APPENDIX C

Engineering

TABLE OF CONTENTS

C-1.0 GENERAL 2
C-2.0 HYDRAULICS AND HYDROLOGY 2
C-2.1.1 Model Studies 2
C-2.1.2 One Dimensional Model 2
C-2.1.3 Two Dimensional Model 4
C-2.1.4 Three Dimensional Model 5
C-3.0 GEOTECHNICAL INVESTIGATIONS AND DESIGN 7
C-3.1 GEOTECHNICAL DESIGN FOR CHANNEL DEEPENING 7
C-3.1.1 Data Collection 7
C-3.1.2 Project Design Criteria 7
C-3.1.3 Field Investigation 7
C-3.1.4 Geology 8
C-3.1.5 Laboratory Tests 11
C-3.1.6 Foundation Design 12
C-3.1.7 Geotechnical Analysis 12
C-4.0 CIVIL DESIGN 13
C-4.1 CHANNEL DESIGN 13
C-4.1.1 General 14
C-4.1.2 48ft Channel Alternative 17
C-4.1.3 50ft Channel Alternative 18
C-4.2 DREDGING AND DISPOSAL FOR CONSTRUCTION OF BOTH THE 48FT AND 50FT ALTERNATIVES 19
C-4.2.1 General 19
C-4.2.2 Mississippi River - SW Pass Channel Reach 19
C-4.2.3 Mississippi River Crossings 19
C-4.2.4 Construction Schedule 20
C-4.3 OPERATIONS AND MAINTENANCE DREDGING 20
C-4.3.1 Operations and Maintenance Dredging - Mississippi River - SW Pass Channel Reach 20
C-4.3.2 Operations and Maintenance Dredging - Mississippi River Crossings 23
C-4.4 ADDITIONAL O&M NEEDS 26
C-4.5 RELOCATIONS 27
C-4.5.1 Purpose 27
C-4.5.2 Scope 28
C-4.5.3 Process 28
C-4.5.4 Estimated Relocations Costs 28
C-5.0 ENVIRONMENTAL ENGINEERING 30
C-5.1 ENVIRONMENTAL OBJECTIVES AND REQUIREMENTS 30

C-5.2 ENVIRONMENTAL CONSIDERATIONS 30
C-5.2.1 Environmental Effects of the Project 30
C-5.2.2 Integration of Environmental Sensitivity into All Aspects of the Project 30
C-5.2.3 Lessons Learned During Past Projects 31
C-5.2.4 Incorporation of Environmental Compliance Measures into the Project Design 31
C-5.2.5 Mitigation for Unavoidable Impacts 31
C-5.3 HAZARDOUS TOXIC AND RADIOACTIVE WASTE (HTRW) 32
C-6.0 COST ESTIMATES 32
C-6.1 BASIS OF COST ESTIMATE 32
C-6.2 CONTINGENCIES 33
C-6.3 DETAILED ESTIMATE 33

C-1.0 GENERAL

This Engineering Appendix presents and documents the feasibility level engineering and design for the recommended plan. Development of the Engineering Appendix was in accordance with Engineering Regulation (ER) 1110-2-1150, "Engineering and Design for Civil Works Projects", dated 31 August 1999. The comparative studies of alternatives, field investigations, designs, and costs estimates presented herein are in sufficient detail to substantiate the recommended plan and baseline estimate.

C-2.0 HYDRAULICS AND HYDROLOGY

C-2.1.1 Model Studies

The Engineering Appendix contains the introduction and the summary for the 1D, 2D, and 3D models for the study. For the full Letter Reports for these models please refer to Appendix H.

C-2.1.2 One Dimensional Model

C-2.1.2.1 Introduction

The 255 mile long Mississippi River Ship Channel extends from Baton Rouge, Louisiana, to the Gulf of Mexico. The Ship Channel provides deep-draft access to the largest port complex in the United States of America. Annually, the port complex serves an average of 11,000 deep-draft vessels and handles 450 million tons of cargo. The authorized navigation depth of the Ship Channel is 55 feet (ft). The navigation depth is currently maintained to 45ft. The US Army Engineer New Orleans District is evaluating the feasibility of increasing the maintained depth to 48ft or 50ft.

Since typical channel depths in much of this reach of the Mississippi River exceed the maintained channel depth, maintenance dredging is required only in relatively short and distinct locations. The Southwest Pass dredging reach is the longest single dredging reach and has been maintained, since 1987, to a depth of 45 ft relative to Mean Low Gulf Southwest Pass (MLG^{SWP}), equivalent to a depth of 48.5 ft below Mean Lower Low Water (MLLW). This reach extends from Venice, Louisiana, at River Mile (RM) 10 Above Head of Passes (AHP), down the Mississippi River to Head of Passes (HOP) at RM 0.0, then through Southwest Pass and the Southwest Pass Bar Channel to the Gulf of Mexico at RM 22 Below Head of Passes (BHP). The majority of the sediment entering this reach is diverted by distributaries with less than half of the remainder being deposited and subsequently removed by dredging. Annual dredging quantities in this reach averaged 19.4 million cubic yards (yd3) from 1970 to 2008.

The remainder of the locations requiring periodic maintenance dredging are river crossings, in the upper 120 miles of the Ship Channel. Four downstream crossings have been maintained to a depth of 45ft relative to the Low Water Reference Plane (LWRP) since December of 1987. The upstream Ship Channel crossings from Baton Rouge at RM 232.4 AHP to RM 181 AHP have been maintained to a depth of 45ft relative to the LWRP since December of 1994. Total annual dredging quantities for the crossings averaged 18 million yd3 from 1995 to 2016. Over the decade ending in 2016, annual dredging in the crossings averaged 22 million yd3.

C-2.1.2.2 Summary and Recommendations

The Mississippi River Hydrodynamic and Delta Management Study 1D (HEC-6T) Sedimentation Model was modified to evaluate the potential impacts of deepening the Mississippi River Ship Channel on maintenance dredging requirements. Projected increases in dredging in the Southwest Pass Dredging Reach (downstream of RM 11 AHP) attributable to deepening were modest and small compared to the variability attributable to annual variations in flow and sediment load. The primary impact of deepening was to shift deposition and subsequent dredging upstream. An upstream shift in deposition also is the primary response of the system to eustatic sea level rise. The model does not address potential increases in the extent or frequency of salinity intrusion due to channel deepening or eustatic sea level rise which may influence the rate of fine sediment deposition. Also, the model does not consider any potential changes in the magnitude of diversion flows at existing diversions due to relative sea level rise.

Model projections indicate the potential for significant increases in maintenance dredging requirements in the crossings due attributable to channel deepening. However, model adjustments evaluated within the time and cost constraints of this study did not produce a satisfactory reproduction of the historical distribution of dredging among the various crossings. Excluding crossings where dredging requirements for the existing channel are significantly underestimated from the model estimate suggests potential increases in the range of 50% to 200% in response to deepening. The lower end of this range correlates to the observed increase in historical dredging coincident with deepening of the channel from 40ft to 45ft and thus probably indicates an upper limit, equivalent to a dredging index of 1.6, to potential increases in crossing maintenance dredging attributable to proposed deepening to 50ft.

Changes in operation of the Old River Control Complex (ORCC) represent one of a number of factors that could be responsible for an increase in dredging and a reported change in the characteristics of the dredged material. MRG&P Report 6, ORCC Sedimentation Investigation, concluded that current sediment diversions are inadequate and ERDC/CHL TR-14-5, Miss River Geomorphic Assessment, indicates that downstream reaches are aggradational. Definitive attribution remains elusive because a complex system is responding

to multiple changes, including a record flood (2011), an extreme drought (2012), construction of channel training works (Smithland Crossing and Redeye Crossing), and other influences. Given the cost of channel maintenance, further investigation of the causes and possible mitigation is certainly merited.

C-2.1.3 Two Dimensional Model

C-2.1.3.1 Introduction

The 255 mile long Mississippi River Ship Channel extends from Baton Rouge, Louisiana to the Gulf of Mexico and provides deep-draft access to the largest port complex in the United States of America. Annually, the port complex serves an average of 11,000 deep-draft vessels and handles 450 million tons of cargo. Although the authorized navigation depth of the Ship Channel is 55 feet (ft), the navigation depth is currently maintained to 45ft. The US Army Engineer New Orleans District is evaluating the feasibility of deepening the channel.

Since typical channel depths in most of this reach of the Mississippi River exceed the maintained channel depth, maintenance dredging is required only in relatively short and distinct locations. The Southwest Pass dredging reach is the longest single dredging reach and has been maintained to a depth of 45ft relative to Mean Low Gulf (MLG) since 1987. Annual dredging quantities in this reach from 1970 to 2008 averaged 19.4 million cubic yards (yd3). The remainder of the locations requiring periodic maintenance dredging are river crossings in the upper 120 miles of the Ship Channel. These crossings have been maintained to a depth of 45 ft relative to the Low Water Reference Plane (LWRP) since 1995. Total annual dredging quantities for the crossings averaged 16 million yd3 from 1999 to 2015.

C-2.1.3.2 Summary and Recommendations

This study consists of an assessment the potential impacts of several proposed deepening alternatives on the dredging requirements for the Lower Mississippi River. This assessment was conducted with the use of an existing Adaptive Hydraulics (AdH) model of the Lower Mississippi River, that was developed and verified against observations as a product of the Mississippi River Hydrodynamic and Delta Management Study. The study consists of the following tasks.

- Verification of the existing model against observed dredging volumes for the crossings in the Lower Mississippi River
- Simulations for the existing conditions, the Tentatively Selected Plan (TSP), and two additional deepening alternatives, and evaluation of system responses to the deepening alternatives by comparison of the alternatives to the existing conditions simulations

- Evaluation of the sensitivity of the alternative comparisons to various eustatic sea level rise conditions.

The validation results show that the model predicts the cumulative volume accurately, but the model does not predict the distribution of deposition among the crossings consistently. Some crossings, such as Baton Rouge Front and Alhambra Crossing, are very well predicted. Others, such as Redeye Crossing and Philadelphia Crossing, are not. To address this, the model results are presented in terms of relative impacts on dredging for the individual crossings (with the use of Dredging Indices), and all integrated results are presented in terms of Cumulative Dredging Indices that are weighted by historical dredging quantities.

The scenario analysis results demonstrate that the implementation of the TSP has very little impact on dredging. The largest impacts for the TSP are observed at Belmont Crossing, with a dredging index of 1.03. The largest relative impacts to dredging (as measured by the dredging index) for any of the scenarios are seen at Redeye Crossing and Baton Rouge front. Specifically, the largest dredging indices are seen for the Alt3 simulations, which specify a 50ft channel from the Gulf to Baton Rouge. The largest single dredging index is for Alt3 at Redeye Crossing, with a value of 1.31.

The sea level rise analysis show little sensitivity to sea level rise for the results, as determined by the relative impacts associated with the implementation of the scenarios. That is, the change in dredging associated with each scenario is not significant influenced by the sea level condition.

Sea level rise in the lowermost river does tend to cause an upstream migration of the location of sand deposition, but this has a relatively small impact on the total deposition due to the fact that sand is only a fraction of the total sediment deposited in the lowermost river.

It must be emphasized that assumptions concerning the behavior of deposition of silts and clays (primarily expected in the lowermost river) have been extrapolated from a 1D analysis of the lowermost river that was itself highly calibrated against observed dredging. The physics that governs this behavior is in fact a complex, nonlinear interaction between fine sediment supply and the position of the salt wedge. Hence, a detailed 3D analysis is necessary to define this fine sediment behavior, in order to ensure that the implementation of deepening will not result in significant changes to deposition patterns in the lowermost river.

C-2.1.4 Three Dimensional Model

C-2.1.4.1 Introduction

A Delft3D model developed under the LCA Mississippi River Hydrodynamic and Delta Management Study (MRH&DM) as recommended by the *Louisiana Coastal Area (LCA),*

Louisiana Ecosystem Restoration Study (January 2005) will be used as the basis for a numerical model study of salinity intrusion impacts of the Mississippi River Ship Channel project. In particular, the model is a Delft3D model utilizing the Cartesian layering scheme option to define the vertical resolution of the model. This layering scheme was found to be crucial to rendering the saline density current or "salinity wedge" present in the lower Mississippi River during drought conditions. The model development is documented in "A Report on the Development, Calibration and Initial Application of a Delft3D Z Coordinate Model in the Mississippi Delta", July 2017 and "1st Addendum to "A Report on the Development, Calibration and Initial Application of a Delft3D Z Coordinate Model in the Mississippi Delta", July 2017.

C-2.1.4.2 Summary

The tidal and river discharge boundary conditions that occurred during the 2012 drought were applied to a Delft3D model grid representing the modern Mississippi Delta extending from RM 116 to the Gulf of Mexico. The model utilized the Cartesian level option with 16 vertical levels. Future scenarios were developed to represent year 2075 conditions with elevated tides based on a projection of the historic rate of sea level rise and channel bottom elevations referenced to the elevated tidal datum. The scenarios included a condition with the existing project depth of 48 feet without the barrier sill at RM 63.4 and the proposed 50ft depth channel condition with and without the barrier sill.

The toe of the saltwater wedge is defined as the leading point with a chloride concentration exceeding 5000 parts per million (ppm). Both of the scenarios without the barrier sill showed the toe of the wedge going no further upstream than the crossing at RM 90. In general, the duration of the presence of the wedge was somewhat longer for the 50ft project over the 48ft project condition, but the crossing proved to be a sufficient impedance preventing further upstream progression of the wedge even with the increased channel depth. Evaluation of model results for occurrences of the toe between RM 85 and RM 90 at the same daily time showed an additional 18 days with the 50ft channel over the 48ft channel. The wedge did not progress past the barrier sill with 50ft project conditions and 2012 drought river flow.

The recommended maximum level of chloride in U. S. drinking water is 250 ppm at which point the water begins to have a detectable salty taste. The modeled surface water salinity concentration was evaluated at the locations of the Boothville (RM 19.0 AHP) and Port Sulphur (RM 49.0 AHP) water treatment plants during the simulation in order to determine the possible impact of the project on these utilities.

At Boothville, the 50ft project condition did not significantly alter the total duration of the time the chloride concentration would exceed 250 ppm, in fact the model results showed a very slight decrease in duration with 50ft project conditions when the barrier sill was not in place at RM 63.4, 4753 hours for the 50 foot channel and 4788 hours for the 48 foot channel. The scenario with the

barrier sill in place with the 50ft project conditions showed the greatest duration of time with the chloride level exceeding 250 ppm during the low water event at Boothville, an additional 3.8 days compared to the 50 foot project alternative without the barrier sill.

At Port Sulphur, the duration of time the chloride concentration was over 250 ppm was 3096 hours, and 2938 hours for the 48 foot channel condition, or approximately 6.6 days longer for the 50ft channel condition. The barrier sill greatly reduced the chloride concentration at Port Sulphur. The 50ft project condition with the barrier sill in place showed a total of 515 hours with chloride concentration exceeding 250 ppm.

C-3.0 GEOTECHNICAL INVESTIGATIONS AND DESIGN

This section includes the existing soils investigations for the channel deepening within the Mississippi River crossings, Cubits Gap to Head of Passes, Southwest Pass, and the Bar Channel.

C-3.1 Geotechnical Design for Channel Deepening

This portion of the report contains the initial feasibility level geotechnical design performed for the proposed channel deepening within the river crossings, Cubits Gap to Head of Passes, Southwest Pass, and the Bar Channel. This report covers the soils, geology, foundation investigation and conditions.

C-3.1.1 Data Collection

No new borings were drilled for this project. Existing general type and undisturbed borings, Cone Penetrometer Tests (CPT), and dredged material grab samples are available throughout the entire project area.

C-3.1.2 Project Design Criteria

For this investigation, the channel depth is 50 feet MLLW in the Bar Channel, Southwest Pass, and Cubits Gap to Head of Passes with a channel width of 600 feet in the Bar Channel and 750 feet in Southwest Pass and Cubits Gap to Head of Passes. For the crossings, the channel depth is 50 feet NAVD88 with a channel width of 500 feet. A 1V on 5H slope will be used for the side slopes. Existing structures along the river bank adjacent to future dredging will be properly protected, as necessary.

C-3.1.3 Field Investigation

C-3.1.3.1 Undisturbed Soil Borings

Numerous undisturbed soil borings exist throughout the project area. The soil borings were obtained by the USACE, A/E contract, and local sponsors. The boring plots are available through a Freedom of Information Act request.

C-3.1.3.2 General Type Soil Borings

Numerous general type soil borings exist throughout the project area. The soil borings were obtained by the USACE, A/E contract, and local sponsors. The boring plots are available through a Freedom of Information Act request.

C-3.1.3.3 Cone Penetrometer Test Data

Cone Penetrometer Test (CPT) data is available for portions of the project area, and were obtained by the USACE and A/E contract. The CPT plots are available through a Freedom of Information Act request.

C-3.1.3.4 Dredged Material Samples

Dredged material grab samples are available for portions of the project area. Spreadsheets of the data are available through a Freedom of Information Act request.

C-3.1.4 Geology

Geologic profiles have been developed for various projects along the river, and are available upon request.

The study area is located partially within the Central Gulf Coastal Plain physiographic province: the upper portion within the Mississippi River Alluvial Plain (from Baton Rouge to the vicinity of Donaldsonville), and the lower portion within the Mississippi River Deltaic Plain (from the vicinity of Donaldsonville to the gulf). The oldest deposits encountered within the study area are of Pleistocene Age (Ice Age). These deposits outcrop in the vicinity of Baton Rouge and dip beneath the surface in a southwesterly direction. At the end of the Ice Age, sea level had been lowered to a stage 400-450 feet below its present level and the Mississippi River Valley system had become deeply entrenched within the coastal plain sediments. Approximately 3,500 to 5,000 years ago, as sea level approached its present stand, the entrenched valley was gradually filled with Holocene (more recent) alluvial sediments which covered the exposed weathered and eroded surface of the Ice Age deposits. As the succeeding Mississippi River system migrated laterally back and forth across the alluvial plain, delta lobe complexes were formed below the general latitude of Donaldsonville, Louisiana. These triangle-shaped delta lobes, which continually shifted deposition to areas of steeper gradient, displaced the gulf waters and deposited fine-grained materials southeastward, eventually forming the existing deltaic plain. The modern “birds-foot” delta is continuing this process and extending deposition gulf ward toward the continental shelf.

(Cited from Deep-Draft Access to the Ports of New Orleans and Baton Rouge, Louisiana, Feasibility Study, 1981.)

C-3.1.4.1 Foundation Conditions

Between Baton Rouge and College Point, below Donaldsonville, Louisiana, the existing Mississippi River channel is incised in more recent deposits consisting of a top-stratum of relatively fine-grained soils overlying a substratum of sand and gravelly sands. The top-stratum is generally composed of natural levee clays and silts, backswamp clays and channel filling clays on the concave sides of the bends and accretionary clays, silts, and sands and point bar silts, silty sands, and sands on the convex sides of the bends. Below Donaldsonville, Louisiana, the river is incised in more recent and Ice Age deposits. Generally, on the concave sides of the bends, the banks are composed of more recent materials consisting of a top stratum of fine-grained soils overlying, and in some areas contacting laterally, Ice Age deposits. Between Donaldsonville and Kenner, Louisiana, this relatively fine-grained top-stratum consists of natural levee, undifferentiated deltaic plain, swamp, and marsh materials. Between Kenner, Louisiana, and the gulf, the top-stratum on the concave sides of the bends consists of natural levee, swamp, marsh, abandoned distributary, interdistributary, intradelta, prodelta, bay sound, estuarine, and nearshore gulf deposits. On the convex sides of the bends, the top stratum consists of accretionary and point bar deposits. The more recent top-stratum deposits are underlain by Ice Age materials throughout the area. A general physical description of the soils encountered in the various geologic environments is as follows:

- Natural levee – Interfingering layers of fat and lean clays and layers of silt.
- Point bar – Silts, silty sands and sands with thin layers of clay.
- Accretionary – Alternating layers of clay, silt, silty sands, and sands.
- Abandoned distributary – Layers of fat and lean clays, silts, and silty sands.
- Abandoned course – Layers of fat and lean clays and silts in upper portions with sands in lower portions.
- Backswamp – Homogeneous fat clays with wood, organic matter, and a few layers of silt.
- Undifferentiated deltaic plain – Fat and lean clays with lenses and layers of silt.
- Marsh – Organic clays, silts, and oozes with plant roots and particles (grasses and sedges).
- Swamp – Organic clays and silts with decayed wood (trees and shrubs).

- Interdistributary – Fat clays with thin lenses and layers of silt and a few thin layers of fine sand.
- Intradelta – Interfingered layers of silt, silty sand, and sand, with lenses and layers of fat clay (forms the sandy "barfinger" wedges at the mouth of the river).
- Prodelta – Homogeneous fat clays of medium consistency.
- Nearshore gulf – Silty sands and sand with shells.
- Estuarine – Silts, silty sands, and sands (reworked) with shells.
- Substratum – Massive sands grading to gravelly sands and gravel with depth.
- Pleistocene – Stiff to very stiff, oxidized clays with lenses and layers of silt, silty sand, and sand.
- (Cited from Deep-Draft Access to the Ports of New Orleans and Baton Rouge, Louisiana, Feasibility Study, 1981)

C-3.1.4.2 Terrain and Land Use

The study area is characterized by low relief with elevations varying from a maximum of approximately 30 feet National Geodetic Vertical Datum in the vicinity of Baton Rouge, Louisiana, to a minimum near sea level in the marsh areas near the mouth of the Mississippi River. Large areas in and below New Orleans have been leveed and subjected to drainage by pumps. As a result of subsidence and shrinkage of the drainage soil, ground surface elevations as low as -10 feet are found. The most prominent topographic features are the natural levees which flank the present course, abandoned courses, and abandoned distributaries of the Mississippi River system. These natural levees form ridges which stand significantly above the surrounding swamps and marshes and vary in width from over 5 miles in the vicinity of Baton Rouge to less than 1,000 feet near the Gulf of Mexico. Drainage in the area is away from the river and its elevated natural levees into the adjoining swamps and marshes. Surrounding the natural levees in the area south and east of New Orleans, Louisiana, are vast marshes which are broken and fragmented by numerous bayous, lagoons, canals, lakes, ponds, and smaller abandoned distributaries.

The silt-laden overflow which formed the delta of the Mississippi River is now confined by a manmade levee system, the construction of which was initiated in 1712 and which now extends from Baton Rouge to Bohemia, Louisiana, on the east bank, and from above the study area to Venice, Louisiana, on the west bank. There are no natural tributaries nor distributaries through the portion on the levee system within the study area, and periodic overflow is limited to the area downstream of the artificial levees. The marshes throughout the study area are being lost to

subsidence and erosion. These marshes no longer receive the sediments necessary for their stabilization or aggradation, and their rate of erosion accelerates as fetch lengths increase and wave action increases. Even though accretion is occurring at the mouths of a few of the passes of the Mississippi River, erosion is occurring in most of the marshes between the passes.

Land adjacent to the Mississippi River between Baton Rouge, Louisiana, and the Gulf of Mexico is extensively developed for agricultural, industrial, urban, and suburban uses. Excluded from this development are natural levees near the mouth of the river that are too low and narrow to justify flood protection. Protected land along the river below New Orleans, Louisiana, is used primarily for agriculture along with some suburban and industrial development. There is extensive urban, suburban, and industrial development in the vicinities of New Orleans and Baton Rouge, Louisiana, while the land between these metropolitan areas is also developed primarily for agriculture along with industrial and suburban development. Continued and increasing restrictions on crops basic to the area, due to this development, and the deep-draft navigational project in the river have accelerated a trend of decreasing agricultural activity and increasing industrialization. This trend is more pronounced in the area between New Orleans and Baton Rouge, Louisiana. Land being converted to industrial sites, for the most part, is located immediately adjacent to the river while recent residential development is mainly located near existing towns. Suburban or semirural development is also spreading along the river and is radiating out from larger population centers such as Baton Rouge and New Orleans, Louisiana. There remains, however, a considerable amount of agricultural land along the entire reach of the Mississippi River within the study area that has not been converted to other uses.

(Cited from Deep-Draft Access to the Ports of New Orleans and Baton Rouge, Louisiana, Feasibility Study, 1981.)

C-3.1.5 Laboratory Tests

C-3.1.5.1 Testing for Undisturbed Soil Borings

For the undisturbed soil borings, visual classifications were made on all samples obtained from the soil borings. Water content determinations were made on all cohesive soil samples. Unconfined Compression (UCT) tests and Unconsolidated-Undrained (Q) shear tests were performed on samples from the undisturbed borings. Liquid and plastic limits were determined for all samples on which UCT's and Q tests were performed. The results of these tests are available through a Freedom of Information Act request.

C-3.1.5.2 Testing for General Type Soil Borings

For the general type soil borings, visual classifications were made on all samples obtained from the soil borings. Water content determinations were made on all cohesive soil samples. Unconfined

Compression Tests (UCTs) were performed on samples from the general type borings. Liquid and plastic limits were determined for all samples on which UCTs were performed. The results of these tests are available through a Freedom of Information Act request.

C-3.1.5.3 Testing for Cone Penetrometer Tests

The results of the Cone Penetrometer Tests are available through a Freedom of Information Act request.

C-3.1.5.4 Testing for Dredged Material Samples

For the dredged material grab samples, classifications were made on all samples in accordance with USCS and as supplemented by "Guide for Moisture Contents Adapted to CEMVN-ED-F Soils". Specific gravity, grain size, hydrometer, and sieve tests were performed on all samples and reports were presented containing the grain size curve, D85, D60, D50, D30, D15, D10, Cc and Cu values. Relative maximum and minimum density testing was performed on granular samples (ASTM D-4253 and ASTM D-4254). The results of these tests are available through a Freedom of Information Act request.

C-3.1.6 Foundation Design

C-3.1.6.1 General

The geotechnical design was broken into several areas, namely the crossings (Baton Rouge Front, Red Eye, Sardine, Medora, Grenada, Bayou Goula, Alhambra, Philadelphia, Smoke Bend, Rich Bend, Belmont, and Fairview), Cubits Gap to Head of Passes (RM 7.0 or 6.0 AHP to 0.5 BHP), Southwest Pass (RM 0.5 BHP to 19.5 BHP), and the Bar Channel (RM 19.5 BHP to 22 BHP). For the foundation design, the project was further divided into soils reaches. The soils reaches were based on subsurface stratifications and subsurface soil shear strengths.

C-3.1.6.2 Design Soil Parameters

Design soil parameters (Q-Case) and subsurface stratifications for each soils reach for the foundation design of each area are available through a Freedom of Information Act request.

C-3.1.7 Geotechnical Analysis

The recommendation to deepen the channel from its current depth to the proposed depth of 50 feet could have a negative impact on the existing channel conditions for both levee and bank stability. Within the river crossings, the areas of the channel that have revetted banks are evaluated annually to determine levee and bank stability issues. For the lower portion of the river from Venice to the

Gulf, the existing factors of safety are great enough that there is little concern that deepening will have an impact on levee or bank stability.

For the crossings, eight of the twelve crossings have existing factors of safety that are at or near critical conditions. For the Mississippi River, critical conditions exist when the factor of safety of the levee into the channel is below 1.30, or when the bank safety factor is below 1.20. Table C-1 provides a summary of the minimum safety factors within each river crossing:

Table C-1 – Factor of Safety

River Crossing	Minimum Levee Safety Factor	Minimum Bank Safety Factor
Baton Rouge Front	1.32	1.13
Red Eye	1.46	1.19
Sardine Point	1.56	1.07
Medora	1.65	1.35
Granada	1.31	1.39
Bayou Goula	1.58	1.28
Alhambra	1.38	1.19
Philadelphia	1.43	1.15
Smoke Bend	1.41	1.28
Rich Bend	1.37	1.19
Belmont	1.56	0.93
Fairview	1.25	1.14

Reported safety factors based on 2016 surveys.

Of these crossings, geotechnical analyses indicate the need for further evaluation of two crossings, Alhambra and Belmont, since the proposed dredging in these crossings falls outside of the permissible excavation limits for geotechnical investigation (reference our standard drawing entitled, "Limits of Permissible Excavation in River", File No. H-8-45755, dated May 2002). The analyses of these crossings indicated that deepening of the channel would not negatively affect the existing factors of safety. See Annex 2 – Technical Plates for Standard Drawing and Stability Analysis.

Further analysis of the crossings will be conducted as needed during Engineering and Design for construction of the project. During this time, should the factors of safety change, additional measures including flattening of the existing slopes or placement of revetment or underwater rock stability berms in the channel may be required.

C-4.0 CIVIL DESIGN

C-4.1 Channel Design

C-4.1.1 General

The currently authorized and maintained Mississippi River – Gulf to Baton Rouge project is located within the Mississippi River between the Gulf of Mexico, approximate Mile 22.1 BHP (Below Head of Passes) and Baton Rouge, Louisiana, approximate Mile 232.4 AHP (Above Head of Passes). The current project was constructed in multiple phases, with Phase I providing a (-)45ft MLG deep draft channel from the Gulf to Mile 181 AHP which was completed in December 1988, and Phase II providing a (-)45ft MLG deep draft channel (reduced by the Low Water Reference Plane (LWRP) within this non-tidal segment of the river) from Mile 181 AHP to the upper limit at Mile 232.4 AHP in Baton Rouge, Louisiana.

For this phase of the study, the 2004–2006 Mississippi River hydrographic survey was utilized in determining the reaches that would be proposed for enlargement, based off of the depths and widths along the river projected in the survey. This Re-evaluation study evaluates the feasibility of deepening the current project to depths of (-)48ft Mean Lower Low Water (MLLW), equal to (-)45ft MLG, and (-)50ft MLLW ((-)47ft MLG), commencing with the Gulf entrance at approximate Mile 22.1 BHP, and proceeding up through Southwest Pass (SWP) to Mile 13.4 AHP north of Venice (tidally influenced stretch of the river). For this reach, an advance maintenance of 6ft below each alternative depth was applied, along with an allowable overdepth of 2ft. Advanced maintenance is performed to avoid frequent re-dredging and to ensure the lease overall cost of maintaining the project, by allowing post-dredging shoaling to occur without impacting project depth. Allowable overdepth will account for inaccuracies in the dredging process as well shoaling during construction and maintenance dredging events, and facilitate obtaining the full advance maintenance prism. For the reach of river extending upstream of Mile 13.4 AHP, the project depths of 48ft and 50ft below the LWRP (Low Water Reference Plane) were evaluated and adjusted using the 2007 LWRP NAVD88 elevations obtained from the curves provided in the following graph. The project reach of extends through the Ports of St Bernard, New Orleans, South Louisiana, and Baton Rouge upstream to Mile 232.4 AHP. This information was used in determining the adjusted dredging elevations of the Mississippi River crossing locations for both the 48ft and 50ft alternatives. See the following tables for the 48ft and 50ft template information utilized for the crossings. As depicted by these tables, an advance maintenance of 3ft below each adjusted crossing project elevation was applied, along with an overdepth of 2ft to account for inaccuracies in the dredging process and to account for shoaling during the dredging process and facilitate obtaining the full advance maintenance.

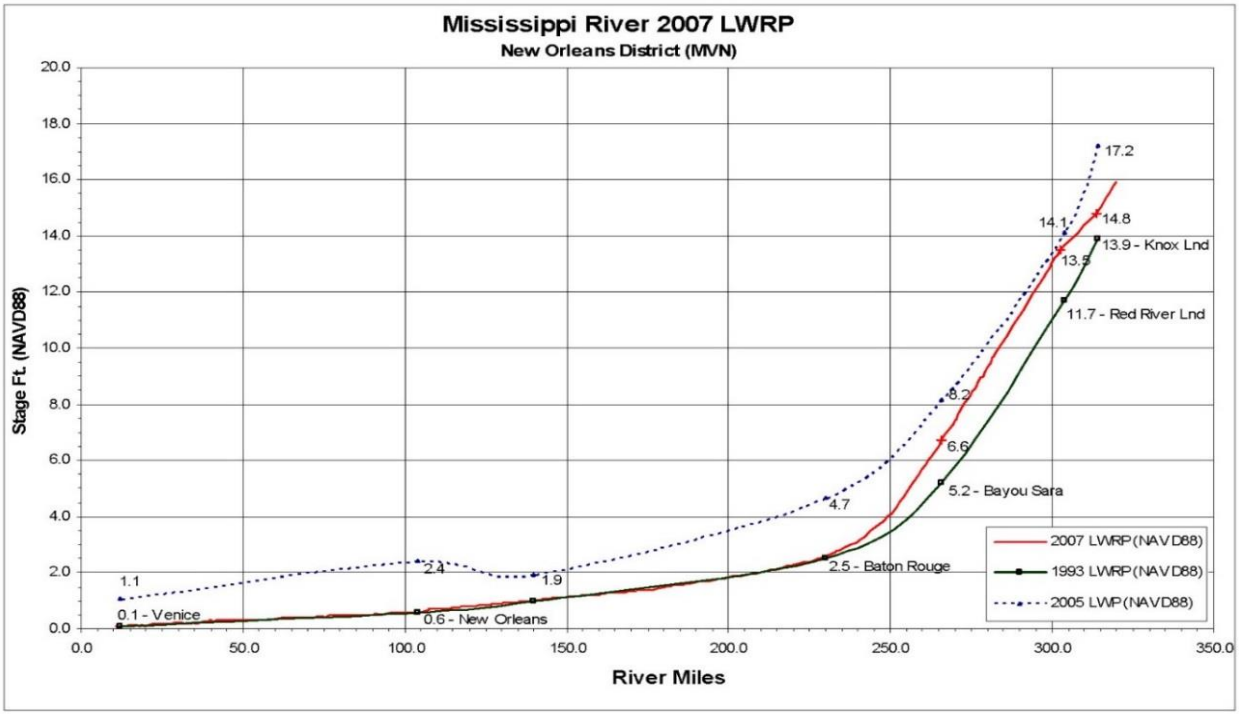


Figure C-1 - 2007 LWRP Elevations – NAVD88

Table C-2 - 48ft Crossing Template Information

Crossing Location	River Mile	2007 LWRP FT. NAVD88	-48' NAVD88	3' Adv Maint	Side Slopes	Bottom Width (250' O/C)	2' Overdepth by 500' Width
Baton Rouge Front	231	2.50	-45.50	-48.50	1 on 5	500	-50.50
Red Eye	224	2.40	-45.60	-48.60	1 on 5	500	-50.60
Sardine Point	219	2.30	-45.70	-48.70	1 on 5	500	-50.70
Manchac Bend	215	2.15	-45.85	-48.85	1 on 5	500	-50.85
Medora	212	2.00	-46.00	-49.00	1 on 5	500	-51.00
Grenada	204	1.90	-46.10	-49.10	1 on 5	500	-51.10
Bayou Goula	198	1.80	-46.20	-49.20	1 on 5	500	-51.20
Alhambra	191	1.70	-46.30	-49.30	1 on 5	500	-51.30
Philadelphia Point	183	1.60	-46.40	-49.40	1 on 5	500	-51.40
81 Mile Point	179	1.55	-46.45	-49.45	1 on 5	500	-51.45
Smoke Bend	175	1.45	-46.55	-49.55	1 on 5	500	-51.55
Rich Bend	159	1.25	-46.75	-49.75	1 on 5	500	-51.75
Belmont	153	1.20	-46.80	-49.80	1 on 5	500	-51.80
Fairview	117	0.80	-47.20	-50.20	1 on 5	500	-52.20

Table C-3 - 50ft Crossing Template Information

Crossing Location	River Mile	2007 LWRP FT. NAVD88	-50' NAVD88	3' Adv Maint	Side Slopes	Bottom Width (250' O/C)	2' Overdepth by 500' Width
Baton Rouge Front	231	2.50	-47.50	-50.50	1 on 5	500	-52.50
Red Eye	224	2.40	-47.60	-50.60	1 on 5	500	-52.60
Sardine Point	219	2.30	-47.70	-50.70	1 on 5	500	-52.70
Manchac Bend	215	2.15	-47.85	-50.85	1 on 5	500	-52.85
Medora	212	2.00	-48.00	-51.00	1 on 5	500	-53.00
Grenada	204	1.90	-48.10	-51.10	1 on 5	500	-53.10
Bayou Goula	198	1.80	-48.20	-51.20	1 on 5	500	-53.20
Alhambra	191	1.70	-48.30	-51.30	1 on 5	500	-53.30
Philadelphia Point	183	1.60	-48.40	-51.40	1 on 5	500	-53.40
81 Mile Point	179	1.55	-48.45	-51.45	1 on 5	500	-53.45
Smoke Bend	175	1.45	-48.55	-51.55	1 on 5	500	-53.55
Rich Bend	159	1.25	-48.75	-51.75	1 on 5	500	-53.75
Belmont	153	1.20	-48.80	-51.80	1 on 5	500	-53.80
Fairview	117	0.80	-49.20	-52.20	1 on 5	500	-54.20

It should be noted that the re-evaluation study strictly considered deepening of the current project, with channel widths remaining the same throughout the entire reach. Channel widths and side slopes utilized in the study for generating quantities and costs are as follows:

Channel Reach	Bottom Width	Side Slopes
Jetty and Bar Entrance Channel	600ft	1V on 3H
(Miles 22.1 BHP to 19.5 BHP)		
SW Pass Reach (Miles 19.5 BHP to 6 AHP)	750ft*	1V on 3H
Miles 6 AHP to 181 AHP	750ft	1V on 3H
Miles 181 AHP to 233.8 AHP	500ft	1V on 5H

* Note that channel transitions from 600ft to 750ft in width between Miles 17.5 BHP and 18.0 BHP

The above limits and dimensions are identical for the current (-)45ft project with the exception of the side slopes for the crossings between Miles 181 AHP and 232.4 AHP where the side slopes for this re-evaluation study have been flattened from the originally authorized 1V on 3H to 1V on 5H to better reflect the actual side slopes that are being obtained during O&M dredging of the crossings due to the sandy material that is encountered while dredging within these reaches of the Mississippi River. The proposed channel alignments within the SW Pass and Mississippi River crossing reaches, which are maintained on an annual basis, will follow the existing alignments that are currently used for navigation and maintenance dredging.

C-4.1.2 48ft Channel Alternative

This alternative will provide a 48ft deep draft project from the Gulf of Mexico to Baton Rouge, Louisiana. The project design elevation for this channel alternative is (-)48.0ft MLLW, beginning at the Gulf entrance at approximate Mile 22.1 BHP, and proceeding up through Southwest Pass (SWP) to Mile 13.4 AHP north of Venice (tidally influenced stretch of the river Reach). This (-)48ft MLLW elevation correlates to the original authorized depth of (-)45ft MLG to which the project was deepened in 1987 and to which it is currently maintained. As stated in paragraph C4.1.1, this reach of channel is often referred to as the SW Pass reach, and will be dredged to a depth of 6ft below (-)48ft MLLW (advanced maintenance), over the bottom widths and side slopes specified at the end of paragraph C4.1.1. An allowable overdepth of 2ft was accounted for in disposal area capacity evaluation and cost estimating. Dredging quantities were based off of hydrographic surveys of the Mississippi River – SW Pass performed in September 2015. It is

anticipated that shoaling within this reach of the river will remain consistent with historical patterns, and similar dredging requirements are anticipated between approximate Miles 6 AHP and 22 BHP.

For the upper portion of the study, the Mississippi River crossings listed in the tables in paragraph C4.1.1 were evaluated under this Re-evaluation study. The crossings which are currently maintained to 45ft below the LWRP (reduced by the appropriate LWRP elevations in NAVD88) for each respective crossing location, would be deepened to 48ft below the LWRP under this alternative. The advance maintenance and allowable overdepth, 3ft and 2ft respectively, which are currently applied for maintenance of the crossings under the current 45ft project, would be retained for this deepening alternative. In addition, the current channel bottom width of 500ft was determined to be adequate to accommodate projected future vessels and was therefore used for this alternative, and channel side slopes of 1V on 5H were utilized for this re-evaluation study in estimating quantities. For determining construction quantities, it was assumed that construction would immediately follow annual O&M dredging of the crossings and be performed during low water season. For this reason, surveys of the crossings performed in late fall and winter of 2014, following the completion of O&M dredging, were utilized in determining construction dredging quantities.

C-4.1.3 50ft Channel Alternative

This alternative will provide a 50ft deep draft project from the Gulf of Mexico to Baton Rouge, Louisiana. The project design elevation for this channel alternative is (-)50.0ft MLLW, beginning at the Gulf entrance at approximate Mile 22.1 BHP, and proceeding up through Southwest Pass (SWP) to Mile 13.4 AHP north of Venice (tidally influenced stretch of the river Reach). As stated in paragraph C4.1.1, this reach of channel is often referred to as the SW Pass reach, and will be dredged to a depth of 6ft below (-)50ft MLLW, over the bottom widths and side slopes specified in paragraph C4.1.1. An allowable overdepth of 2ft was accounted for in disposal area capacity evaluation and cost estimating. Dredging quantities were based off of hydrographic surveys of the Mississippi River – SW Pass performed in September 2015. It is anticipated that shoaling within this reach of the river will remain consistent with historical patterns, and similar dredging requirements are anticipated between approximate Miles 6 AHP and 22 BHP.

The Mississippi River crossings listed in the tables in paragraph C4.1.1 were evaluated under this Re-evaluation study. The crossings which are currently maintained to 45ft below the LWRP (reduced by the appropriate LWRP elevations in NAVD88) for each respective crossing location, would be deepened to 50ft below the LWRP under this alternative. The potential for required dredging of any additional crossings is being evaluated under the ongoing 2D model analysis. The advance maintenance and allowable overdepth, 3ft and 2ft respectively, which are currently applied for maintenance of the crossings under the current 45ft project, would be retained for this

deepening alternative. In addition, the current channel bottom width of 500ft was determined to be adequate to accommodate projected future vessels and was therefore used for this alternative, and channel side slopes of 1V on 5H were utilized for this re-evaluation study in estimating quantities. For determining construction quantities, it was assumed that construction would immediately follow annual O&M dredging of the crossings and be performed during low water season. For this reason, surveys of the crossings performed in late fall and winter of 2014, following the completion of O&M dredging, were utilized in determining construction dredging quantities.

C-4.2 Dredging and Disposal for Construction of Both the 48ft and 50ft Alternatives

C-4.2.1 General

Dredging and disposal alternatives investigated in this study centered on identifying the least-cost, environmentally acceptable plan. Dredging for construction of both the 48ft and 50ft channels would be accomplished via different types of dredging equipment, similar to that utilized for the construction of the current 45ft channel.

C-4.2.2 Mississippi River - SW Pass Channel Reach

For the deepening of the SW Pass reach from the current project depth of (-)48ft MLLW ((-)45ft MLG) to (-)50ft MLLW, it is anticipated that deepening will be required between approximate Mile 6 AHP and approximate Mile 22.1 BHP. Construction of the -50ft MLLW project in SW Pass would be accomplished via 3 separate contracts: two (2) hydraulic cutterhead contracts covering the reach between Miles 6 AHP to 19.5 BHP, and one (1) hopper dredge contract covering the jetty and bar channel reach from Miles 19.5 BHP to 22.1 BHP. For the hydraulic cutterhead dredging work, all dredge material would be utilized in a beneficial manner for either bank stabilization behind existing foreshore dikes along the channel or for marsh creation in the adjacent open waters. Construction of the jetty and bar channel reach from Miles 19.5 BHP to 22.1 BHP would be performed via mobile hopper dredge(s) versus stationary cutterhead dredges as this area of work will be within the Gulf entrance channel and susceptible to high sea conditions, as well as having to contend with deep draft vessels both exiting to and entering from the Gulf of Mexico via the jetties. For the hopper dredging work, all material will be dredged and hauled to the EPA approved ODMDS (Ocean Dredge Material Disposal Sites) adjacent to and west of the gulf entrance channel between Approximate Miles 20.4R BHP and 23.1R BHP.

C-4.2.3 Mississippi River Crossings

While there are a total of 24 crossing locations between New Orleans and Baton Rouge, only 12 of these crossings currently require maintenance dredging. These 12 deep draft crossings were evaluated as part of the deepening study based upon channel conditions that existed in the fall/

winter of 2014. The crossings that are being carried over for further evaluation in the next study phase are: Baton Rouge Front, Red Eye, Sardine Point, Medora, Granada, Bayou Goula, Alhambra, Philadelphia Point, Smoke Bend, Rich Bend, Belmont, and Fairview. Other crossing locations that will be reconsidered during the next phase of this re-evaluation study as potentially requiring maintenance dredging, based off of future channel surveys and 2D model results, will include: Missouri Bend and 81 Mile Point.

As previously stated in paragraph C4.1.3, the crossings are currently maintained to 45ft below the LWRP (reduced by the appropriate LWRP elevations in NAVD88 datum) for each respective crossing location, and would be deepened to either 48ft or 50ft below the LWRP under this study. Construction would be accomplished via contract and/or Government dustpan dredge(s) which is consistent with the method of construction utilized for deepening as well as maintenance of the crossings. Material dredged from the crossings would be placed adjacent to the crossing and put back into the system for the material to be carried downstream and to fallout into deeper holes within the river.

C-4.2.4 Construction Schedule

For initial construction of either alternative, it is anticipated that construction of the project will be accomplished within a four year period, commencing during low water season following routine annual O&M dredging of the channel.

C-4.3 Operations and Maintenance Dredging

Annual maintenance dredging will be required within the reaches of the Mississippi River addressed in this re-evaluation report. For this phase of the study, EDRC was tasked with developing a 1D model to determine the annual maintenance dredging quantities that could be anticipated within the crossings, as well as the lower Mississippi River reach between Venice and the Gulf, otherwise referred to as the Mississippi River - SW Pass Channel reach.

C-4.3.1 Operations and Maintenance Dredging - Mississippi River - SW Pass Channel Reach

The ERDC 1D model results received broke out the anticipated shoaling over the following reaches:

Southwest Pass Reach– Miles 18.0 BHP to 0.5 BHP

Head of Passes Reach – Miles 0.5 BHP to 1.5 AHP

Fairway/ Anchorage at Pilottown Reach – Miles 1.5 AHP to 5.0 AHP

Venice Reach – Miles 5.0 AHP to 11.0 AHP

While the projected annual quantities from both the 1D and 2D models were, for the most part, in line with those obtained during historical O&M dredging of the channel, there were some issues with the results that were projected for the Head of Passes and Fairway at Pilottown reaches where the model projections were well above the average annual quantities dredged within these reaches. The District and ERDC have both agreed that shoaling and maintenance dredging needs within the lower portion of the Mississippi River, from Venice, Louisiana (Mile 11 AHP) to the Gulf entrance channel (Mile 22.1 BHP), would remain essentially the same as for the current 45ft project (-48ft MLLW). As a result, the dredging needs for both the 48ft and 50ft channel alternatives in this reach were based off of average annual quantities obtained from historical dredging performed within the above reaches of the Mississippi River - SW Pass channel. The following annual maintenance plan was developed through coordination with the District's Operations Manager and used in obtaining the average annual O&M dredging costs for both the (-)48ft MLLW and (-)50ft MLLW alternatives:

Cubits Gap to Head of Passes reach (Approximate Miles 6 AHP to 0.5 BHP)

The ERDC models indicated annual dredging of approximately 19,000,000 cys/yr for this reach, referred to in the EDRC model as the Head of Passes Reach – Miles 0.5 BHP to 1.5 AHP, combined with the Fairway at Pilottown Reach – Miles 1.5 AHP to 5.0 AHP. However, based off of annual dredging performed within these reaches combined, and accounting for the possible extension of dredging to Mile 6.0 AHP, cost estimates were based off of an annual quantity of 9,000,000 cys for the reach between Miles 0.5 BHP and 6.0 AHP. It is estimated that approximately 2,500,000 cys would be removed annually by one (1) cutter head dredge (1 mob and demob), and 6,500,000 cys being removed by hopper dredges (assumes 4 hopper contracts and 4 mobs and demobs). If and when the need arises, dredging may also be performed by Government hopper dredge(s) in the event Contract hoppers are unable to meet the O&M needs. Disposal of material dredged within the reach of the channel would be for 100% beneficial use through cutterhead dredging, and material removed by hopper dredges placed within the hopper dredge disposal area (HDDA) within Pass A Loutre via the dredge-and-haul method. The HDDA, as shown in Figure C-2, is a designated in channel hopper disposal site. The site is mined on a periodic basis via cutterhead dredge, using project funds, and the material is transported either east or west of the channel and used for wetland creation.

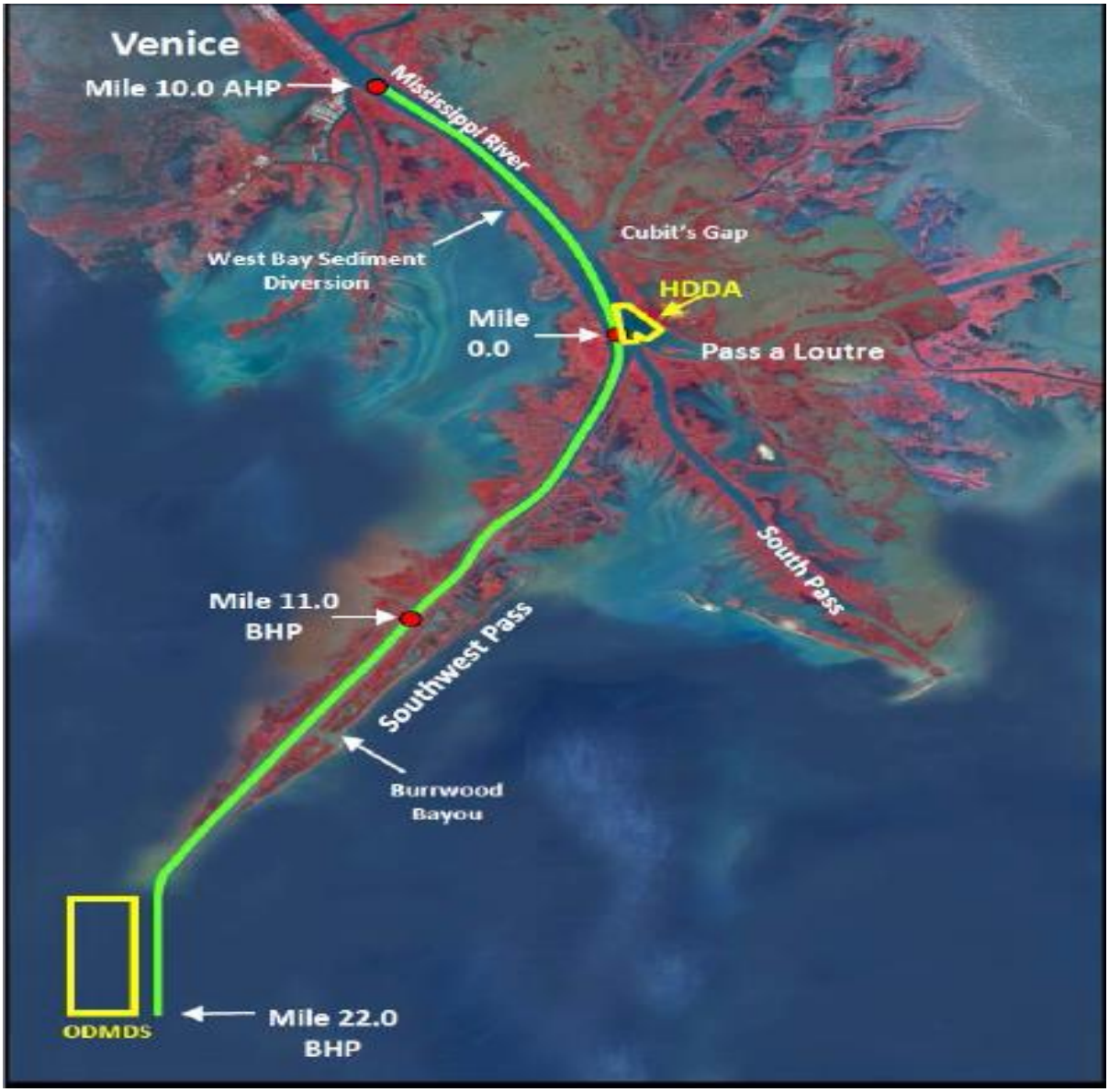


Figure C-2 – Southwest Pass Dredging Reach

SW Pass reach; Mile 0.5 BHP to 19.5 BHP

The ERDC models indicated annual dredging of approximately 9,000,000 cys/yr for the Mile 0.5 BHP to 18 BHP reach. However, based off of annual dredging performed within this reach, and accounting for the extension of dredging below Mile 18.0 BHP to Mile 19.5 BHP, cost estimates were based off of an annual quantity of approximately 9,500,000 cys for the reach between Miles 0.5 BHP and 19.5 BHP, as compared to the 9,000,000 cys/ yr estimated by the ERDC models for Miles 0.5 BHP to 18.0 BHP. It is estimated that approximately 5,250,000 cys would be removed annually by two (2) cutter head dredges (assumes 2 mobs and demobs), and 4,250,000 cys being removed by hopper dredges (assumes 3 hopper contracts and 3 mobs and demobs). If and when

the need arises, dredging may also be performed by Government hopper dredge(s) in the event the dredging industry is unable to meet the O&M needs. Disposal of material dredged within the reach of the channel would be for 100% beneficial use through cutterhead dredging, while material removed by hopper dredges would be placed within the Hopper Dredge Disposal Area (HDDA) within Pass A Loutre or the ODMDS located adjacent to the entrance bar channel via the dredge-and-haul method.

Jetty and Bar Channel Reach; Mile 19.5 BHP to approx. 22.1 BHP

As the ERDC models did not account to for this reach of the channel, previous historical quantities were utilized in developing an average annual quantity to be dredged. It is estimated that approximately 3,750,000 cys would be removed annually by hopper dredging. (Assumes 1 contract hopper so 1 mob and demob) This quantity falls with the range of average annual quantities dredged based off averages for the last 5 and 10 years of dredging in the bar channel. The dredged material would be disposed of within the designated EPA ODMDS via the dredge and haul method. However, on occasions when weather and tidal conditions are appropriate, agitation dredging may be performed. If and when the need arises, dredging may also be performed by Government hopper dredge(s) in the event Contract hoppers are unable to meet the O&M needs.

C-4.3.2 Operations and Maintenance Dredging - Mississippi River Crossings

ERDC 2-D model evaluated shoaling within the Mississippi River at the following crossing locations:

Site	River Miles	Site	River Miles
Fairview Crossing	115.2 to 117.2	Granada	203.3 to 206.6
Belmont Crossing	152.6 to 155.1	Medora Crossing	211.6 to 212.3
Rich Bend	157.9 to 159.5	Sardine Point	218.7 to 219.9
Smoke Bend	174.5 to 175.9	Red Eye Crossing	223.4 to 225.4
Philadelphia Point	181.72 to 183.6	Baton Rouge Front	228.1 to 232.7
Alhambra	189.4 to 190.9	Wilkerson Point	233.9 to 234.5
Bayou Goula Crossing	197.5 to 198.4		

The model assessed annual dredging that would be required at each of the above crossings for the current (-)45ft project, as well as the proposed (-)48ft LWRP and (-)50ft LWRP project alternative depths. The crossing width utilized was the current 500ft to which the current project is maintained. Based off of results obtained from the 2D model, the following alternatives were developed and average annual quantities estimated to be dredged at each crossing were based off of indices that the model provided for each crossing under the following alternatives: 1) the former

TSP (a 50ft channel to be constructed and maintained through the Port of South Louisiana (Fairview, Belmont and Rich Bend crossings, and the current 45ft channel to be maintained from that point up to Baton Rouge); 2) Alternative 3 - the current Recommended Plan (a 50ft channel to be constructed and maintained throughout all crossings); and 3) Alternative 3E, (a 50ft channel through the Port of South Louisiana (Fairview, Belmont and Rich Bend crossings, and a 48ft channel to be to be constructed and maintained from that point up to Baton Rouge). These indices were applied to the average annual quantities removed at each crossing during O&M dredging of the current 45ft project and based off of information received from the District's Operations Division covering years 1999 through 2015. The following table provides 17 years of data that was collected during this time frame and used to develop the average annual quantity for each crossing.

Based off of the table for the Average Annual Dredging Quantities for 45ft project, (See Annex 2), the following tables were generated for all three of the alternatives and include the average annual dredging required, as well as the anticipated annual dredging for each crossing based of the off of the indices generated by the 2D model.

Table C-4 - Projected Annual O&M of Crossings for the former TSP ((-)50ft at Port of South Louisiana and (-)45ft U/S to Baton Rouge)

Crossing Name	1999 - 2015	Crossing Index	2D Model Results	2D Model Results
	From Ops 45ft Dredging	from 2D Model	(-)45ft	(-)50ft
Baton Rouge Front	1,845,387.00	1.02	1,882,300.00	0.00
Red Eye	4,359,091.00	1.00	4,359,100.00	0.00
Sardine	1,181,210.00	1.01	1,193,000.00	0.00
Medora	1,051,192.00	1.01	1,061,700.00	0.00
Granada	1,125,646.00	1.00	1,125,600.00	0.00
Bayou Goula	950,932.00	1.01	960,400.00	0.00
Alhambra	2,481,629.00	1.02	2,531,300.00	0.00
Philadelphia	256,276.00	1.01	258,800.00	0.00
Smoke Bend	518,415.00	1.02	528,800.00	0.00
Rich Bend	15,041.00	1.01	0.00	15,200.00
Belmont	1,949,741.00	1.03	0.00	2,008,200.00
Fairview	0.00	0.99	0.00	0.00

Table C-5 - Projected Annual O&M of Crossings for the Recommended Plan ((-)50ft at all crossings)

Crossing Name	1999 - 2015	Crossing Index	2D Model Results
	From Ops 45ft Dredging	from 2D Model	-50ft
Baton Rouge Front	1,845,387.00	1.16	2,140,600.00
Red Eye	4,359,091.00	1.31	5,710,400.00
Sardine	1,181,210.00	1.03	1,216,600.00
Medora	1,051,192.00	1.03	1,082,700.00
Granada	1,125,646.00	1.08	1,215,700.00
Bayou Goula	950,932.00	1.06	1,008,000.00
Alhambra	2,481,629.00	1.12	2,779,400.00
Philadelphia	256,276.00	1.04	266,500.00
Smoke Bend	518,415.00	1.07	554,700.00
Rich Bend	15,041.00	1.00	15,000.00
Belmont	1,949,741.00	1.03	2,008,200.00
Fairview	0.00	0.99	0.00

Table C-6 - Projected Annual O&M of Crossings for the former TSP ((-)50ft at Port of South Louisiana and (-)45ft U/S to Baton Rouge)

Crossing Name	1999 - 2015	Crossing Index	2D Model Results	2D Model Results
	From Ops 45ft Dredging	from 2D Model	(-)48ft	(-)50ft
Baton Rouge Front	1,845,387.00	1.08	1,993,000.00	0.00
Red Eye	4,359,091.00	1.17	5,100,100.00	0.00
Sardine	1,181,210.00	1.02	1,204,800.00	0.00
Medora	1,051,192.00	1.02	1,072,200.00	0.00
Granada	1,125,646.00	1.05	1,181,900.00	0.00
Bayou Goula	950,932.00	1.04	989,000.00	0.00
Alhambra	2,481,629.00	1.07	2,655,300.00	0.00
Philadelphia	256,276.00	1.02	261,400.00	0.00

Smoke Bend	518,415.00	1.01	523,600.00	0.00
Rich Bend	15,041.00	1.00	0.00	15,000.00
Belmont	1,949,741.00	1.04	0.00	2,027,700.00
Fairview	0.00	1.01	0.00	0.00
Crossing Name	1999 - 2015	Crossing Index	2D Model Results	2D Model Results
	From Ops 45ft Dredging	from 2D Model	(-)48ft	(-)50ft
Baton Rouge Front	1,845,387.00	1.08	1,993,000.00	0.00
Red Eye	4,359,091.00	1.17	5,100,100.00	0.00
Sardine	1,181,210.00	1.02	1,204,800.00	0.00
Medora	1,051,192.00	1.02	1,072,200.00	0.00
Granada	1,125,646.00	1.05	1,181,900.00	0.00
Bayou Goula	950,932.00	1.04	989,000.00	0.00
Alhambra	2,481,629.00	1.07	2,655,300.00	0.00
Philadelphia	256,276.00	1.02	261,400.00	0.00
Smoke Bend	518,415.00	1.01	523,600.00	0.00
Rich Bend	15,041.00	1.00	0.00	15,000.00
Belmont	1,949,741.00	1.04	0.00	2,027,700.00
Fairview	0.00	1.01	0.00	0.00

For all crossings, it is projected that O&M dredging would be accomplished via contract (1) and Government (1-2) dustpan dredges, with the material dredged from the crossings disposed of adjacent to the crossings and put back into the system for the material to be carried downstream and to fallout into deeper holes within the river.

C-4.4 Additional O&M Needs

In order to properly maintain the project, there are other existing features that would warrant O&M, but for which cannot be accommodated due to shortfalls in the annual O&M budget. The following is a list of O&M needs and projected "annual costs" that need to be captured in the overall project costs for the deepening study. The breakdown of those annual costs/needs is as follows:

- O&M dredging of New Orleans Harbor - While dredging is not projected to increase from that currently performed for the existing (-)45ft MLG project, the average annual costs required to maintain the NO harbor is estimated to be approx. $4.5 Million/ Year.

- O&M of the Hopper Dredge Disposal Area at HOP - Continued O&M will be required and is estimated to cost approx. $17 Million/ Year.

- O&M for the Saltwater Barrier Sill - Average annual cost is estimated to be approx. $1.2 Million/ Year.

- O&M of training works (i.e. foreshore and pile dike repairs, jetty repairs, and existing dikes in crossings) - Average annual cost is estimated to be approx. $15 Million/ Year.

TOTAL - $37.7 Million/ Year

Note: These are estimated annual O&M requirements and some of these costs are due to the fact that the project has not been properly budgeted in the past to perform some of these O&M needs. And while these are needs for the current project that simply do not get funded, they still need to be captured in the annual costs developed for this deepening study.

C-4.5 Relocations

C-4.5.1 Purpose

Relocation data was collected, tabulated and detailed in this appendix by the U.S. Army Corps of Engineers, New Orleans District, Engineering Division, Relocations Team, to a feasibility level of design, prior to the selection of the TSP. The Relocations Team reviewed proposed designs against pipeline databases to obtain information and location of existing facilities. Historical project documents, correspondence, and permits were also reviewed against the scope of this effort. For the purpose of this feasibility study, facility crossings are referenced by river miles above Head of Passes along the Mississippi River.

The Relocations Team then made assumptions based on the proposed feasibility level project design and project location to determine project relocation requirements. These requirements are based on the latest relocation methods and means previously used by facility owners on Corps of Engineers projects. Facility relocations cited in this report are required to achieve 25 feet of cover from the new design depth. To maintain continuous service for gas and liquid pipelines, we assume existing pipelines will be hot tapped into new bypass pipes directionally drilled beneath the river. The cost estimates presented in this report were developed by owners for expected conflicts with dredge plans.

C-4.5.2 Scope

Improvements for the Mississippi River will involve dredging to a bottom depth of 50 feet MLLW. The list of affected facilities in Table C-7 covers those facilities located from River Mile 234.0 to River Mile 158.0 (non-continuous).

C-4.5.3 Process

Corps of Engineers pipeline permits for Mississippi River crossings between River Mile 155 and River Mile 234 were provided by Operations Division, Regulatory Branch and were used as a preliminary reference. Pipeline ownership information was compiled from pipeline databases including HTSI, NPMS, and LA-DNR. Drawings were prepared showing the proposed limits of dredging and pipelines identified therein. Pipeline owners were contacted to confirm ownership, identify additional pipelines, and provide depth information to determine potential conflicts. Cost estimates were provided for expected conflicts, assuming relocation by directional drill, and are summarized in Table C-7.

C-4.5.4 Estimated Relocations Costs

The total estimated cost for relocations of pipe, power and communication lines is $60,074,000. This estimate includes basic costs for the relocation items but does not include contingency and escalation. Estimated relocation costs for utilities are summarized in Table C-7.

Table C-7 - River Deepening Facilities Relocation Costs

Owner	RM (AHP)	Quantity	Size	Description	Total Estimated Relocation Cost (provided by owner)
		River Mile 234 to 229			
Enterprise	233.4	1	16 inch	Natural Gas	$0.00
Enterprise	232.9	4	10 inch	Natural Gas	$15,600,000.00
Enterprise	232.9	2	16 inch	Natural Gas	$0.00
Dow	232.7	1	4 inch	Propylene	$3,974,000.00
Exxon	232.6	1	6 inch	Propane	$0.00
Boardwalk	232.5	2	8 inch	Propane	$6,000,000.00
Exxon	232.5	2	8 inch	Ethane	$0.00
Exxon	232.5	1	12.75 inch	Ethylene	$0.00
Exxon	232.5	4	12 inch	Crude Oil	$0.00
Exxon	231.7	2	8 inch	Propylene	$0.00
Exxon	231.7	3	4 inch	Butane	$0.00
Exxon	231.7	2	24 inch	Crude Oil	$0.00
Exxon	231.7	1	6 inch	Petroleum	$0.00
Exxon	231.7	2	6 inch	Butadiene	$0.00
		River Mile 199 to 197			
Boardwalk	198	1	12 inch	Brine	$0.00
		River Mile 192 to 189			
Southern Natural Gas Co	190.1	1	30 inch	Natural Gas	$0.00
Southern Natural Gas Co	190.1	1	24 inch	Natural Gas	$0.00
Enterprise	189.8	3	8.63 inch	Petroleum	$18,600,000.00
		River Mile 184 to 182			
Gulf South	183.4	3	20 inch	Natural Gas	$13,000,000.00
Enterprise	182.9	1	10 inch	Propylene	$0.00
Shell	182.9	1	10 inch	Ethylene	$0.00
		River Mile 176 to 174			
Entergy	175.4	1	?	Power Cable	$0.00
AT&T	175.4	1	5 inch	Fiber Optic	$0.00
		River Mile 160 to 158			
Marathon	159.5	2	30 inch	Petroleum	$0.00
Marathon	159.5	2	40 inch	Petroleum	$0.00
Enterprise	159.2	1	8.63 inch	Natural Gas	$0.00
Gulf South	158.2	1	6 inch	Natural Gas	$2,900,000.00
				Total Expected Pipeline Relocation Costs	**$60,074,000.00**

C-5.0 ENVIRONMENTAL ENGINEERING

C-5.1 Environmental Objectives and Requirements

Environmental objectives and requirements described herein will be fulfilled by compliance with plans for the management of dredged material and by adopting and enforcing prudent and reasonable measures to avoid impacts and by the completion of measures described in the Environmental Impact Statement (EIS) prepared for this study.

C-5.2 Environmental Considerations

C-5.2.1 Environmental Effects of the Project

a. Emissions from the dredging vessel and other heavy equipment will locally degrade air quality during channel dredging and dredged material pumping operations.

b. Water clarity and quality at the dredging and disposal sites will be temporarily affected by the dredging process. Some soil particles are temporarily lost in the water column during the dredging process. With time, the sediments are winnowed out, and settle back down on the channel and disposal area water bottoms thus re-establishing water clarity and quality as it existed prior to the dredging and disposal operations.

c. The benthic microorganism community will be temporarily affected in disposal area water bottom habitats while the area adjusts to the new environment created by the project.

C-5.2.2 Integration of Environmental Sensitivity into All Aspects of the Project

Environmental sensitivity has been incorporated into all aspects of project design, with an emphasis on the proposed plan for disposal of dredged material. Avoidance and minimization of adverse impacts have been incorporated into the project construction and maintenance plan to the maximum extent practicable. Shoal material removed from Southwest Pass by cutterhead dredges will be placed in shallow open water and eroded marsh areas for the purpose of creating and restoring coastal habitat in the Mississippi River delta. Dredged material placement sites used for coastal habitat development will be monitored annually by acquisition of aerial photography used to determine land loss/gain.

C-5.2.3 Lessons Learned During Past Projects

Dredged material placement sites that have been utilized over the past 30 years will continue to be utilized for this project. Lessons learned over this period will be incorporated into disposal operations to help maintain the channel while contributing positively to Louisiana coastal restoration efforts.

C-5.2.4 Incorporation of Environmental Compliance Measures into the Project Design

There are numerous environmental laws and regulations which govern protection of the public and environment during the construction phase of a project that are incorporated into the feasibility design for this project. Environmental compliance measures for this project are related primarily to the methods used for dredged material disposal during both project construction and project maintenance. The plan for dredged material disposal is contained in the project EIS.

Local, State and Federal environmental compliance measures incorporated into the project include:

- Protection of Environmental Resources
- Preservation and Recovery of Historical, and Cultural Resources
- Protection of Water Resources
- Protection of Fish and Wildlife Resources
- Protection of Air Resources
- Pollution Prevention

C-5.2.5 Mitigation for Unavoidable Impacts

Partial implementation of the deep draft Mississippi River Ship Channel Project to a depth of 45 feet resulted in increased frequency and duration of salinity intrusion events along the Lower Mississippi River channel. These salinity intrusion events affect municipal and industrial river water supplies below River Mile 64 AHP. Engineering measures capable of mitigating water quality problems were included with channel deepening design studies.

Principal components of the salinity intrusion mitigation plan are:

1. Measures to increase Plaquemines Parish water treatment capacity of Belle Chasse, LA water treatment (River Mile 75.8 AHP)

2. Water transmission lines and booster pump stations to connect the additional capacity at Belle Chasse to other water treatment plans on west bank of Mississippi River at West Pointe-a-la-Hache and Boothville, LA.

3. Previously constructed improvements for East Bank Mitigation Works

4. Conversion of existing community pond at Davant, LA to a storage reservoir

5. Construction of a siphon from the Mississippi River to the reservoir for purpose of replenishing fresh water in reservoir;

6. Construction of transmission lines from reservoir to water treatment plan on east bank of Mississippi River at East Pointe-a-la-Hache, LA.

7. Upgrades, as necessary to provide for future increases in demand for potable water in the affected region of Plaquemines Parish, LA at such time as average consumption increases by an increment of 25 percent over average consumption in the last two years preceding beginning of construction of the mitigation plan.

8. Construction of a submarine barrier sill in the Mississippi River, Louisiana, between River Miles 65.1 AHP and 63.1 AHP

Since completion of the 45-foot channel, the submarine barrier sill has been constructed three times, in 1988, 1999, and 2012.

C-5.3 Hazardous Toxic and Radioactive Waste (HTRW)

Historic dredging events within the channel have not encountered HTRW. Therefore, based upon the HTRW assessment performed as described in the EIS and prior in-house investigations, it has been determined that there would be a low probability of encountering contaminated sites or toxic substances during project construction and maintenance activities.

C-6.0 COST ESTIMATES

C-6.1 Basis of Cost Estimate

The final initial construction cost estimate for the selected plan was also finalized utilizing the Micro-Computer Aided Cost Estimating System (M-CACES), and is included in Appendix I. The cost estimate reflects current and applicable pricing and addresses specific construction procedures for the various line items in the estimate.

The estimated costs for Southwest Pass and its Bar Channel were based upon an analysis of each line item evaluating quantity, production rate, and time, together with the appropriate equipment, labor, and material costs. Cost were developed using actual in-house knowledge and experience by MVN cost engineers who either personally designed or estimated similar projects.

The estimated costs for the Mississippi River Crossings were based upon the unit prices for the US Government owned Dustpan Dredge Hurley. Analysis of each line item evaluating quantity, production rate, and time. Cost were developed using actual in-house knowledge and experience by MVN cost engineers who either personally designed or estimated similar projects.

All the construction work is common to MVN.

C-6.2 Contingencies

Contingencies for the cost estimates were based upon similar cost estimates that had a risk analysis performed using the Crystal Ball Cost and Schedule Risk Analysis. See Appendix I.

Contingencies for engineering and design are based on uncertainties involved in the preparation of plans and specifications, and in engineering during construction.

These include cost of field data collection; unanticipated design problems; change in design based on the review of the report, changes in design criteria; and changes in overhead rates.

Contingencies for construction management are based on using historical average of time growth for similar type contracts in the area. The time growth includes additional duration for unusually severe weather and unknown changes to the contracts.

C-6.3 Detailed Estimate

The project cost estimate for the selected plan in M-CACES format is included in Appendix I. The project estimate of first cost, which included costs for lands and damages, and real estate costs during construction, as well as construction cost is included in Appendix I.

References

Engineering Regulation (ER) 1110-2-1150, *Engineering and Design for Civil Works Projects*, dated 31 August 1999.

Louisiana Coastal Area (LCA), *Louisiana Ecosystem Restoration Study*, dated January 2005.

A Report on the Development, Calibration and Initial Application of a Delft3D Z Coordinate Model in the Mississippi Delta, dated July 2017.

1st Addendum to "A Report on the Development, Calibration and Initial Application of a Delft3D Z Coordinate Model in the Mississippi Delta, dated July 2017.

Deep-Draft Access to the Ports of New Orleans and Baton Rouge, Louisiana, Feasibility Study, dated 1981.

USACE, New Orleans District, Geotechnical Branch, *Guide for Moisture Contents Adapted to CEMVN-ED-F Soils.*

USACE, New Orleans District, Geotechnical Branch, *Limits of Permissible Excavation in River*, File No. H-8-45755, dated May 2002.

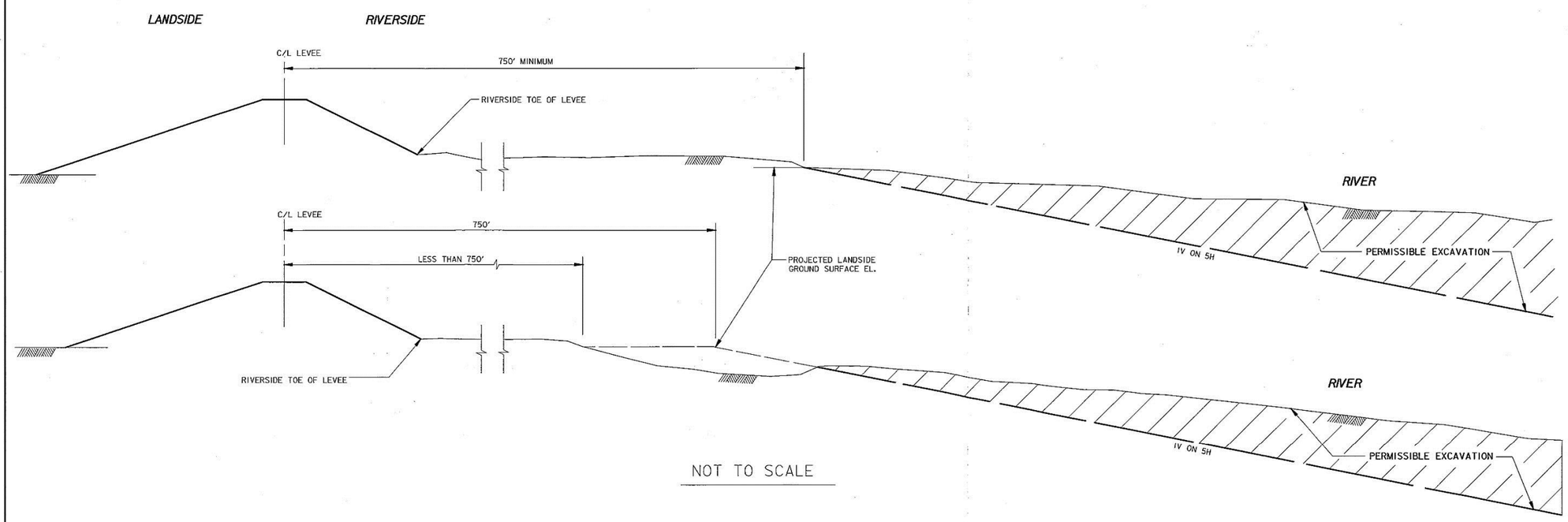
ANNEXES

ANNEX 1 **GEOTECHNICAL PLATES for STANDARD DRAWING and STABILITY ANALYSIS**

ANNEX 2 **AVERAGE ANNUAL DREDGING QUANTIESFOR 45ft PROJECT**

ANNEX 1 – GEOTECHNICAL PLATES for STANDARD DRAWING and STABILITY ANALYSIS

STANDARD DRAWING



NOT TO SCALE

NOTES:

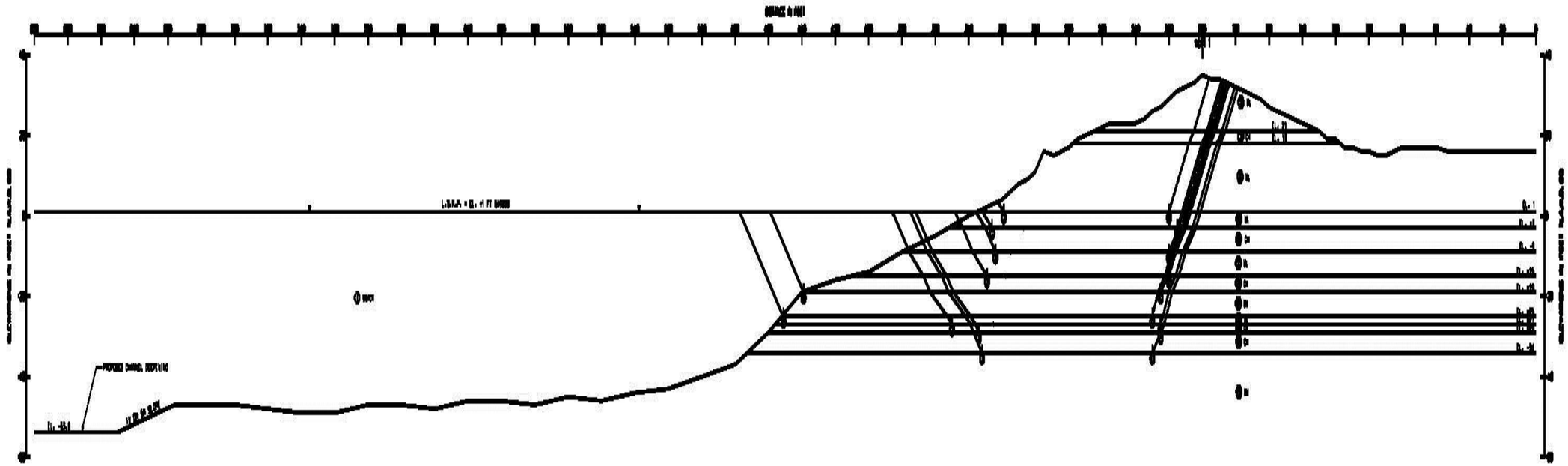
1. NORMALLY, DREDGING WILL NOT BE PERMITTED CLOSER THAN 4,000 FEET TO THE UPSTREAM SIDE OF BRIDGES CROSSING THE MISSISSIPPI RIVER.
2. EXCAVATION MADE WITHIN THE PERMISSIBLE AREA SHALL HAVE AVERAGE SLOPES NOT STEEPER THAN 1 ON 5. BOX CUTS ARE PERMITTED TO A MAXIMUM DEPTH OF 6 FEET.
3. EXCAVATION SHALL PROCEED FROM THE LANDSIDE TO THE RIVERSIDE LIMITS OF EXCAVATION TO MINIMIZE THE POSSIBILITY OF AN "OVERBURDEN FAILURE" OF THE BANK.

LIMITS OF PERMISSIBLE EXCAVATION IN RIVER

U.S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS
NEW ORLEANS, LOUISIANA

DRAWN BY: PHIL MARCHESE	PLOT SCALE: 10	PLOT DATE: X	CADD FILE: 457551.01.dgn
	DATE: MAY 2002		FILE NO. H-8-45755

STABILITY ANALYSIS



GENERAL NOTES

[illegible]

[illegible]

SLIDING BLOCK NO.	DIR.	WEIGHTS			FACTOR OF SAFETY
	TYPE	EXT.	INT.	EXT.	INT.	
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

SLIDING BLOCK NO.	DIR.	AVERAGE VALUE OF SHEAR STRENGTH			RESISTING FORCES			DRIVING FORCES			RESULTANT OF FORCES	FACTOR OF SAFETY
		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

NOTES

[illegible]

MISSISSIPPI RIVER SHIP CHANNEL
LEVEE STABILITY ANALYSIS
[illegible]
[illegible]
[illegible]
[illegible]

ANNEX 2 - AVERAGE ANNUAL DREDGING QUANTIES FOR 45ft PROJECT

Fiscal Year	Alhambra	Belmont	Smoke Bend	Medora	Red Eye	Baton Rouge Front	Missouri Bend	Sardine Point	Philadelphia Point	Bayou Goula	Granada	81 Mile Point	Rich Bend	Unknown	Total CYS
2015	1,462,302	3,911,537	253,740	1,729,408	5,624,707	971,116	0	490,000	0	1,015,955	2,083,005	0	0	0	**17,541,770**
2014					2,065,000			1,653,920							
2014	764,030	1,720,110	330,120	368,506	1,352,769	1,494,797	294,074	397,978	259,140	205,533	293,133				
2014	764,030	1,720,110	330,120	368,506	3,417,769	1,494,797	294,074	2,051,898	259,140	205,533	293,133	0	0	0	**11,199,110**
2013	964,860	2,755,000			1,124,073				288,620	106,900	377,026				
2013	1,381,383	151,000	782,420	653,478	2,886,549	470,263	287,489	1,083,656	289,144	688,195	1,552,301				
2013	2,346,243	2,906,000	782,420	653,478	4,010,622	470,263	287,489	1,083,656	577,764	795,095	1,929,327	0	0	0	**15,842,357**
2012					1,474,743										
2012	1,829,880	1,589,050	489,600	899,620	477,195	1,748,144		1,448,116							
2012	2,565,039	158,088	266,045	1,792,265	3,365,894	2,863,034	477,196	1,207,490	238,436	873,253	647,175		112,890		
2012	4,394,919	1,747,138	755,645	2,691,885	5,317,832	4,611,178	477,196	2,655,606	238,436	873,253	647,175	0	112,890	0	**24,523,153**
2011		293,668													
2011		481,120													
2011		177,715													
2011	3,356,680	1,374,522	598,040					2,002,605		1,147,363					
2011	235,051	796,377	182,932	1,360,873	5,992,014	1,485,331		198,333	572,510	410,984	1,156,767				
2011	3,591,731	3,123,402	780,972	1,360,873	5,992,014	1,485,331	0	2,200,938	572,510	1,558,347	1,156,767	0	0	0	**21,822,885**
2010		1,796,658									1,218,951				
2010		995,879	477,095	1,182,938	1,368,260						225,290				
2010	2,839,155	392,049	949,291	794,089	5,247,949	2,390,678	577,308	620,065		621,614	1,297,291				
2010	2,839,155	3,184,586	1,426,386	1,977,027	6,616,209	2,390,678	577,308	620,065	0	621,614	2,741,532	0	0	0	**22,994,560**
2009	882,645	1,362,580	1,151,743	860,648	7,492,725	4,094,395	96,467	448,794	571,176	893,004	454,794		127,763		
2009	2,861,971	156,541		524,808				1,095,205		301,316	976,444				
2009		704,328		274,272						939,063					
2009	3,744,616	2,223,449	1,151,743	1,659,728	7,492,725	4,094,395	96,467	1,543,999	571,176	2,133,383	1,431,238	0	127,763	0	**26,270,682**
2008	2,862,616	1,750,716	432,795	447,366	3,117,293	2,695,046	414,709	596,074	867,248	214,793	320,297				
2008	2,516,019	229,932	711,662	579,265	3,359,384			1,132,462		1,950,574	1,238,552				
2008		874,328													
2008		696,639		496,305						102,006	117,747				
2008		349,601		53,419											
2008	5,378,635	3,901,216	1,144,457	1,576,355	6,476,677	2,695,046	414,709	1,728,536	867,248	2,267,373	1,676,596	0	0	0	**28,126,848**
2007	1,144,748	555,320	187,730		3,804,170	222,703	1,060,694	950,476	104,859	249,846	392,768	588,755		421,542	
2007	784,096	901,885								392,494					
2007	1,928,844	1,457,205	187,730	0	3,804,170	222,703	1,060,694	950,476	104,859	642,340	392,768	588,755	0	421,542	**11,762,086**
2006	1,349,945	655,931	191,918		355,195	1,212,909		1,131,372		407,667	542,390				
2006		739,782	197,733		1,441,994	296,773				184,899					
2006	1,349,945	1,395,713	389,651	1,245,098	1,797,189	1,509,682	0	1,131,372	0	592,566	542,390	0	0	0	**9,953,606**
2005	1,547,799	1,371,671	210,434	1,680,784	5,156,586	2,791,086		637,173		1,659,015	746,114				
2005	962,687	1,130,864	206,066	330,612	517,576	265,903					154,570				
2005	2,510,486	2,502,535	416,500	2,011,396	5,674,162	3,056,989	0	637,173	0	1,659,015	900,684	0	0	0	**19,368,940**
2004	759,375	609,517	42,889	590,039	1,426,494	1,168,591		698,241		322,983	630,547				
2004					1,404,112	1,003,724									
2004	759,375	609,517	42,889	590,039	2,830,606	2,172,315	0	698,241	0	322,983	630,547	0	0	0	**8,656,512**
2003	1,286,452	792,433	62,144	759,914	1,064,350	1,445,393		483,605		371,777	904,933				
2003	976,969	612,098	87,248	302,654	2,367,533			482,098		555,802	465,422				
2003										83,608					
2003	2,263,421	1,404,531	149,392	1,062,568	3,431,883	1,445,393	0	965,703	0	1,011,187	1,370,355	0	0	0	**13,104,433**
2002	1,152,876	1,325,671	410,537	380,340	203,973	210,414		994,873	165,728	316,631	1,466,208				
2002	1,179,907	190,616		371,620	1,867,064	1,331,221		360,184	297,287	369,205					
2002				80,003	517,774			144,148							
2002	2,332,783	1,516,287	410,537	831,963	2,588,811	1,541,635	0	1,499,205	463,015	685,836	1,466,208	0	0	0	**13,336,280**
2001	356,623	362,920	79,994	161,724	1,764,615	493,897		161,334		513,441	308,641				
2001	1,168,865	641,713			1,567,964	46,133		517,803		410,316	805,790				
2001	483,445	342,967									506,624				
2001	2,008,933	1,347,600	79,994	161,724	3,332,579	540,030	0	679,137		923,757	1,621,055	0	0	0	**10,694,809**
2000	1,445,296	82,088	246,206	137,084	996,229	410,212		224,822	370,500	253,941	315,119				
2000		293,008			68,822	690,835					272,399				
2000		331,150													
2000	1,445,296	706,246	246,206	137,084	1,065,051	1,101,047	0	224,822	370,500	253,941	587,518	0	0	0	**6,137,711**
1999	1,182,992	748,001		417,366	2,939,777	496,999		228,525	75,765	151,025	141,680				
1999	864,656	702,315		73,986	2,957,375	197,703				174,670	481,362				
1999										342,999					
1999	2,047,648	1,450,316	0	491,352	5,897,152	694,702	0	228,525	75,765	668,694	623,042	0	0	0	**12,177,196**
Sum Total	**39,706,060**	**31,195,851**	**8,294,642**	**16,819,076**	**69,745,451**	**29,526,184**	**3,207,937**	**18,899,352**	**4,100,413**	**15,214,917**	**18,010,335**	**588,755**	**240,653**	**421,542**	**255,971,168**
Annual Average	**2,481,629**	**1,949,741**	**518,415**	**1,051,192**	**4,359,091**	**1,845,387**	**200,496**	**1,181,210**	**256,276**	**950,932**	**1,125,646**	**36,797**	**15,041**	**26,346**	**15,998,198**

[B1][B2]