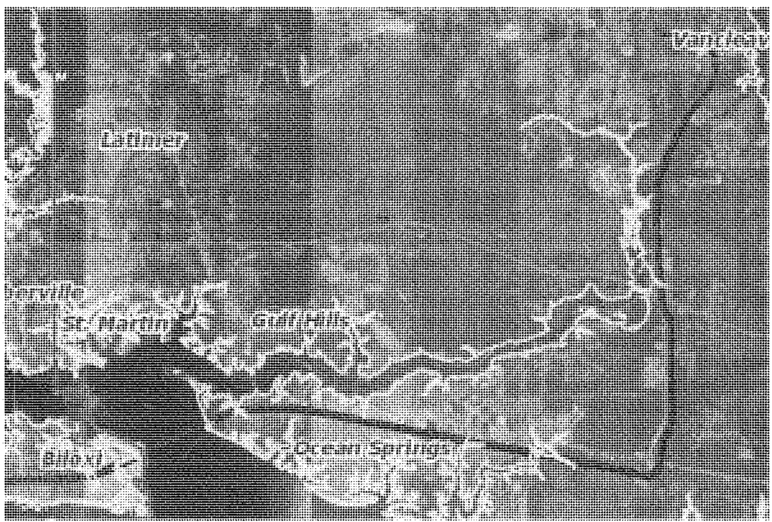


Figure 3.4.5.1-5. Biloxi Bay 10-yr Ponding to Elev 8.4 ft NAVD88

This ponded water area in Harrison County above the surge barrier gates at the 10-yr flood is at 8.4 ft NAVD88 and is approximated by the 8-ft ground contour line shown in Figure 3.4.5.1-6.

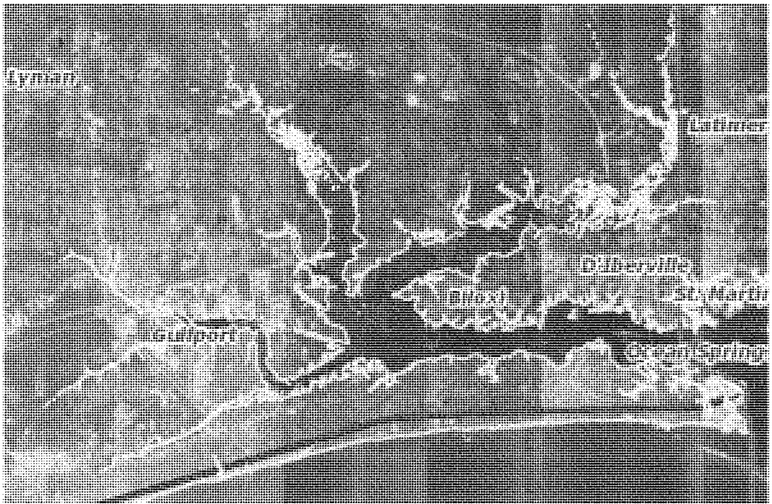


Figure 3.4.5.1-6. Biloxi Bay 10-yr Ponding to Elev 8.4 ft NAVD88

3.4.5.1.2 Geotechnical Data

The available mapping covering the bay bottom is very sketchy consisting mostly of quad maps. This data indicates that the existing bay bottom elevation along the study alignment would vary from a maximum of about (-)12 feet at the maintained channel (the nominal channel depth) to approximately (-)3 feet near, and for some distance out from, each bank. Information gathered from the Mississippi Department of Transportation subsequent to their emergency replacement of the U.S. Highway 90 Bridge indicates that the bay bottom materials are very loose and unstable to a significant depth below the bay bottom, indicating that a significant amount of undercutting would be required for any structure that might be installed, and that structures of the magnitude under consideration would require very deep pile foundations.

3.4.5.1.3 Structural, Mechanical and Electrical

See sections 3.4.5.1.3.1 through 3.4.5.1.3.3.

3.4.5.1.3.1 Structural

Structurally, the Barrier as configured for this study would consist of a series of 25 large stainless steel clad, structural steel framed gates called rising sector gates. Each of these would be supported on reinforced concrete piers resting on large continuous concrete sills with pile foundations. The tentative layout used to estimate the scope of the structure was configured having gates 132 feet long mounted on 28-foot wide piers. The number of gates was determined by the extent of water having depth sufficient to support their operation. To facilitate as nearly as possible the normal ebb and flow of tide waters through the barrier, the concrete connector wall and rock fill portions of the barrier either side of the gated structure would be fitted with a series of closely spaced low level gated culverts. The gate and pier heights were varied to accommodate the "level of protection" under consideration. The three elevations selected for this study were 20, 30, and 40 NAVD88. In each case the gate heights were set to match the protection level elevations with pier heights set approximately 3 feet higher to provide minor wave clearance for protection of operating equipment. Atop each pier an operating machinery block would be mounted to house the operating equipment. No lateral access over the tops of the piers was envisioned because of the long spans and the desire to keep the vista across the structure as clear as possible. Operating and utility access would be provided through two continuous tunnels passing through the sill section and the rock fill, to operating facilities located on each bank.

3.4.5.1.3.2 Mechanical

The mechanical equipment and appurtenances required for operation of these facilities would include very large steel gate linkages and hydraulic rams and pivot pins for operation of each gate. Each gate would rotate on large bearings and pivot hubs at each end of the gate. Various operating hydraulic and lubrication oil systems would also be required. Each gate would have an opening/closing time of approximately 15 minutes.

3.4.5.1.3.3 Electrical

Primary electrical power for operating the gates would be provided using dedicated, standard transformers with emergency back-up generators. The size of the generators would be greatly reduced by minimizing the wattage output through reduction of the demand on the facility. The demand would be minimized by phasing the operation of the gates to the greatest extent possible. For this study it was determined that this could possibly be done by operating a maximum of eight gates at a time, with the last eight gates being left open until the storm threat was definite and eminent. The operation would require that a maximum of four gates be started at one time, with the remaining four gates sequenced to start 1 minute later. It was determined that this would allow the entire closure and subsequent opening operation to be done over a period of 4 to 6 hours. The supplemental generation aspect was considered to be a vital component of the design because of the very high cost of commercial standby power and because commercial electric power would almost certainly be unavailable during and immediately following a storm event.

3.4.5.1.4 HTRW

Due to the extent and large number of real estate parcels along with the potential for re-alignment of the structural aspects of this project, no preliminary assessment was performed to identify the possibility of hazardous waste on the sites. These studies will be conducted during the next phase of work after the final siting of the various structures. The real estate costs appearing in this report therefore will not reflect any costs for remediation design and/or treatment and/or removal or disposal of these materials in the baseline cost estimate.

3.4.5.1.5 Construction Procedures and Water Control Plan

Following is a very tentative description of a sequence of construction by which the barrier structure and embankments might be built. There are admittedly myriad other means by which this could be accomplished as demonstrated by the construction methods used in construction of the Thames River Barrier and various structures in The Netherlands and elsewhere, any one of which might result in more economical and expeditious construction of the barrier. However, at this juncture, in the interest of clarity and brevity, it was considered expedient to describe this work using customary construction techniques common to most of our large civil works projects constructed to date.

3.4.5.1.5.1 Construction Procedure

As configured for this study, the physical construction of the barrier would begin with installation of the first of what would likely be a two stage cellular cofferdam. The arrangement assumed for this study consisted of a series of circular sheet pile cells and connecting arcs measuring approximately 60 feet in diameter and extending 100 feet from the top of the cell to the pile tip elevation. These cells would encompass either the east side or west side transition monoliths and the portion of the gated structure extending to the center of the boat channel. The second phase cofferdam would encompass the remainder of the gated structure and the remaining non-overflow concrete section. It was assumed that for structures designed to provide the highest protection level (Elevation 40 NAVD88) the top of cells could be placed at elevation 35 with reasonable degree of safety. This would provide cell embedment of approximately 30 feet below the lowest structure foundation elevation. This configuration was, naturally, modified to fit the lower levels of protection but in each case the configuration was made to provide the same relative of protection during construction. With the cofferdam in place the interior would be dewatered using hydraulic pumps, and excavation for the concrete structures would begin. Once the excavation in a given area is brought to the required grade work would continue in this area with the installation of foundation piles. Prior to completion of the first phase of the concrete work, installation would begin on the next phase of the cofferdam.

Once the first phase of the concrete structure is completed and the first phase cofferdam removed, installation of the gates and operating machinery would begin. Fabrication of the gates would have been done on land in an outfitting yard and the gates transported by water to the proper installation site. Note that this would likely require dredging of a temporary construction channel parallel to the barrier for a portion of its length.

Construction of the rock fill embankments would require surcharging and pre-consolidation of the bay bottom materials. (See section 3.4.3.1.2 above for discussion of the Geotechnical aspects of this site.)

3.4.5.1.5.2 Water Control Plan

As this work progresses the flow into and out of Biloxi Bay would be somewhat restricted for practically the entire construction time. This restriction could be minimized by removal of the cofferdams immediately upon completion of the concrete piers to some point above the normal high tide level thus allowing flow over the completed sill sections as construction continues on the piers and as the gates are being installed. It is estimated the maximum flow restriction at any time would be approximately 50% of the inlet width and that this restriction could endure for as much as three to five years using the methods and approximate sequence of construction indicated above.

3.4.5.1.6 Physical Security

During the construction of the project the contractor would be responsible for maintaining security of all his work sites. This would be done in accordance with guidance noted under Section 3.4.1.7 General, above, in addition to the normal site security requirements.

Upon completion of the project the facilities security responsibilities would pass to the U.S. Army Corps of Engineers and the state, county and municipal law enforcement entities, all of whom would coordinate a program of oversight under which the facilities would be operated and maintained and under which specific security responsibilities would be defined and allocated. These agreements would also be required to reflect the provisions of the guidance noted in Section 3.4.1.7 General, above, in addition to normal security criteria.

3.4.5.1.7 Operations and Maintenance

In order to assure proper functioning of the facilities once they are placed in service a program of Operations and Maintenance would be developed by the U.S. Army Corps of Engineers, in conjunction and cooperation with the affected state and local entities. This O & M Plan would address specific responsibilities as to daily operation of the facilities, the periodic testing and maintenance of the operating machinery, maintenance of specified stocks of replacement parts, security of the facilities, and maintenance of any buildings and grounds associated with the operation and maintenance of the facilities. As presently envisioned, this O & M responsibility would remain under control of the U.S. Army Corps of Engineers and would be administered under its Operations mission.

3.4.5.1.8 Cost Estimate

The costs for the various options included in this measure are presented in Section 3.4.5.8 Cost Summary. Construction costs for the various options are included in Table 3.4.5.8-1 and costs for the annualized Operation and Maintenance of the options are included in Table 3.4.5.8-2. Estimates are comparative-Level "Parametric Type" and are based on Historical Data, Recent Pricing, and Estimator's Judgment. Quantities listed within the estimates represent Major Elements of the Project Scope and were furnished by the Project Delivery Team. Price Level of Estimate is April 07. Estimates exclude project Escalation and HTRW Cost. The construction costs include real estate, engineering design (E&D), construction management, and contingencies. The E&D cost for preparation of construction contract plans and specifications includes a detailed contract survey, preparation of contract specifications and plan drawings, estimating bid quantities, preparation of bid estimate, preparation of final submittal and contract advertisement package, project engineering and coordination, supervision technical review, computer costs and reproduction. Construction Contingency developed and assigned at 25% to cover the Cost Growth of the project.

3.4.5.1.9 Schedule and Design for Construction

The scheduling for events following this conceptual study would of necessity include extensive further study to ascertain in greater detail the specific requirements of the project and the most feasible means by which to fulfill these requirements. The Sequence of events would include but not be limited to the following:

a. The alignment and extent of the proposed barrier should be subjected to detailed study to determine the most feasible routing. This study should address, among other factors, the exact location of utilities features crossing the bay inlet, the present and projected future needs of the boat channel passing through the barrier, and how best to minimize the effects that the barrier could have on the existing marine environment.

b. Detailed deep geotechnical investigation should be made to determine as accurately as possible the engineering capabilities of the soils making up the bay bottom along the alignment (or alignments) under consideration.

c. A more thorough and painstaking investigation of various types of gate structures should be undertaken to confirm the choice of the rising sector gate for this application, or to replace this type gate with another perhaps more appropriate to the circumstances.

d. Once this search and these investigations and analyses have been completed a thorough design of the structures to be included in the final facility would be undertaken addressing the full range of hydraulic events that the structure might see, and making certain that all pertinent design considerations are accounted for.

e. A thorough analysis of the power required to operate the gates in a timely manner in time of storm must be made and the very best, most dependable means of providing this power determined.

f. The link between the operation of the gates and the best available storm forecasting system(s) would be designed and its operating features and equipment detailed.

3.4.5.2 Location

The alignment suggested herein for the barrier structure would run parallel with and south of the Railroad Bridge crossing Biloxi Bay. This would approximate the shortest route across the inlet leading from the Mississippi Sound into the bay. As the preliminary layout of the barrier was developed it became apparent that, because of the excavation required, a significant amount of separation would be required between the railroad bridge and the ultimate location of the structures included in the barrier. For this study the centerline of the barrier was positioned approximately 260 feet from the center of the railroad bridge. This was left unaltered for all protection levels. The entire barrier would be approximately 6,100 feet in length from water's edge to water's edge, and would consist of rock fill levees extending from the overland levee at each bank for some distance into the bay and enveloping the mass concrete non-overflow wall sections leading to each end of the gated structure.

3.4.5.3 Existing Conditions

The points at which the barrier would come ashore in Jackson County on the east and Harrison County on the west, are in urban areas with extensive residential and commercial development. Several structures would need to be relocated and it is uncertain the extent to which existing utilities might have to be relocated to clear the way for this facility.

3.4.5.4 Coastal and Hydraulic Data

Historic coastal data is shown in Paragraph 1.4, elsewhere in this report. High water marks taken by FEMA after Hurricane Katrina in 2005 as well as the 6-ft(blue), 12-ft(green), 16-ft(brown), and 20-ft(pink) ground contour lines are shown in Figure 3.4.5.4-1. The data indicates the Katrina high water was as high as 21 ft NAVD88 at the mouth of the bay.

Stage-Frequency data for a suite of severe storms using Joint Probability Method (JPM) and hydrodynamic modeling were developed by the Engineer Research and Development Center (ERDC) for 80 locations along the study area. These data were combined with historical gage frequencies for smaller storms to establish stage-frequency curves at 54 economic reaches in the study area which were entered into Hydrologic Engineering Center's (HEC) Flood Damage Analysis (HEC-FDA) application to evaluate benefits. An expanded description of the procedure is shown elsewhere in this report. Points near the mouth of the bay at which data from hydrodynamic modeling was saved are shown in Figure 3.4.5.4-2.

Existing Condition Stage –Frequency data for Save Point 9, near the mouth of the bay, is shown in Figure 3.4.5.4-3. The 95% confidence limits, approximately equally to plus and minus two standard deviations, are shown bounding the median curve. The elevations are presented at 100 ft higher than actual to facilitate HEC-FDA computations.

Figure 3.4.5.4-1. Ground Contours and Katrina High Water

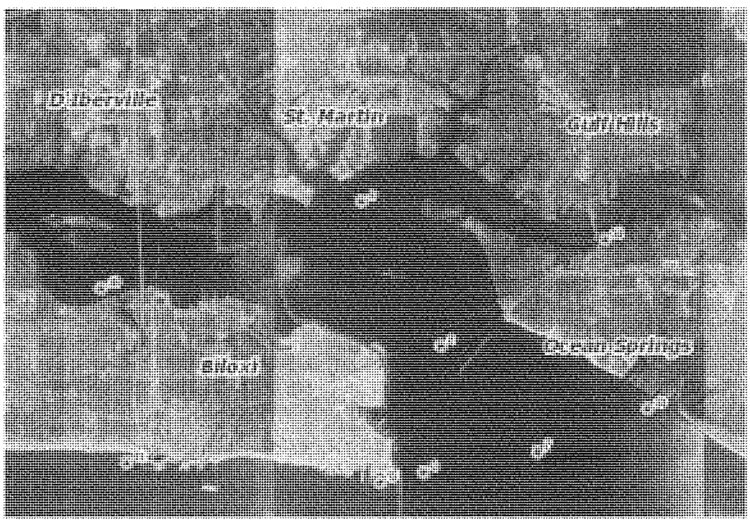


Figure 3.4.5.4-2. Hydrodynamic Modeling Save Points near Biloxi Bay

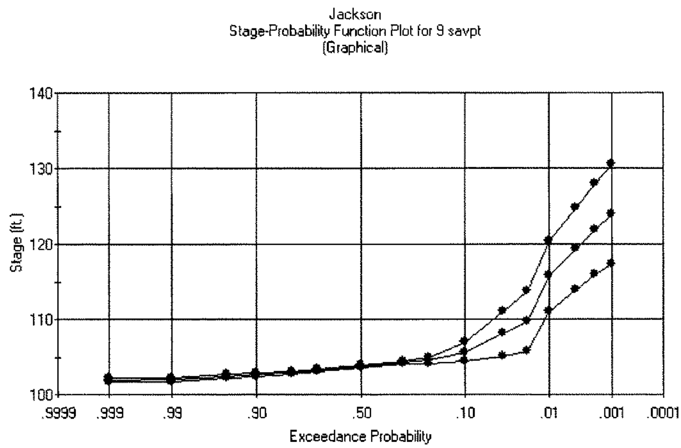


Figure 3.4.5.4-3. Existing Conditions at Save Point 8, near the Mouth of Biloxi Bay

3.4.5.5 Option A – Elevation 20.0

3.4.5.5.1 Structural

In order to reasonably accurately approximate the scope of the structures required to form a moveable barrier to elevation 20 a very preliminary rising sector gate design was made for the gate and its operating disks, and the piers and foundations were approximated on a proportional basis. A system of foundation piles was then estimated from a stability analysis made for the most stringent hydraulic situation, water with wave impact to the top of the gates on the flood side and at elevation "Zero" on the protected side of the gate. Uplift for the situation described was assumed to vary from full static water head at the flood side edge of the sill to static water pressure equivalent to the embedment of the sill below elevation "zero" at the protected side edge of the sill. Static lateral water forces were derived for static water pressure to elevation 20 on the flooded side of the structure and to elevation "zero" on the protected side. Wave impact data from model testing was not yet available when these analyses were made. Therefore an approximation of the wave impact loading was made by applying 25% of the flooded side static head pressure at the top of the gate and allowing this to taper to zero at the base of the monolith. The force and moment resulting from this inverted triangular load was then added to that derived for the static head situation.

The preliminary design for a gated structure providing protection up to elevation 20 resulted in gross quantities of basic construction materials as indicated in Table 3.4.5.5-1.

Table 3.4.5.5-1.
Gross Quantities for Biloxi Bay Surge Barrier Elevation 20.0 NAVD88

Item	Quantity	Units
Cofferdam Piling	23,294	Tons
Foundation Piling	50,540	Each
Concrete	493,700	Cubic Yards
Reinforcement	1,210	Tons
Rising Sector Gates (25 Each)	19,750	Tons
Gate Operating Machinery (Steel, 25 sets)	10,100	Tons

Note: Quantities taken from preliminary stability and other design computations.

3.4.5.6 Option B – Elevation 30.0

3.4.5.6.1 Structural

In order to reasonably accurately approximate the scope of the structures required to form a moveable barrier to elevation 30, a very preliminary rising sector gate design was made for the gate and its operating disks, and the piers and foundations were approximated on a proportional basis. The foundation piles were then estimated from a stability analysis made for the most stringent hydraulic situation, water with wave impact to the top of the gates on the flood side and at elevation "Zero" on the protected side of the gate. Uplift for the situation described was assumed to vary from full static water head at the flood side edge of the sill to static water pressure equivalent to the embedment of the sill below elevation "zero" at the protected side edge of the sill. Static lateral water forces were derived for static water pressure to elevation 30 on the flooded side of the structure and to elevation "zero" on the protected side. Wave impact data from model testing was not yet available when these analyses were made. Therefore an approximation of the wave impact loading was made by applying 25% of the flooded side static head pressure at the top of the gate and allowing this to taper to zero at the base of the monolith. The force and moment resulting from this inverted triangular load was then added to that derived for the static head situation.

The preliminary design for a gated structure providing protection up to elevation 30 resulted in gross quantities of basic construction materials as indicated in Table 3.4.5.6-1 below.

Table 3.4.5.6-1.
Gross Quantities for Biloxi Bay Surge Barrier Elevation 30.0 NAVD88

Item	Quantity	Units
Cofferdam Piling	31,837	Tons
Foundation Piling	14,538	Each
Concrete	552,800	Cubic Yards
Reinforcement	1,083	Tons
Rising Sector Gates (25 Each)	24,260	Tons
Gate Operating Machinery (Steel, 25 sets)	10,100	Tons

Note: Quantities taken from preliminary stability and other design computations.

3.4.5.7 Option C – Elevation 40.0

3.4.5.7.1 Structural

In order to reasonably accurately approximate the scope of The structures required to form a moveable barrier to elevation 40, a very preliminary rising sector gate design was made for the gate and its operating disks, and the piers and foundations were approximated on a proportional basis. The foundation piles were then estimated from a stability analysis made for the most stringent hydraulic situation, water with wave impact to the top of the gates on the flood side and at elevation "Zero" on the protected side of the gate. Uplift for the situation described was assumed to vary from full static water head at the flood side edge of the sill to static water pressure equivalent to the embedment of the sill below elevation "zero" at the protected side edge of the sill. Static lateral water forces were derived for static water pressure to elevation 40 on the flooded side of the structure and to elevation "zero" on the protected side. Wave impact data from model testing was not yet available when these analyses were made. Therefore an approximation of the wave impact loading was made by applying 25% of the flooded side static head pressure at the top of the gate and allowing this to taper to zero at the base of the monolith. The force and moment resulting from this inverted triangular load was then added to that derived for the static head situation.

The preliminary design for a gated structure providing protection up to elevation 40 resulted in gross quantities of basic construction materials as indicated in Table 3.4.5.7-1 below.

Table 3.4.5.7-1.
Gross Quantities for Biloxi Bay Surge Barrier Elevation 40.0 NAVD88

Item	Quantity	Units
Cofferdam Piling	31,837	Tons
Foundation Piling	20,540	Each
Concrete	561,300	Cubic Yards
Reinforcement	1,061	Tons
Rising Sector Gates (25 Each)	40,291	Tons
Gate Operating Machinery (Steel, 25 sets)	10,100	Tons

Note: Quantities taken from preliminary stability and other design computations.

3.4.5.8 Cost Estimate Summary

The costs for construction and for operations and maintenance of all options are shown below. Estimates are comparative-Level "Parametric Type" and are based on Historical Data, Recent Pricing, and Estimator's Judgment. Quantities listed within the estimates represent Major Elements of the Project Scope and were furnished by the Project Delivery Team. Price Level of Estimate is April 07. Estimates excludes project Escalation and HTRW Cost.

Table 3.4.5.8-1.
Back Bay of Biloxi Surge Barrier Construction Cost Summary

Option	Total project cost
Option A – Elevation 20 ft NAVD88	$989,800,000
Option B – Elevation 30 ft NAVD88	$1,267,100,000
Option C – Elevation 40 ft NAVD88	$1,810,700,000

Table 3.4.5.8-2.
Back Bay of Biloxi Surge Barrier O & M Cost Summary

Option	O&M Costs
Option A – Elevation 20 ft NAVD88	$13,770,000
Option B – Elevation 30 ft NAVD88	$17,646,000
Option C – Elevation 40 ft NAVD88	$25,243,000

3.4.5.9 References

See 3.4.3 General discussion above for references.

3.4.6 Jackson County Inland Barrier

3.4.6.1 General

Several high density residential and business areas are located in Jackson County. These are subject to damage from storm surges associated with hurricanes. Earthen levees were evaluated for protection of these areas. The levees were evaluated at elevations 20 ft NAVD88 and 30 ft NAVD88 and 40 ft NAVD88. The top width was assumed 15 ft with sideslopes of 1 vertical to 3 horizontal. Each of the levees is presented separately in this report. Storm surge gates across Biloxi Bay are also included to prevent flooding from hurricanes. Additional options not evaluated in detail are described elsewhere in this report.

Evaluation of this option was done by comparing benefits computed by Hydrologic Engineering Center's (HEC) Flood Damage Analysis (FDA) computer application HEC-FDA and costs computed. HEC-FDA modeling was done comparing the study reaches using variations in expected sea-level rise and development. Details regarding the methodology are presented elsewhere in this report.

3.4.6.2 Location

The location of the levee in Jackson County is shown in Figures 3.4.6-1 through 3.4.6-4 parallel to the CSX railroad, Hwy 57 and Hwy 90.

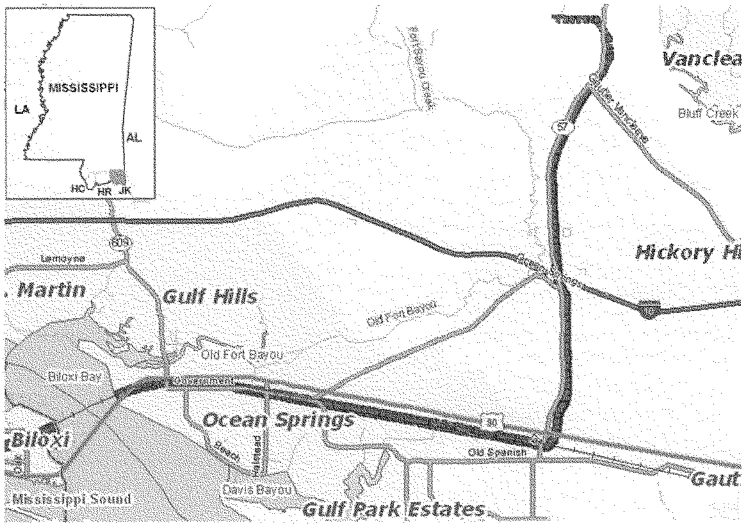


Figure 3.4.6-1. Vicinity Map Jackson County, MS

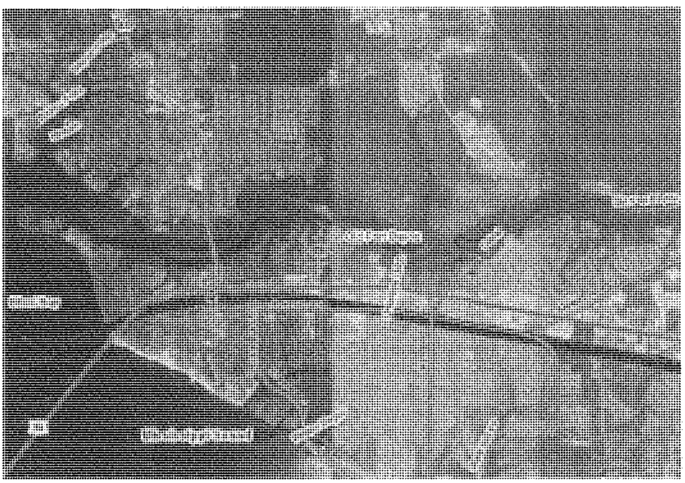


Figure 3.4.6-2. Jackson County Inland Barrier

Figure 3.4.6-3. Jackson County Inland Barrier

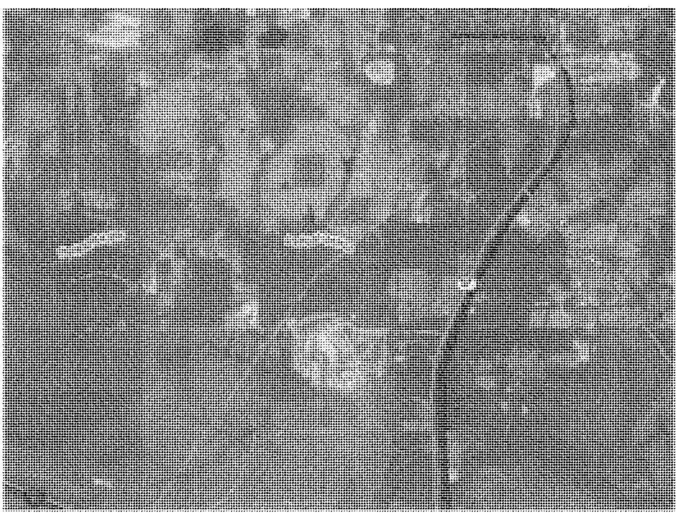


Figure 3.4.6-4. Jackson County Inland Barrier

3.4.6.3 Existing Conditions

Jackson County is located on the east side of the Mississippi at the Mississippi Sound coast. The main residential and business area is at Ocean Springs, which is mostly south of the levee. Ground elevations over the areas behind the levee vary between Elevations 10-20 ft NAVD88 at low areas to as high as 50 ft NAVD88. The area is drained by Old Fort Bayou. The 4-ft (blue), 10-ft (green), 20-ft (pink), 30-ft (dark Blue), 40-ft (purple), and 50-ft (gray) ground contour lines are shown in Figure 3.4.6-5.

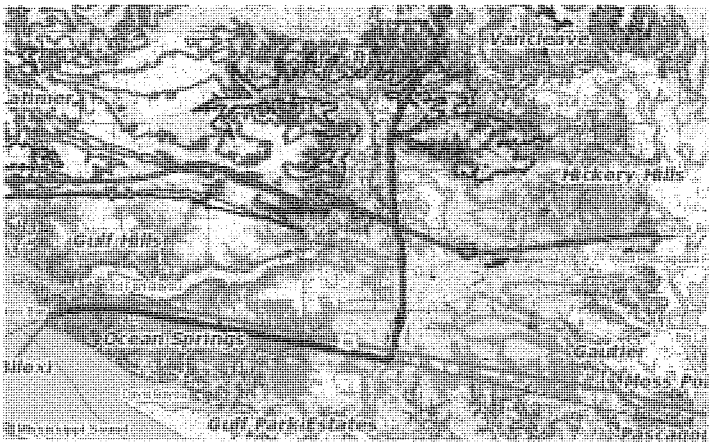


Figure 3.4.6-5. Existing Conditions Jackson County, MS

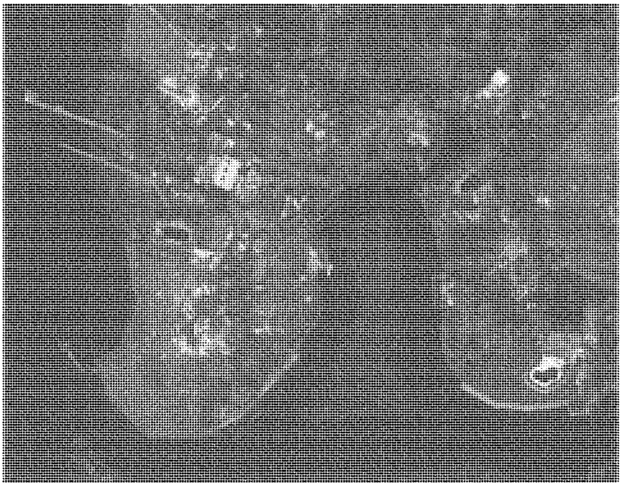
Drainage from ordinary rainfall is hindered on occasions when either of the rivers or the gulf is high, but impacts from hurricanes are devastating.

Recent damage from Hurricane Katrina in August, 2005 near the mouth of the Old Fort Bayou area are shown in Figures 3.4.6-6 and 3.4.6-7.

3.4.6.4 Coastal and Hydraulic Data

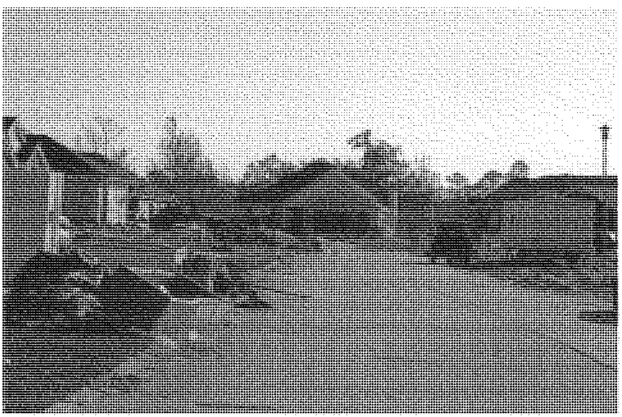
Historic coastal data is shown in Paragraph 1.4, elsewhere in this report. High water marks taken by FEMA after Hurricane Katrina in 2005 as well as 4-ft(blue), 10-ft(green),20-ft(pink), 30-ft(dark Blue), 40-ft(purple), and 50-ft(gray) ground contour lines are shown in Figure 3.4.6-8 below. The data indicates the Katrina high water was as high as 21-22 ft NAVD88 in the Old Fort Bayou area north of Ocean Springs.

Stage-Frequency data for a suite of severe storms using Joint Probability Method (JPM) and hydrodynamic modeling were developed by the Engineer Research and Development Center (ERDC) for 80 locations along the study area. These data were combined with historical gage frequencies for smaller storms to establish stage-frequency curves at 54 economic reaches in the study area which were entered into Hydrologic Engineering Center's (HEC) Flood Damage Analysis (HEC-FDA) application to evaluate benefits. An expanded description of the procedure is presented elsewhere in this report. Points near Gautier at which data from hydrodynamic modeling was saved are shown in Figure 3.4.6-9.



Source: http://ngs.woc.noaa.gov/storms/katrina/24806787.jpg

Figure 3.4.6-6. Hurricane Katrina Damage Near mouth of Old Fort Bayou, MS



Source: http://www.flickr.com/photos/cbsnaps/53488199/, cbatesteach

Figure 3.4.6-7. Hurricane Katrina Damage in St Martin (nr Ocean Springs), MS

Figure 3.4.6-8. Ground Contours and Katrina High Water Elevations

Figure 3.4.6-9. Hydrodynamic Modeling Save Points near Gautier, MS

Existing Condition Stage –Frequency data for Save Point 33, near the Ocean Springs, is shown in Figure 3.4.6-10 as an example. The 95% confidence limits, approximately equally to plus and minus two standard deviations, are shown bounding the median curve. The elevations are presented at 100 ft higher than actual to facilitate HEC-FDA computations.

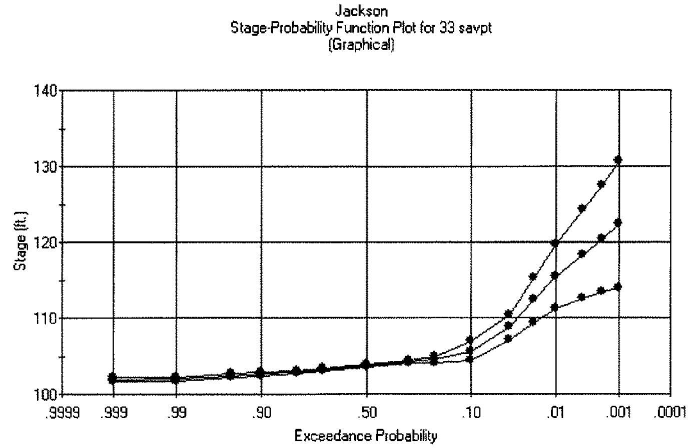


Figure 3.4.6-10. Existing Conditions at Save Point 33, near Ocean Springs, MS

3.4.6.5 Option A – Elevation 20 ft NAVD88

This option consists of an earthen dike around the areas north of Hwy 90 as shown on Figure 3.4.6-11, along with the internal sub-basins and levee culvert/pump locations. The levee would have a top width of 15 ft and slopes of 1 vertical to 3 horizontal. The levee is located mostly along high ground so ponding at the levee would be minimal. The levee surfaces will be armored with a layer of gabions to prevent scour during overtopping. Ponding will occur on the outside of the levee which would require ditching to other drainage basins. The ditch locations are shown in Figure 3.4.6-11 in dark blue.

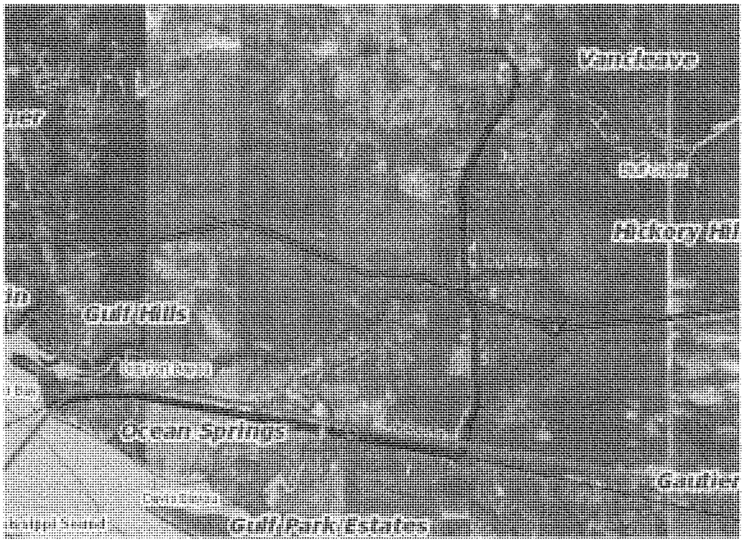


Figure 3.4.6-11. Pump/Culvert/Sub-basin Site Locations

Damage and failure by overtopping of levees could be caused by storms surges greater than the levee crest as depicted in Figure 3.4.6-12.

Source: Wave Overtopping Flow on Seadikes, Experimental and Theoretical Investigations, Holger Schüttrumpf, (Photo: Leichtweiss-Institute) http://kfki.baw.de/fileadmin/projects/E_35_134_Lit.pdf

Figure 3.4.6-12. North Sea, Germany, March 1976

Overtopping failures are caused by the high velocity of flow on the back side of the levee. Although significant wave attack on the seaward side of some of the New Orleans levees occurred during Hurricane Katrina, the duration of the wave attack was for such a short time that major damage did not occur from wave action. The erosion shown in Figure 3.4.6-13 was caused by approximately 1-2 ft of overtopping crest depth.

Revetment would be included in the levee design to prevent overtopping failure.

Source: ERDC, Steven Hughes

Figure 3.4.6-13. Crown Scour from Hurricane Katrina at Mississippi River Gulf Outlet (MRGO) Levee in St. Bernard Parish, New Orleans, LA

The levee would be protected by gabions on filter cloth as shown in Figure 3.4.6-14, extending across a drainage ditch which carries water to nearby culverts and which would also serve to dissipate some of the supercritical flow energy during overtopping conditions.

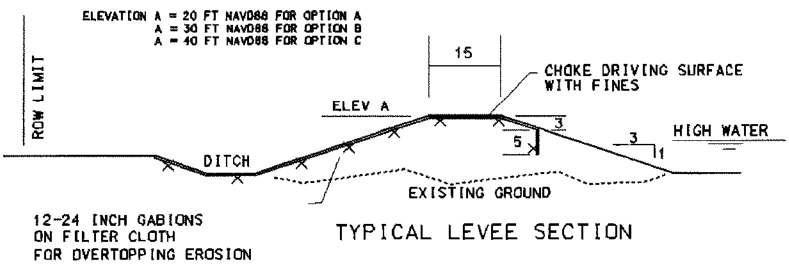


Figure 3.4.6-14. Typical Section at Inland Barrier

3.4.6.5.1 Interior Drainage

For smaller drainage areas, drainage on the interior of the inland barrier would be collected at the levee and channeled to culverts placed in the levee at the locations shown in Figure 3.4.6-11. The culverts would have tidal 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 the upstream end at every culvert in the levee for manual control in the event the tidal gate malfunctions. A typical section is shown in Figure 3.4.6-15.

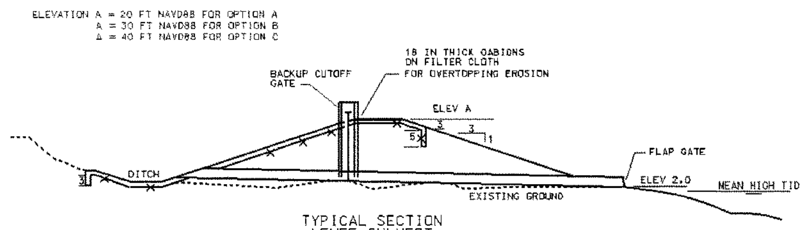


Figure 3.4.6-15. Typical Section at Culvert

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 inland barrier into major sub-basins as shown in Figure 3.4.6-11 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.

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. For the culvert design, headwater elevations at the culverts were maintained at an elevation no greater than 5 ft NAVD88 with a tailwater elevation of 2.0 ft NAVD88 assumed. Drainage ditches along the toe of the levee will be required to assure that smaller basins can be drained to a culvert/pump site. These ditches were sized using a normal depth flow computation. Curve numbers, pump, and culvert capacity tables are not included in the report beyond that necessary to obtain a cost estimate. The data is considered beyond the level of detail required for this report.

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. This decision was based on an evaluation of rainfall observed during hurricane and tropical storm events as presented in two sources. The first is "Frequency and Aerial 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. However, in some of the areas, existing storage could be adequate to pond water without causing damage, even without pumps. In other areas that do have pumps, some rise in interior water during interior events greater than the 10-yr rain could occur, but may not cause damage. Designing the pumps for the peak 10-yr flow provides a significant pumping capacity. Further studies will detail the requirement for the appropriate ponding areas, pump sizes, or buyouts in the affected areas.

During non-hurricane periods of low water in the sound, when rainfall greater than the 25-yr event occurs, the pumps could also be used to augment the flow capacity of the levee culverts.

In addition to the local drainage outlets at the levee described above, in the event of an imminent hurricane, barrier gates across the Back Bay of Biloxi would be closed, and flow from the Biloxi and Tchoutacabouffa Rivers, as well as local runoff would pond behind the gates. The location of the barrier is shown in Figure 3.4.6-16.

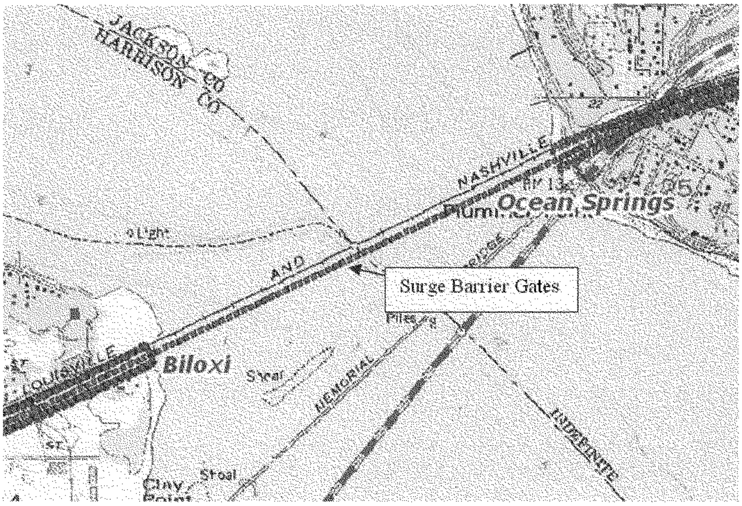


Figure 3.4.6-16. Biloxi Bay Surge Barrier Location

The gates would be similar to the gates across the Thames River in London, England, shown in Figure 3.4.6-17.

The Hydrologic Engineering Center's Hydrologic Modeling System (HEC-HMS) was used to model the Biloxi Bay watershed in order to predict the maximum water elevation behind the gates in the bay under several different scenarios.

Figure 3.4.6-17. Thames River Barrier Gates

The Biloxi Bay watershed is an approximately 640 square mile watershed comprised of six subbasins that stretch across Harrison, Stone, and Jackson County, MS. There is one United States Geological Survey (USGS) discharge gage located in the watershed along the Biloxi River and one National Oceanic and Atmospheric Administration (NOAA) hourly precipitation gage located on the east side of the watershed. The discharge gage is USGS gage 2481000 at Wortham, MS and the precipitation gage is NOAA gage 107840 (Saucier Experimental Forest). Data from these gages, along with soils data from the National Cooperative Soil Survey and Technical Paper 40 (TP-40) synthetic rainfall events were used to determine the peak discharge and total run-off volume entering Biloxi Bay from the Biloxi Bay watershed for the 2-100 year rainfall events. The Hydrologic Engineering Center's Hydrologic Modeling System (HEC-HMS) was used for the modeling effort. The Biloxi Bay watershed is shown in Figure 3.4.6-18.

The components of the model include the precipitation specification, the loss model, the direct runoff model, and observed discharge data. Precipitation data used in the modeling process included hourly precipitation from NOAA gage 107840 and the 2-100 year TP-40 rainfall events. The initial and constant loss rate and SCS curve number methods were used for the loss model while the Snyder's unit hydrograph (UH) and SCS UH methods were used for the direct runoff model. The model was calibrated to observed hourly discharge data for two events at USGS gage 2481000.

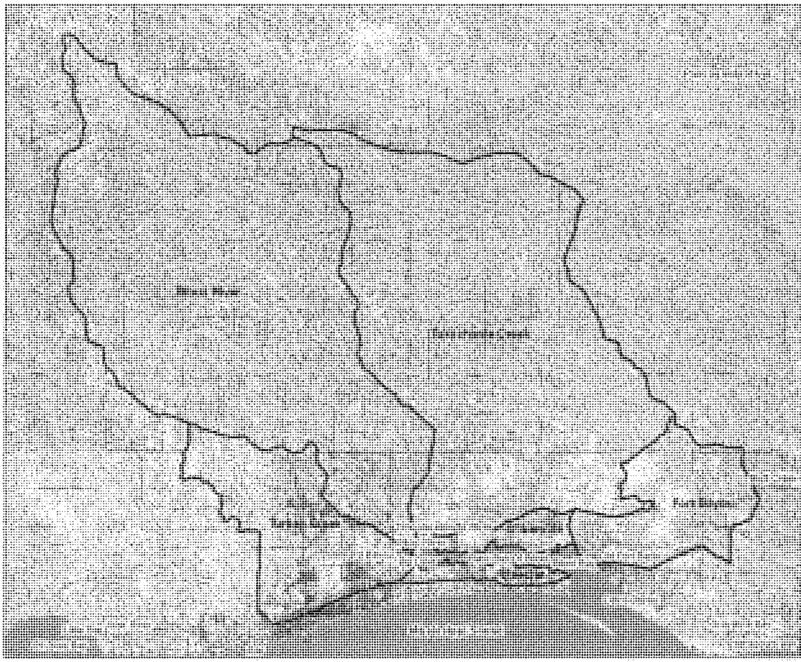


Figure 3.4.6-18. Biloxi Bay Watershed

Calibration results agree reasonable well with observed data as shown in Figures 3.4.6-19 and 3.4.6-20.

Ponding from the interior rivers behind the gates will depend partially on the elevation of the gulf when the gates are closed. Several historical stage hydrographs of hurricanes were reviewed to determine the duration of various stages along the gulf. From this review, it was determined that storms generally reach 4 ft NAVD88 and recede to that elevation within 24 hours. Using this information, various theoretical coincident rainfall events taken from T.P 40 were modeled to determine the resulting water surface elevations behind the barrier during the 24-hour period the gates are to be closed. A 10-yr rain was selected for the design condition, in accordance with studies cited above. The highest inflow period of the inflow hydrograph was used to compute changes in bay elevations in the 24-hour gate closure period.

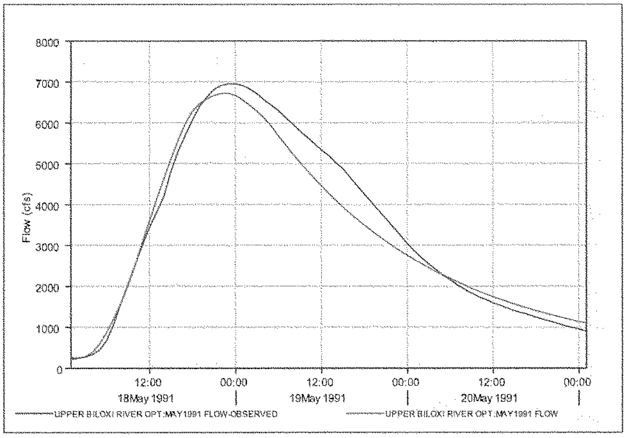


Figure 3.4.6-19. Biloxi Bay Watershed Calibration, 19 May 1991

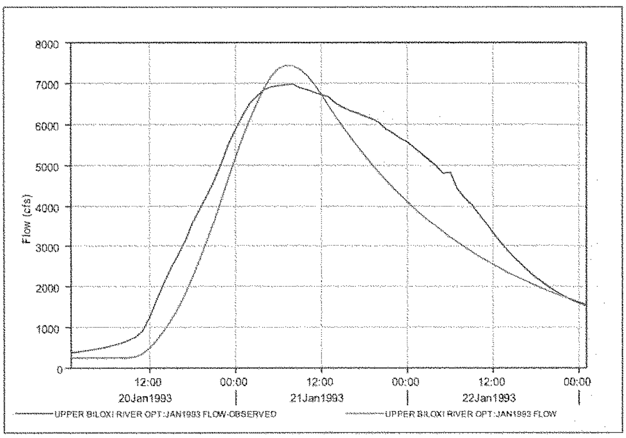


Figure 3.4.6-20. Biloxi Bay Watershed Calibration, 21 Jan 1993

Based on this method of analysis, the resulting elevations for the various storms are shown in Table 3.4.6.1-1, with the 10-yr elevation of 8.4 ft NAVD88 the design condition.

Table 3.4.6.1-1.
Biloxi Bay Ponding

Biloxi Bay 4 ft. Base Elevations	
Strom Event	**Bay Elevation (ft NAVD88)**
2-year	6.0
5-year	7.6
10-year	8.4
25-year	9.4
50-year	10.0
100-year	10.8

This area in Jackson County is approximated by the 8-ft ground contour line shown in Figure 3.4.6-21.

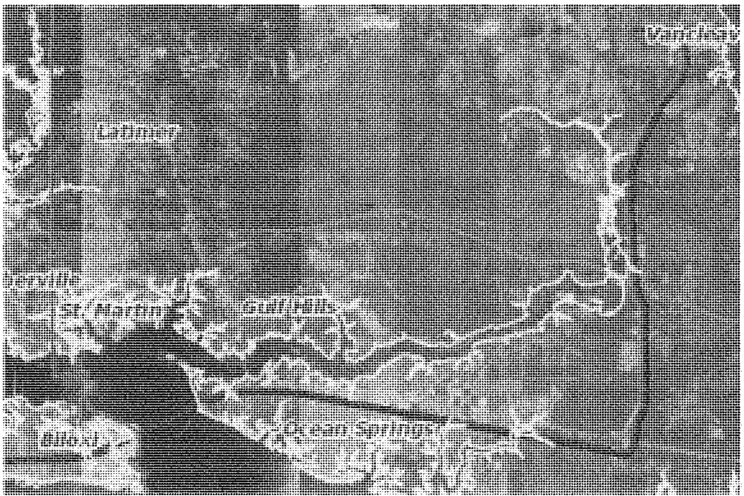


Figure 3.4.6-21. Biloxi Bay 10-yr Ponding to Elev. 8.4 ft NAVD88

3.4.6.5.2 Geotechnical Data

Geology: Citronelle formation is found above the Interstate 10 alignment and is a relatively thin unit of fluvial deposits of Plio-Pleistocene age consisting of gravelly sand and silty sand layers. Typically the formation is 30 to 80 feet thick, except where it has filled eroded channels in the underlying formations. The sand in the formation has a variety of colors, often associated with the presence of iron oxides in the form of hematite or goethite. Thin discontinuous clay layers are found in some areas. The iron oxide has occasionally cemented the sand into friable sandstone, usually occurring only as a localized layer. Within the study area, this formation outcrops north of Interstate 10 and will not be encountered at project sites other than any levees that might extend northward to higher ground elevations.

Prairie formation is found along the rest of the Line 4 alignment within Jackson County. The Prairie formation is found southward of the Citronelle formation and is of Pleistocene age. This formation consists of fluvial and floodplain sediments that extend southward from the outcrop of the Citronelle formation to or near the mainland coastline. Sand found within this formation has an economic value as beach fill due to its color and quality. Southward from its outcrop area, the formation extends under the overlying Holocene deposits out into the Mississippi Sound.

Gulfport Formation is found along the coastline in most of western Jackson County at Belle Fontaine Beach. This formation of Pleistocene age overlies the Prairie formation and is present as well sorted sands that mark the edge of the coastline during the last high sea level stage of the Sangamonian Interglacial period. It does not extend under the Mississippi Sound.

Geotechnical: The inland barrier earthen levee section will have one vertical to three horizontal side slopes with a fifteen foot crest width. All work areas to receive the fill shall be cleared and grubbed of all trees and surface organics and all existing foundations, streets, utilities, etc. will be removed and the subsequent cavities backfilled and compacted. The levee will be constructed of sand clay materials obtained from off site commercial sources, trucked to the work area, placed in thin lifts and compacted to 95 percent of the maximum modified density. The final surface will be armored by the placement of 24 inch thick gabion mattress filled with small stone for erosion protection during an event that overtops the levee. The armoring will be anchored on the front face by trenching and extend across the downstream slope and the 25 foot easement area beyond the toe. The front side of the levee and all non critical surface areas will be subsequently covered by grassing. Road crossings will incorporate small gate structures or ramping over the embankment where the surface elevation is near that of the crest elevation. The elevation relationship of the crest and the adjacent railroad will be a governing factor. The surfaces will be paved with asphalt and the corresponding drainage will be accommodated. Those areas where the subgrade geology primarily consists of clean sands, seepage underneath the levee and the potential for erosion and instability must be considered. Final designs may require the installation of a bentonite concrete cutoff wall deep within the foundation. This condition will be investigated during any design phase and its requirement will be incorporated.

3.4.6.5.3 Structural, Mechanical and Electrical

See sections 3.4.6.5.3.1 and 3.4.6.5.3.2.

3.4.6.5.3.1 Culverts

Reinforced concrete box culverts would be required at 2 locations, as described above, with the culvert requirement ranging from seven 7' wide by 3' high, to eleven 10' wide by 4' high water passages. Each of these culverts was configured having nominally sized and reinforced structure walls and top and bottom slabs. Each water passage would be fitted with both a flap gate at the outlet end and a sluice gate placed near the center of the culvert with a manually operated vertical operator stem extending through an access shaft to the top of levee elevation.

3.4.6.5.3.2 Pumping Stations

Design hydraulic heads derived for the 2 pumping facilities included in the Jackson County Inland Barrier for the elevation 20 protection level were 15 and 10 feet and the corresponding flows required were 567,772 and 213,195 gallons per minute respectively. The facilities thus derived would consist of one plant having six, 60-inch diameter, 560 horsepower pumps and one having four, 54-inch diameter pumps each running at 290 horsepower.

3.4.6.5.4 HTRW

Due to the extent and large number of real estate parcels along with the potential for re-alignment of the structural aspects of this project, no preliminary assessment was performed to identify the possibility of hazardous waste on the sites. These studies will be conducted during the next phase of work after the final siting of the various structures. The real estate costs appearing in this report therefore will not reflect any costs for remediation design and/or treatment and/or removal or disposal of these materials in the baseline cost estimate.

3.4.6.5.5 Construction Procedures and Water Control Plan

The construction procedures required for this option are similar to general construction in many respects in that the easement limits must be established and staked in the field, the work area cleared of all structures, pavements, utilities, trees, organics, etc. and the foundation prepared for the new work. Where the levee alignment crosses the existing streams or narrow bays, the alignment base shall be created by displacement with layers of crushed stone pushed ahead and compacted by the placement equipment and repeated until a stable platform is created. The required drainage culverts or other ancillary structures can then be constructed. The control of any surface water will be handled by temporary sheetpile cofferdams and pumping. The control of groundwater will be a series of wellpoints systems designed to keep the excavations dry to a depth and width sufficient to install the new work.

3.4.6.5.6 Project Security

The Protocol for security measures for this study has been performed in general accordance with the Risk Assessment Methodology for Dams (RAM-D) developed by the Interagency Forum for Infrastructure Protection (IFIP). This methodology has been used for physical security for the critical infrastructure throughout the Corps of Engineers. The determination of the level of physical security provided for each facility is based on the following critical elements: 1) threat assessment of the likelihood that an adversary will attack a critical asset, 2) consequence assessment should an adversary be successful in disrupting, disabling or destroying the asset and 3) effectiveness to prevent a successful attack against an operational component.

3.4.6.5.7 Operations and Maintenance

The features that require periodic operations will be the exercising of the pumps and emergency generators at the various pump stations, the testing of the gate structures at the various road crossings, grass cutting of the levee slopes and toe areas and the filling of rilled areas within the embankment due to surface erosion. Scheduled maintenance should include periodic greasing of all gears and coupled joints, maintaining any battery backup systems, and replacement of standby fuel supplies.

3.4.6.5.8 Cost Estimate

The costs for the various options included in this measure are presented in Section 3.4.6.8 Cost Summary. Construction costs for the various options are included in Table 3.4.6.8-1 and costs for the annualized Operation and Maintenance of the options are included in Table 3.4.6.8-2. Estimates are comparative-Level "Parametric Type" and are based on Historical Data, Recent Pricing, and Estimator's Judgment. Quantities listed within the estimates represent Major Elements of the Project Scope and were furnished by the Project Delivery Team. Price Level of Estimate is April 07. Estimates excludes project Escalation and HTRW Cost. The construction costs include real estate, engineering design (E&D), construction management, and contingencies. The E&D cost for preparation of construction contract plans and specifications includes a detailed contract survey, preparation of contract specifications and plan drawings, estimating bid quantities, preparation of bid estimate, preparation of final submittal and contract advertisement package, project engineering and coordination, supervision technical review, computer costs and reproduction. Construction Contingency developed and assigned at 25% to cover the Cost Growth of the project.

3.4.6.5.9 Schedule and Design for Construction

After the authority for the design has been issued and funds have been provided, the design of these structures will require approximately 12 months including comprehensive plans and specifications, independent reviews and subsequent revisions. The construction of this option should require in excess of two years.

3.4.6.6 Option B – Elevation 30 ft NAVD88

This option consists of an earthen levee around the most populated areas of Gautier The alignment of the levee is the same as Option A, above, and is not reproduced here. The only difference between the description of this option and preceding description of Option A is the height of the levee, pumping facilities, and the length of the levee culverts. Other features and methods of analysis are the same.

3.4.6.6.1 Interior Drainage

Interior drainage analysis and culverts are the same as those for Option A, above, except that the culvert lengths through the levees would be longer.

3.4.6.6.2 Geotechnical Data

Geology: Citronelle formation is found above the Interstate 10 alignment and is a relatively thin unit of fluvial deposits of Plio-Pleistocene age consisting of gravelly sand and silty sand layers. Typically the formation is 30 to 80 feet thick, except where it has filled eroded channels in the underlying formations. The sand in the formation has a variety of colors, often associated with the presence of iron oxides in the form of hematite or goethite. Thin discontinuous clay layers are found in some areas. The iron oxide has occasionally cemented the sand into a friable sandstone, usually occurring only as a localized layer. Within the study area, this formation outcrops north of Interstate 10 and will not be encountered at project sites other than any levees that might extend northward to higher ground elevations.

Prairie formation is found along the rest of the Line 4 alignment within Jackson County. The Prairie formation is found southward of the Citronelle formation and is of Pleistocene age. This formation consists of fluvial and floodplain sediments that extend southward from the outcrop of the Citronelle formation to or near the mainland coastline. Sand found within this formation has an economic value as beach fill due to its color and quality. Southward from its outcrop area, the formation extends under the overlying Holocene deposits out into the Mississippi Sound.

Gulfport Formation is found along the coastline in most of western Jackson County at Belle Fontaine Beach. This formation of Pleistocene age overlies the Prairie formation and is present as well sorted sands that mark the edge of the coastline during the last high sea level stage of the Sangamonian Interglacial period. It does not extend under the Mississippi Sound.

Geotechnical: The inland barrier earthen levee section will have one vertical to three horizontal side slopes with a fifteen foot crest width. All work areas to receive the fill shall be cleared and grubbed of all trees and surface organics and all existing foundations, streets, utilities, etc. will be removed and the subsequent cavities backfilled and compacted. The levee will be constructed of sand clay materials obtained from off site commercial sources, trucked to the work area, placed in thin lifts and compacted to 95 percent of the maximum modified density. The final surface will be armored by the placement of 12 inch thick gabion mattress filled with small stone for erosion protection during an event that overtops the levee. The armoring will be anchored on the front face by trenching and extend across the downstream slope and the 25 foot easement area beyond the toe. The front side of the levee and all non critical surface areas will be subsequently covered by grassing. Road crossings will incorporate small gate structures or ramping over the embankment where the surface elevation is near that of the crest elevation. The elevation relationship of the crest and the adjacent railroad will be a governing factor. The surfaces will be paved with asphalt and the corresponding drainage will be accommodated. Those areas where the subgrade geology primarily consists of clean sands, seepage underneath the levee and the potential for erosion and instability must be considered. Final designs may require the installation of a bentonite concrete cutoff wall deep within the foundation. This condition will be investigated during any design phase and its requirement will be incorporated.

3.4.6.6.3 Structural, Mechanical and Electrical

See sections 3.4.6.6.3.1 through 3.4.6.6.3.3.

3.4.6.6.3.1 Culverts

Reinforced concrete box culverts would be required at 2 locations, as described above, with the culvert requirement ranging from seven 7' wide by 3' high, to eleven 10' wide by 4' high water passages. Each of these culverts was configured having nominally sized and reinforced structure walls and top and bottom slabs. Each water passage would be fitted with both a flap gate at the outlet end and a sluice gate placed near the center of the culvert with a manually vertical operator stem extending through an access shaft to the top of levee elevation.

3.4.6.6.3.2 Pumping Stations

Design hydraulic heads derived for the 2 pumping facilities included in the Jackson County Inland Barrier for the elevation 30 protection level were 25 and 20 feet and the corresponding flows required were 567,772 and 213,195 gallons per minute respectively. The facilities thus derived would consist of one plant having six, 60-inch diameter, 1000 horsepower pumps, and one having four, 54-inch diameter pumps each running at 560 horsepower.

3.4.6.6.3.3 Dedicated Flood Barriers

There are two sites in Jackson County that would require special flood protection with the flood protection level set at elevation 40, the court facilities located immediately south of the protection line in downtown Biloxi and similar governmental facilities in downtown Moss Point.

The Biloxi facilities would require a three sided Tee Wall structure approximately 1410 feet long originating and terminating in the levee at its northwest and northeast ends. It would be fitted with four face sealing roller gates to close off the required street and driveway access points in time of flood.

The Moss Point Tee Wall would be similarly configured and would extend approximately 1552 feet. It would require two roadway closure gates.

3.4.6.6.4 HTRW

Due to the extent and large number of real estate parcels along with the potential for re-alignment of the structural aspects of this project, no preliminary assessment was performed to identify the possibility of hazardous waste on the sites. These studies will be conducted during the next phase of work after the final siting of the various structures. The real estate costs appearing in this report

therefore will not reflect any costs for remediation design and/or treatment and/or removal or disposal of these materials in the baseline cost estimate.

3.4.6.6.5 Construction Procedures and Water Control Plan

The construction procedures required for this option are similar to general construction in many respects in that the easement limits must be established and staked in the field, the work area cleared of all structures, pavements, utilities, trees, organics, etc. and the foundation prepared for the new work. Where the levee alignment crosses the existing streams or narrow bays, the alignment base shall be created by displacement with layers of crushed stone pushed ahead and compacted by the placement equipment and repeated until a stable platform is created. The required drainage culverts or other ancillary structures can then be constructed. The control of any surface water will be handled by temporary sheetpile cofferdams and pumping. The control of groundwater will be a series of wellpoints systems designed to keep the excavations dry to a depth and width sufficient to install the new work.

3.4.6.6.6 Project Security

The Protocol for security measures for this study has been performed in general accordance with the Risk Assessment Methodology for Dams (RAM-D) developed by the Interagency Forum for Infrastructure Protection (IFIP). This methodology has been used for physical security for the critical infrastructure throughout the Corps of Engineers. The determination of the level of physical security provided for each facility is based on the following critical elements: 1) threat assessment of the likelihood that an adversary will attack a critical asset, 2) consequence assessment should an adversary be successful in disrupting, disabling or destroying the asset and 3) effectiveness to prevent a successful attack against an operational component.

Three levels of physical security were selected for use in this study:

Level 1 Security provides no improved security for the selected asset. This security level would be applied to the barrier islands and the sand dunes. These features present a very low threat level of attack and basically no consequence if an attack occurred.

Level 2 Security applies standard security measures such as road barricades, perimeter fencing, and intrusion detection systems for unoccupied building and vertical structures and security lighting. The intrusion detection systems will be connected to the local law enforcement office for response during an emergency. Facilities requiring this level of security would possess a higher threat level than those in Level 1 and would include assets such as levees, access roads and pumping stations. Level 2 Security is the level to be applied to this option.

Level 3 Security includes all of the features of Level 2 plus enhanced security measures such as the use of video cameras for real-time monitoring of the facility, monitors, motion detectors and alarm sound system in the occupied control buildings. Facilities requiring this level of security would possess the highest threat level of all the critical assets. The surge barriers located in the bays, manned control buildings, and power plants would require this level of security.

3.4.6.6.7 Operations and Maintenance

The features that require periodic operations will be the exercising of the pumps and emergency generators at the various pump stations, the testing of the gate structures at the various road crossings, grass cutting of the levee slopes and toe areas and the filling of rilled areas within the embankment due to surface erosion. Scheduled maintenance should include periodic greasing of all gears and coupled joints, maintaining any battery backup systems, and replacement of standby fuel supplies.

3.4.6.6.8 Cost Estimate

The costs for the various options included in this measure are presented in Section 3.4.6.8 Cost Summary. Construction costs for the various options are included in Table 3.4.6.8-1 and costs for the annualized Operation and Maintenance of the options are included in Table 3.4.6.8.-2. Estimates are comparative-Level "Parametric Type" and are based on Historical Data, Recent Pricing, and Estimator's Judgment. Quantities listed within the estimates represent Major Elements of the Project Scope and were furnished by the Project Delivery Team. Price Level of Estimate is April 07. Estimates excludes project Escalation and HTRW Cost. The construction costs include real estate, engineering design (E&D), construction management, and contingencies. The E&D cost for preparation of construction contract plans and specifications includes a detailed contract survey, preparation of contract specifications and plan drawings, estimating bid quantities, preparation of bid estimate, preparation of final submittal and contract advertisement package, project engineering and coordination, supervision technical review, computer costs and reproduction. Construction Contingency developed and assigned at 25% to cover the Cost Growth of the project.

3.4.6.6.9 Schedule and Design for Construction

After the authority for the design has been issued and funds have been provided, the design of these structures will require approximately 12 months including comprehensive plans and specifications, independent reviews and subsequent revisions. The construction of this option should require in excess of two years.

3.4.6.7 Option C – Elevation 40 ft NAVD88

3.4.6.7.1 Interior Drainage

The alignment of the levee is the same as Option A, above, and is not reproduced here. Differences between the description of this option and preceding description of Option A include the height of the levee, pumping facilities (because of the increased head), and the length of the levee culverts. The methods of analysis for interior drainage and computed flows are the same.

3.4.6.7.2 Geotechnical Data

Geology: Citronelle formation is found above the Interstate 10 alignment and is a relatively thin unit of fluvial deposits of Plio-Pleistocene age consisting of gravelly sand and silty sand layers. Typically the formation is 30 to 80 feet thick, except where it has filled eroded channels in the underlying formations. The sand in the formation has a variety of colors, often associated with the presence of iron oxides in the form of hematite or goethite. Thin discontinuous clay layers are found in some areas. The iron oxide has occasionally cemented the sand into friable sandstone, usually occurring only as a localized layer. Within the study area, this formation outcrops north of Interstate 10 and will not be encountered at project sites other than any levees that might extend northward to higher ground elevations.

Prairie formation is found along the rest of the Line 4 alignment within Jackson County. The Prairie formation is found southward of the Citronelle formation and is of Pleistocene age. This formation consists of fluvial and floodplain sediments that extend southward from the outcrop of the Citronelle formation to or near the mainland coastline. Sand found within this formation has an economic value as beach fill due to its color and quality. Southward from its outcrop area, the formation extends under the overlying Holocene deposits out into the Mississippi Sound.

Gulfport Formation is found along the coastline in most of western Jackson County at Belle Fontaine Beach. This formation of Pleistocene age overlies the Prairie formation and is present as well sorted sands that mark the edge of the coastline during the last high sea level stage of the Sangamonian Interglacial period. It does not extend under the Mississippi Sound.

Geotechnical: The inland barrier earthen levee section will have one vertical to three horizontal side slopes with a fifteen foot crest width. All work areas to receive the fill shall be cleared and grubbed of all trees and surface organics and all existing foundations, streets, utilities, etc. will be removed and the subsequent cavities backfilled and compacted. The levee will be constructed of sand clay materials obtained from off site commercial sources, trucked to the work area, placed in thin lifts and compacted to 95 percent of the maximum modified density. The final surface will not be armored for this option since the elevation of this option will not permit overtopping. The surface of the levee and all non critical surface areas will be subsequently covered by grassing. Road crossings will incorporate small gate structures or ramping over the embankment where the surface elevation is near that of the crest elevation. The elevation relationship of the crest and the adjacent railroad will be a governing factor. The surfaces will be paved with asphalt and the corresponding drainage will be accommodated. Those areas where the subgrade geology primarily consists of clean sands, seepage underneath the levee and the potential for erosion and instability must be considered. Final designs may require the installation of a bentonite concrete cutoff wall deep within the foundation. This condition will be investigated during any design phase and its requirement will be incorporated.

3.4.6.7.3 Structural, Mechanical and Electrical

See sections 3.4.6.7.3.1 through 3.4.6.7.3.4.

3.4.6.7.3.1 Culverts

Reinforced concrete box culverts would be required at 2 locations, as described above, with the culvert requirement ranging from seven 7' wide by 3' high, to eleven 10' wide by 4' high water passages. Each of these culverts was configured having nominally sized and reinforced structure walls and top and bottom slabs. Each water passage would be fitted with both a flap gate at the outlet end and a sluice gate placed near the center of the culvert with a vertical operator stem extending through an access shaft to the top of levee elevation.

3.4.6.7.3.2 Pumping Stations

Design hydraulic heads derived for the 2 pumping facilities included in the Jackson County Inland Barrier for the elevation 30 protection level were 35 and 30 feet and the corresponding flows required were 567,772 and 213,195 gallons per minute respectively. The facilities thus derived would consist of one plant having eight, 54-inch diameter, 1000 horsepower pumps, and one having seven, 42-inch diameter pumps each running at 500 horsepower.

3.4.6.7.3.3 Levee and Roadway/Railway Intersections

With the installation of Line 4 protection to elevation 40, three roadway intersections would have to be accommodated. It was determined that roller gate structures would suffice for all three of these locations.

3.4.6.7.3.4 Dedicated Flood Barriers

There are two sites in Jackson County that would require special flood protection with the flood protection level set at elevation 40, the court facilities located immediately south of the protection line in downtown Biloxi and similar governmental facilities in downtown Moss Point.

The Biloxi facilities would require a three sided Tee Wall structure approximately 1410 feet long originating and terminating in the levee at its northwest and northeast ends. It would be fitted with four face sealing roller gates to close off the required street and driveway access points in time of flood.

The Moss Point Tee Wall would be similarly configured and would extend approximately 1552 feet. It would require two roadway closure gates.

3.4.6.7.4 HTRW

Due to the extent and large number of real estate parcels along with the potential for re-alignment of the structural aspects of this project, no preliminary assessment was performed to identify the possibility of hazardous waste on the sites. These studies will be conducted during the next phase of work after the final siting of the various structures. The real estate costs appearing in this report therefore will not reflect any costs for remediation design and/or treatment and/or removal or disposal of these materials in the baseline cost estimate.

3.4.6.7.5 Construction Procedures and Water Control Plan

The construction procedures required for this option are similar to general construction in many respects in that the easement limits must be established and staked in the field, the work area cleared of all structures, pavements, utilities, trees, organics, etc. and the foundation prepared for the new work. Where the levee alignment crosses the existing streams or narrow bays, the alignment base shall be created by displacement with layers of crushed stone pushed ahead and compacted by the placement equipment and repeated until a stable platform is created. The required drainage culverts or other ancillary structures can then be constructed. The control of any surface water will be handled by temporary sheetpile cofferdams and pumping. The control of groundwater will be a series of wellpoints systems designed to keep the excavations dry to a depth and width sufficient to install the new work.

3.4.6.7.6 Project Security

The Protocol for security measures for this study has been performed in general accordance with the Risk Assessment Methodology for Dams (RAM-D) developed by the Interagency Forum for Infrastructure Protection (IFIP). This methodology has been used for physical security for the critical infrastructure throughout the Corps of Engineers. The determination of the level of physical security provided for each facility is based on the following critical elements: 1) threat assessment of the likelihood that an adversary will attack a critical asset, 2) consequence assessment should an adversary be successful in disrupting, disabling or destroying the asset and 3) effectiveness to prevent a successful attack against an operational component.

Three levels of physical security were selected for use in this study:

Level 1 Security provides no improved security for the selected asset. This security level would be applied to the barrier islands and the sand dunes. These features present a very low threat level of attack and basically no consequence if an attack occurred.

Level 2 Security applies standard security measures such as road barricades, perimeter fencing, and intrusion detection systems for unoccupied building and vertical structures and security lighting. The intrusion detection systems will be connected to the local law enforcement office for response during an emergency. Facilities requiring this level of security would possess a higher threat level than those in Level 1 and would include assets such as levees, access roads and pumping stations. This option will be best supported by the Level 2 Security.

Level 3 Security includes all of the features of Level 2 plus enhanced security measures such as the use of video cameras for real-time monitoring of the facility, monitors, motion detectors and alarm sound system in the occupied control buildings. Facilities requiring this level of security would

possess the highest threat level of all the critical assets. The surge barriers located in the bays, manned control buildings, and power plants would require this level of security.

3.4.6.7.7 Operations and Maintenance

The features that require periodic operations will be the exercising of the pumps and emergency generators at the various pump stations, the testing of the gate structures at the various road crossings, grass cutting of the levee slopes and toe areas and the filling of rilled areas within the embankment due to surface erosion. Scheduled maintenance should include periodic greasing of all gears and coupled joints, maintaining any battery backup systems, and replacement of standby fuel supplies.

3.4.6.7.8 Cost Estimate

The costs for the various options included in this measure are presented in Section 3.4.6.8 Cost Summary. Construction costs for the various options are included in Table 3.4.6.8-1 and costs for the annualized Operation and Maintenance of the options are included in Table 3.4.6.8-2. Estimates are comparative-Level "Parametric Type" and are based on Historical Data, Recent Pricing, and Estimator's Judgment. Quantities listed within the estimates represent Major Elements of the Project Scope and were furnished by the Project Delivery Team. Price Level of Estimate is April 07. Estimates excludes project Escalation and HTRW Cost. The construction costs include real estate, engineering design (E&D), construction management, and contingencies. The E&D cost for preparation of construction contract plans and specifications includes a detailed contract survey, preparation of contract specifications and plan drawings, estimating bid quantities, preparation of bid estimate, preparation of final submittal and contract advertisement package, project engineering and coordination, supervision technical review, computer costs and reproduction. Construction Contingency developed and assigned at 25% to cover the Cost Growth of the project.

3.4.6.7.9 Schedule and Design for Construction

After the authority for the design has been issued and funds have been provided, the design of these structures will require approximately 12 months including comprehensive plans and specifications, independent reviews and subsequent revisions. The construction of this option should require in excess of two years.

3.4.6.8 Cost Estimate Summary

The costs for construction and for operations and maintenance of all options are shown below. Estimates are comparative-Level "Parametric Type" and are based on Historical Data, Recent Pricing, and Estimator's Judgment. Quantities listed within the estimates represent Major Elements of the Project Scope and were furnished by the Project Delivery Team. Price Level of Estimate is April 07. Estimates excludes project Escalation and HTRW Cost.

Table 3.4.6.8-1.
Jackson Co Inland Barrier Construction Cost Summary

Option	Total project cost
Option A – Elevation 20 ft NAVD88	$126,900,000
Option B – Elevation 30 ft NAVD88	$224,800,000
Option C – Elevation 40 ft NAVD88	$266,000,000

Table 3.4.6.8-2.
Jackson Co Inland Barrier O & M Cost Summary

Option	O&M Costs
Option A – Elevation 20 ft NAVD88	$819,000
Option B – Elevation 30 ft NAVD88	$2,028,000
Option C – Elevation 40 ft NAVD88	$2,438,000

3.4.6.9 References

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3.5 Line of Defense 5 – Retreat and/or Relocation of Critical Facilities

3.5.1 General

Hurricanes are a naturally occurring phenomena that wreak havoc on natural and man-made environments through three different but related mechanisms: torrential rainfall, high winds, and storm surge. While each of these can produce costly outcomes in their own right, storm surge is typically the most damaging and particularly deadly. It is also the most difficult and costly to provide enduring and confident protection against. However, if one cannot be reached by storm surge by virtue of being on ground at elevation higher than any storm surge might reach, one cannot be directly damaged by it. The limit of storm surge represents the first line of avoidance to hurricane related damages. It therefore makes sense to identify the potential inland limit of storm surge so that prudent choices might be made by any and all regarding their exposure to damage by storm surge.

The primary measures identified for the project area include permanent acquisitions, floodproofing by elevation and other means, relocations of public buildings, flood preparedness and evacuation planning, public education, changes in the current municipal and county NFIP and building codes, implementation of either a transfer of development rights or purchase of development rights program, potential changes in zoning ordinances, development impact fees, and redirection of new development. These measures have been combined into several plans that can be implemented by either agencies of the Federal government or collaboratively by those agencies and state, county and local governmental units. In several cases, only local jurisdictions can implement some of the measures identified.

3.5.1.1 Existing Conditions

Computer simulations have predicted[1] how far inland storm surge will extend if the worse-case hurricane or maximum possible intensity (MPI) event hits the Mississippi coast.

This line of defense is shown in Figure 3.5-1. This line represents a line of safety where homes, facilities or transportation routes north of this line should not be directly damaged by storm surge. This would be an area where hospitals, schools, emergency response and management facilities, power stations, water supply facilities, or other critical infrastructure might be located. It would also represent an area whereby future development (commercial, industrial, or residential) might be redirected. The maximum water level along the Mississippi coastline was determined to be approximately 30 ft along the entire western half of the state and east of Pascagoula. The landward extent of the inundation indicates the storm surge reaches Interstate 10 for much of the western portion of the state. Lower peaks near Biloxi and Mobile Bay (24-27 ft) may be attributed to the protection afforded by the barrier islands. The line of defense accordingly approximates the 24 to 30 ft. (NAVD '88 datum) contours.

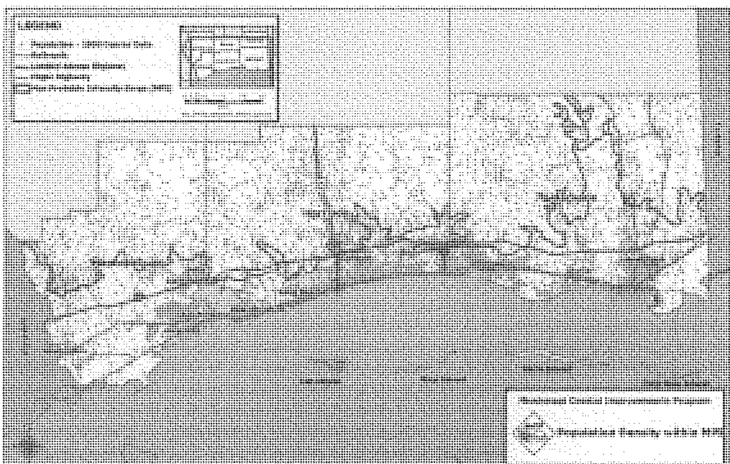

Figure 3.5-1. Maximum Probable Intensity Storm Surge Limits

[1] Storm surge modeling is described in Chapters 2.2 through 2.8.

This 'line of defense' is a naturally occurring measure against storm surge. This line of defense is not intended to suggest preferential protection against hurricane force winds. The line of defense is located based on storm surge only and is best considered jointly with riverine flood inundation maps published by FEMA for the purposes of promulgating the National Flood Insurance Program. FEMA is currently revising inland riverine regulatory flood maps. In keeping with historic hydrologic engineering practice, no probability of occurrence has been assigned to the MPI storm related surge, though in the future, USACE may adopt methods targeted at assigning risk to the occurrence of maximum probable storm events.

The area seaward of the line of defense is occupied by natural, rural, suburban, and urban environments and residential, commercial, and industrial development. Approximately 1/3 (visually estimated) of the coastal county areas fall within the estimated surge limits. With the exceptions of seawalls fronting Harrison County, Bay St. Louis, and the city of Pascagoula, there are no hurricane storm damage reduction structures in place. These structures provide little inundation protection over what the natural ground elevation would provide for and do not provide hurricane protection for surge events approaching or exceeding the 1 in 100 annual chance event.

3.5.1.2 Coastal and Hydraulic Data

The line of defense shown on Figure 3.5-1 is resultant of hydrodynamic modeling of six maximum possible intensity (MPI) storms with landfall points along the Mississippi coast were simulated to determine inundation limits for the Mississippi coastline. The six MPI storms made landfall at various points along the Mississippi Coast. All MPI storms were defined at their most intense point as having a minimum central pressure of 880 mb, radius to maximum winds of 36 n mi, and a forward speed of 11 kt. Peak water level envelopes from each of the six MPI simulations were computed. The six peak water level envelopes were then compared to compute the "peak of peaks", which is considered the inundation limit along the entire Mississippi coastline.

3.5.1.3 Alternative Plans

There are no alternative alignments to this line of defense. The line of defense alignment could be changed or modified due to any of the following: (a) revised hydrodynamic modeling results; (b) the construction of storm damage reduction measures, such as levees and/or storm surge barriers; (c) sea level rise; (d) construction of other infrastructure (e.g. roadway embankments) that might materially obstruct or alter surge flow pathways.

A thorough discussion of non-structural alternative measures is provided in the Non-Structural Formulation Appendix.

FOR CONTINUATION OF HOUSE DOCUMENT 111-95 COMPREHENSIVE PLAN REPORT ON THE MISSISSIPPI COASTAL IMPROVEMENTS PROGRAM (MsCIP)

SEE PART 3