3.0 PLAN FORMULATION

Plan formulation is the key to supporting the U.S. Army Corps of Engineers (USACE) Civil Works water resources development mission. It is a process requiring experience, analysis, intuition, and inspiration. To ensure sound decision-making, the process requires a systematic and repeatable approach. The 1983 Principles and Guidelines, published by the United States Water Resources Council, describes the study process for Federal water resource projects, and the systematic formulation of alternative plans that contribute to the Federal objective.

Plans or alternatives are composed of measures. Measures consist of features, which are structural elements that require construction or assembly and/or activities that are nonstructural actions implemented to address planning objectives. Each feature and/or activity represents an implemental measure to address planning objectives at a specific geographic site.

This study considered measures to accomplish objectives pursuant to NED and to maximize project benefits. All measures were evaluated and screened for capability to meet objectives and avoid constraints, for engineering and economic feasibility, and for benefits provided over the 50-year period of analysis from year 2020 to 2070. Those measures that warranted continued consideration and met the success thresholds were assembled into alternative plans. In the evaluation process, each alternative plan was required to meet study-specific minimum standards and qualifying criteria in order to merit further consideration.

3.1 Prior Studies

USACE has conducted numerous studies concerning deep-draft navigation on the Mississippi River below Baton Rouge, LA. The 1981 Feasibility Report documents details of some of the early studies.

The Federal project "Mississippi River Ship Channel, Gulf to Baton Rouge, Louisiana," sometimes referred to as the "Mississippi River Ship Channel, Baton Rouge, Louisiana to the Gulf of Mexico" has been authorized in parts dating back to the River and Harbor Acts of 1925. Subsequently, additional authorization was included in portions of the following Public Laws: the Rivers and Harbor Act of 1937; the Rivers and Harbor Act of 1945, and the Rivers and Harbor Act of 1962 (Refer to Chapter 1 for details on project authority).

Table 3-1 provides a list of studies completed since the 1981 Feasibility Study and identifies their relevance to the MRSC study. The table is not intended to be a comprehensive list, it is intended to provide a list of relevant documents that have bene completed since the 1981 Feasibility study. That report provides information on studies and reports completed prior to its completion.

Table 3-1 Relevant prior reports and studies.

		Relevance to MRSC Study				
Comprehensive Planning Studies		Data Source	Consistency	Structural Measures	Non-Structural Measures	FWOP Conditions
1981	Final EIS and Feasibility Study *Deep-Draft Access to the Ports of New Orleans and Baton Rouge, Louisiana*	X	X	X	X	X
1983	Chief's Report, *Mississippi River Ship Channel, Gulf to Baton Rouge, Louisiana*	X	X	X	X	X
General Design Memoranda						
1983	General Design Memorandum No. 1 *Mississippi River Deep Draft*	X	X	X	X	X
1986	General Design Memorandum No. 1 Supplement No 1. *Mississippi River Ship Channel, Gulf to Baton Rouge, Louisiana* (Venice, La. To RM 181)	X	X	X	X	X
1986	General Design Memorandum No. 1 Supplement No 4. *Mississippi River Ship Channel, Gulf to Baton Rouge, Louisiana* (Training Works 45-ft channel)	X	X	X	X	X
1990	General Design Memorandum No. 1 Supplement No 6. *Mississippi River Ship Channel, Gulf to Baton Rouge, Louisiana, Saltwater Intrusion Mitigation*	X	X	X	X	X
1992	General Design Memorandum No. 1 Supplement No 2. *Mississippi River Ship Channel, Gulf to Baton Rouge, Louisiana, Phase II 45 Foot Channel (Mile 181 – 232.4)*	X	X	X	X	X
Deferred	General Design Memorandum No. 1 Supplement No 3. *Mississippi River Ship Channel, Gulf to Baton Rouge, Louisiana* (Training Works RM 181 to 232.4)					
Deferred	General Design Memorandum No. 1 Supplement No 5. *Mississippi River Ship Channel, Gulf to Baton Rouge, Louisiana* (Widening of Jetty in Southwest Pass)					
April 1984	Mississippi River Baton Rouge to the Gulf of Mexico, LA South West Pass and the Bar Channel General Design Memorandum Supplement No. 2	X	X	X	X	X
May 1987	Mississippi River Baton Rouge to the Gulf of Mexico, LA South West Pass and the Bar Channel General Design Memorandum Supplement No. 3	X	X	X	X	X
March 1988	Mississippi River Baton Rouge to the Gulf of Mexico, LA South West Pass and the Bar Channel General Design Memorandum Supplement No. 5	X	X	X	X	X
Environmental Assessments						
1990	Mississippi River Ship Channel, Gulf to Baton Rouge, Louisiana Channel Training, Miles 181.0- 232.4	X	X	X	X	X

Comprehensive Planning Studies		Relevance to MRSC Study				
		Data Source	Consistency	Structural Measures	Non-Structural Measures	FWOP Conditions
1991	Mississippi River Ship Channel Gulf to Baton Rouge, Louisiana, Saltwater Intrusion Mitigation, Plaquemines Parish, Louisiana	X	X	X	X	X

3.2 Planning Objectives

The planning goal of the study is to re-evaluate alternative channel depths between 45 ft and 50 ft and identify the depth that provides the greatest net benefits to the Nation in order to determine whether it is in the Federal interest to proceed with construction of the channel to a deeper dimension, as opposed to a recommendation of the no action alternative (maintaining the existing constructed and maintained condition). The goal of the MRSC project is to improve deep draft navigation on the MRSC in a deeper channel, up to the authorized 55 ft depth, through phased construction.

The plan formulation was based on the following project objectives and constraints:

- **Objective 1**: Reduce transportation costs related to the limiting depths of the MRSC from the entrance channel in the Gulf of Mexico (RM 22 BHP) to Baton Rouge (RM 232.4 AHP), beginning in base year 2020. This is measured in terms of transportation cost savings for current and future shipping fleets.

- **Objective 2:** Preserve, enhance, and restore ecological resources in the lower delta adjacent to the MRSC to the extent possible under the requirements of the Federal Standard; measured in terms of acres built from beneficial use of dredge material.

- **Objective 3:** Maintain or improve operations and maintenance dredging intervals within MRSC Crossings, particularly in areas where improvements have already been investigated for the existing 45 ft depth channel. This is measured based on the anticipated shoaling rates, deposition rates, annual dredging costs, and training dike construction costs.

3.3 Planning Constraints

Plan formulation is based on the objectives as defined, while considering the following constraints:

- **Constraint 1:** Avoid or minimize impacts on existing ecological resources in the lower delta.

- **Constraint 2:** Avoid or minimize impacts to existing channel training works in the lower Mississippi River Delta, particularly in South West Pass.

- **Constraint 3:** Avoid or minimize impacts to the riverine and hurricane risk reduction system adjacent to the MRSC.

- **Constraint 4:** As described in Chapter 1, at the request of the NFS, the alternatives considered were limited to a maximum depth of 50 ft.

3.4 Management Measures Considered

Management measures considered for providing larger deep draft navigation access channels in the Mississippi River from the Gulf of Mexico to Baton Rouge, La were limited to deep draft navigation approaches within the lower reaches of the Mississippi River from RM 22 BHP to RM 13.4 AHP, and the crossings which are located between RM 115 AHP to RM 232.2 AHP, to provide deep draft access to the Port of Plaquemines, Port of New Orleans, Port of South Louisiana, and the Port of Baton Rouge. Construction and OMRR&R measures considered for providing deep draft access were limited to existing dredging practices, including the current fleet of hopper, dustpan, and cutterhead dredges. Existing dredge practices include dredging the reach from RM 22 BHP to RM 13.4 AHP with hopper dredges, and disposing the material in the Hopper Dredge Disposal Area (HDDA). The crossings are dredged with a dustpan dredge that disposes the dredge material into the channel where it is displaced downstream.

The following additional considerations were taken into account during the evaluation and comparison of alternative plans:

3.4.1 Training Works

The implementation of training structures helps stabilize the channel to provide reliable depths and widths for safe vessel passage. Currently training works are authorized and in place in Southwest Pass, and are not authorized in any other reach of the project. Training works have the potential to reduce the long-term Operation Maintenance Repair, Rehabilitation, and Relocation (OMRR&R) cost. Due to the complexities of various types, quantities, and locations that could be considered, the evaluation of training works within the crossings will be delayed to the feasibility design phase. Deferring consideration of training works until this phase ensures that identification of the TSP is based on the most conservative analysis. Optimization of the TSP will be conducted through the evaluation of training works through feasibility level design and documented in the final GRR and associated environmental documentation. If trainings works in the crossings are determined to be warranted, a post authorization change will be recommended to the Chief of

Engineers, and may be implemented within the Chief of Engineers' discretionary authority or through Congressional action.

3.4.2 Salt-Water Sill

The 1983 Chief's Report recommended, during periods of low flow in the river, installation of a submerged sill at RM 64.1 AHP, to mitigate the impacts of saltwater intrusion upriver. Comparison of alternatives considered the frequency of installing the sill based on the alternative depths. Consideration was given to both the long term OMRR&R cost, and the potential loss of sediment that could be used for other purposes.

In addition to the salt-water sill, the 1983 Chief's Report, as approved for implementation by supplemental general design documents, included the following principal components: measure to increase the capacity of the water treatment plant for Plaquemines Parish located on the West bank of the Mississippi River in Belle Chasse, La (RM 75.8 AHP); water transmission lines and booster pumps stations to connect this added capacity to the other water treatment plants on the west bank in West Pointe-a-la Hache and Boothville, and on the east bank included conversion of the existing community pond at Davant, La to a storage reservoir; construction of a siphon from the river to the reservoir required to replenish the reservoir with fresh water; and construction of transmission lines and booster pumps to connect the reservoir to the water treatment plant on the east bank of the river at Pointe-a-la-Hache; and upgrades as necessary to [provide for future increases in the demand for potable water.

Implementation of the project mitigation features included the following measures: On the west bank of the river, the capacity of the Belle Chasse Water Plant was increased by approximately 50%. Water lines were constructed to "connect" the Belle Chasse water system with Port Sulphur and Empire municipal water systems. Two booster pumps were also constructed to help "push" water to the Port Sulphur and Empire water systems. When salinity levels at municipal water intakes become too high for these downriver communities, the additional capacity at Belle Chasse maybe utilized. The connecting water lines and booster pumps help deliver fresh water to the communities down stream of Belle Chasse on the west bank of the river. To protect this intake at Belle Chasse, a saltwater sill is constructed at River Mile 64.

On the east bank of the river, a community pond at Davant was converted to a storage reservoir and a siphon from river to the reservoir was constructed to keep the reservoir supplied. A water line and booster pump was constructed to connect the reservoir at Davant to a water plant downriver at East Pointe-a-la-Hache. The reservoir at Davant will provide needed freshwater to the eastbank of Plaquemines Parish if salinity levels get too high at East Point Ala Hache, but only if properly maintained by the non-Federal sponsor.

3.4.3 Construction and OMRR&R

Construction for each depth considered the dredge quantities, the total construction cost (major NED cost), and the acres of beneficial use from the initial construction dredge material (incidental benefits) that could be attained through placement of dredge materials within the Federal Standard.

Long term OMRR&R for each depth considered the annual dredge quantities, the incremental increase in OMRR&R annual cost for dredging of sediment, and the acres of beneficial use from long term OMRR&R of dredging (incidental benefit) that can be attained within the Federal Standard requirements.

3.4.4 Navigation Benefits

Navigation benefits (transportation cost savings) were considered under two scenarios: current benefits (no growth scenario), and future transportation cost savings through reducing the need for light loading of vessels.

3.5 Additional Project Considerations - Project Datum

The MRSC project, as authorized by the Rivers and Harbor Acts of 1925 provided depths based on a tidal datum defined in the Rivers and Harbors Act of 1915. The 1915 Act defined depths of navigation projects within tidal water and tributaries of the Atlantic and Gulf to mean low water (MLW). MLW is the average of all the low water heights observed over the National Tidal Datum Epoch. For the MRSC project, the MLW was computed based on the average of all low water heights observed in the Gulf Mexico, and was therefore called mean low Gulf (MLG). MLG has been used as a navigation reference datum in coastal waterways such as the Gulf Intracoastal Waterway (GIWW) and the coastal portion of the MRSC.

Subsequent to the 1925 Rivers and Harbor Act and continuing through the 1986 authority, MLG datum was used to define the channel depth. The 1983 Chief's Report, as authorized by subsequent Congressional enactments in 1985 and 1986, recommended a channel depth of 55 ft, except for those portions of the project that lie within the limits of the Port of New Orleans.

The Water Resource Development Act (WRDA) 1992 amended the datum as defined in the Rivers and Harbors Act of 1915 from mean low water to mean lower low water.

USACE Engineering Circular (EC 1110-2-6070), titled "Engineering and Design, Comprehensive Evaluation of Project Datums" dated July 1 2009, provided guidance that all districts perform an assessment called the Comprehensive Evaluation of Project Datums (CEPD) to ensure projects are referenced to the proper nationally recognized vertical datum. Subsequently, a memorandum from

the Director of Civil Works dated 24 October 2014, Subject: "Navigation Projects Compliance with Vertical Datum Guidance," stated:

> For federal navigation, projects where the MLLW depth differs from the depths stated in the project authorization, an Engineering Documentation Report (EDR) shall be prepared in accordance with reference 1.d [ER 1110-2-1150], paragraph 8.3 for each project and posted on a navigation home page for each district. The EDR will be of limited scope to document the datum change only.

The statutory directive in WRDA 1992, as well as the cited guidance and subsequent datum policy, resulted in an assessment and conversion of the datum used for the MRSC project from MLG to MLLW. The results of this conversion are documented in EDR-OD-01 "Mississippi River Venice, Louisiana to the Gulf of Mexico (Vicinity of South West Pass)", dated 02 November 2016 (Project Datum Conversion EDR). A copy of the Project Datum Conversion EDR is included in Appendix H of this report. A brief discussion of the findings of this EDR follows: however, for further information regarding the basis of the conversion determination, refer to the Project Datum Conversion EDR.

For purposes of this project, MLG is defined as equal to Mean Low Water (MLW) at the Biloxi gauge. MLW is the average of all low tides, whereas Mean Lower Low Water (MLLW) is the average of only the lower of the two daily low tides.

MLG at SWP has become a localized reference, set to and maintained to National Geodetic Vertical Datum of 1929 (NGVD29). Utilizing that reference, the Project Datum Conversion EDR determined that MLG at Southwest Pass is approximately 3.5 ft below MLLW. This EDR further determined that at Southwest Pass, maintaining the channel at a depth of 45 ft MLG is comparable to maintaining the channel at a depth of 48.5 ft MLLW. Pursuant to the findings and determinations outlined in the above referenced EDR, the existing condition for the MRSC project reach between RM 13.4 AHP to 22 BHP, which is tidally influenced, is defined as a depth of 48.5 ft MLLW. For the purposes of this GRR's plan formulation, evaluation of alternatives, engineering analysis and hydraulic modeling, MVN rounded this depth to a full increment of 48 ft MLLW in order to provide a conservative estimate.

The datum adjustment from MLG to MLLW does not apply to the crossings within the Ports of Baton Rouge and South Louisiana because tidal influence in the river ceases to exist in the vicinity of New Orleans. The crossings, which are located between RM 115 AHP to RM 232.4 AHP, are defined to a depth referenced to a hydraulic datum referred to as the lower water reference plane (LWRP). The LWRP is a hydraulic vertical datum for channel depths represented by a zero foot low water elevation established from long-term observations of the river's stages, discharge rates,

and flow duration periods. With no need for a datum adjustment in this area, the existing conditions for the crossings are defined as 45 ft LWRP.

3.6 Existing Project Description

The MRSC extends from RM 22 BHP to RM 232.4 AHP. Among other things, Phase I deepened the MRSC to 45 ft from Donaldsonville, LA, (RM 181 AHP) to the Gulf of Mexico and construction of Phase II, deepened the MRSC to a depth of 45 ft between Donaldsonville, LA, (RM 181 AHP) to Baton Rouge, LA (RM 232.2 AHP), and included dredging of eight river crossings to an equivalent depth. The initial array of alternatives as defined below, considered deepening the MRSC based on the original Phase I and Phase II of construction, and identified RM 181 AHP as a break point. As the initial array of alternatives was further refined it was determined that the MRSC consists of three routinely dredged reaches to allow for navigation. These three reaches were used to define the final array of alternatives.

The first reach is located in the lower Mississippi River reach, and extends from RM 13.4 AHP to RM 22 BHP. This reach includes the portion referred to as Southwest Pass which extends form RM 0 (Head of Passes) to RM 22 BHP (Figure 1-2). This reach is located down river from the jurisdictional limits of the Port of Plaquemines, which jurisdictional limits extend from RM 0 to RM 81.2 AHP.

The second reach, the New Orleans Harbor, lies within the jurisdictional limits of the Port of New Orleans and extends between RM 81.2 AHP and RM 114.9 AHP, (Figure 3-1). Although the New Orleans Harbor is maintained and dredged under operation and maintenance of the MRSC, deepening of this portion is not included in the evaluation of alternatives. The Rivers and Harbor Act of 1962 included deepening portions of the Port of New Orleans to a depth of 40 ft. However the 1981 Chief's Report and subsequent 1985 Supplemental Appropriations Act did not include authority to deepen the Port of New Orleans beyond the previously authorized 40 ft.

The third reach is from RM 115 AHP to RM 232.4 AHP, immediately downstream of the US Highway 190 bridge in Baton Rouge. The area consists of crossings (locations where the channel crosses the river between bendways). Of the crossings, 12 require routine maintenance dredging. Of these 12 crossings, three crossings, Fairview, Belmont, and Richbend, lie within the footprint of the Port of South Louisiana, which extends from RM 115 AHP to RM 168.3 AHP, and the remaining 9 crossings are within the footprint of the Port of Baton Rouge, which extends from RM 168.3 AHP to RM 232.4 AHP (Figure 1-3).

The three reaches as described above are dredged annually to maintain deep draft navigation. The portions of the river in between RM 13.4 AHP to RM 115 AHP, and in between the crossings historically have depths in excess of 55 ft. Evaluation indicated this will remain the case through

the period of analysis. If future conditions result in changes in the naturally deep condition of these excluded reaches, an economic and environmental analysis and reassessment of the project will be needed in order to address the channel depth in those reaches.

Figure 3-1 Project Reaches

3.7 Initial Array of Alternatives

The initial array of alternatives was developed prior to the implementation of the datum conversion based on the premise that the depth in the lower Mississippi from RM 13.4 AHP to RM 22 BHP was at 45 ft MLLW, (rather than the 48.5 ft MLLW, as was later determined). This depth was used to define the initial array. The initial array of alternatives considered varying channel depths and widths for the MRSC.

The alternatives defined in the initial array are referenced to MLLW from RM 22 BHP to 13.4), and to LWRP for the crossings, located between RM 115 AHP to 232.4 AHP.

Initial Array Alternative 1:

45 ft LWRP depth with a 500 ft channel width at the crossings,

45 ft depth (defined to the appropriate hydraulic datum, for each particular reach of the river) with a 750 ft channel width from mile 181 AHP to mile 17.5 BHP and,

45 ft MLLW with a 600 ft channel width from mile 17.5 BHP to the Gulf of Mexico

Initial Array Alternative 2:

48 ft LWRP depth with a 750 ft channel width at the crossings,

48 ft depth (defined to the appropriate hydraulic datum, for each particular reach of the river) with a 750 ft channel width from mile 181 AHP to mile 17.5 BHP and,

48 ft MLLW depth with a 600 ft channel width from mile 17.5 BHP to the Gulf of Mexico

Initial Array Alternative 3:

50 ft LWRP depth with a 750 ft channel width at the crossings,

50 ft depth (defined to the appropriate hydraulic datum, for each particular reach of the river) with a 750 ft channel width from mile 181 AHP to mile 17.5 BHP and,

50 ft MLLW depth with a 600 ft channel width from mile 17.5 BHP to the Gulf of Mexico

3.7.1 Screening of the Initial Array

In evaluating the initial array of alternatives, several considerations were made to narrow the array.

Channel Widths: The initial array of alternatives considered varying channel widths from 500 ft to 750 ft. Based on discussions with CEMVN Operations Division and local stakeholders, it was determined that the existing channel width was adequate to safely pass the existing ship fleet, which includes Post-Panamax ships. Because vessels can safely pass at the existing width; and because widening the channel would result in additional cost and increased environmental impacts with no additional benefits, changes in the channel width were eliminated from the array of alternatives. Safety of the existing channel widths may be a concern with future shipping fleets if ship length and width increases.

Channel Depths: As discussed under "Additional Project Considerations," when implementing the April 2007 datum guidance, it was determined that the channel from RM 13.4 AHP to RM 22

BHP has been maintained at a depth of 45 ft MLG, which is equivalent to a depth of 48.5 ft MLLW. The array of alternatives was therefore redefined based on the current dredging practice in the lower Mississippi River.

3.7.2 Evaluation of the Existing Condition

The terms "existing conditions" and "future without project conditions (FWOP**)**" are used to conduct economic evaluations. Existing condition is defined as the condition that exist at the start of the study. As discussed above, for purposes of this report and the alternatives analysis herein, the existing condition in the lower Mississippi, from RM 13.4 AHP to 22 BHP is 48 ft MLLW.

Because the channel depth in this area was originally assumed to exist at a depth of 45 ft, the economic justification for the incremental difference between 45 ft. and its current depth of 48 ft. was assessed. The study looked at a scenario in which the lower Mississippi Channel would silt in overtime to the depth of 45 ft, and then determined the associated cost to reconstruct the channel from 45 ft to 48 ft. The benefits were estimated based on current vessel traffic data with an artificial 45 ft draft limit enforced. Since the channel is already at a depth of 48 ft, construction cost associated with going from 45 ft to 48 ft is considered a sunk cost. The evaluation of alternatives to deepen the channel from RM 22 BHP to 13.4 AHP from the current depth of 48 ft to a depth of 50 ft indicated there was no incremental difference in the annual OMRR&R requirements. Therefore it was assumed there would also be no difference in the annual OMRR&R requirements between 48 ft and 50 ft. Table 3-2 shows the results.

Table 3-2 Economic Justification for Existing Condition

MRSC – SWP and Bar Channel	
Average Annual Benefits and Costs (3.125%)	
Channel Alternative	**From 45 ft to 48 ft**
First Cost of Construction	$84,939,642
Average Annual Cost	$3,541,763
Average Annual Incremental OMRR&R	None
Total Average Annual Benefits	$45,922,826
Benefit to Cost (B/C) Ratio	13.0:1

This provides a B/C ratio of 13.0:1. The incremental benefits would be lost if the channel was to return to 45 ft MLLW. The B/C ratio and average annual benefits show that even if no additional increment was constructed, there is justification for maintaining the channel at its current depth. Having established that, the remaining plan formulation evaluates alternatives based on the existing condition of 48.5 ft for RM 13.4 AHP to RM 22 BHP.

3.8 Final Array of Alternatives

The following is the final array of alternatives:

- **Alternative 1 (No action/Future Without Project):** The alternative considers a depth of 45 ft LWRP for the 12 actively maintained crossings and a depth of 48 ft MLLW in the lower Mississippi from RM 13.4 AHP to RM 22 BHP.

- **Alternative 2**: The alternative considers a depth of 48 ft LWRP for the 12 actively maintained crossings and a depth of 48 ft MLLW in Lower Mississippi River from RM 13.4 AHP to RM 22 BHP.

- **Alternative 3**: This alternative considers a depth of 50 ft LWRP for the 12 actively maintained crossings and a depth of 50 ft MLLW in the Lower Mississippi River from RM 13.4 AHP to RM 22 BHP.

For the final array of alternatives, locations between RM 13.4 AHP to RM 115 AHP historically have a depth in excess of 55 ft and are considered naturally deep, with the exception of the New Orleans Harbor. For RM 115 AHP to RM 232.4 AHP the portions of the river between the 12 actively maintained crossings are also considered naturally deep. Therefore the alternatives only consider the reaches of the river where construction and subsequent operation and maintenance is required to provide deep draft access.

Analysis of the final array indicated opportunities to construct the channel with varying depths for the lower Mississippi (RM 22 BHP to RM 13.4 AHP) and the crossings, as long as the depth in the lower Mississippi was equal to or greater than that provided in the crossings. This scenario could possibly achieve greater benefits with lower cost. For instance, the lower Mississippi from RM 22 BHP to RM 13.4 AHP could be deepened to a depth of 50 ft MLLW while the crossings could remain at a depth of 45 ft LWRP or could be deepened to 48 ft LWRP. Deepening to RM 13.4 AHP, coupled with the naturally deep channel above RM 13.4 AHP, would effectively provide deep draft access for a depth at or in excess of 50 ft MLLW to the Port of Plaquemines and the Port of Orleans, but would limit the ability for the ships, which require this additional draft, to reach the ports above RM 115 AHP. The value of considering varying depths is it allows analysis of economic benefits provided by each port compared to the construction and operation and maintenance cost for each reach. Note, however, that this report is not conducting an analysis of implementing any construction action to sustain the naturally deep portions of the channel. Should the naturally deep portions of the channel become shallower than the existing condition, a new reevaluation report and environmental analysis would be required in order to sustain depths in excess of 50 feet for the reaches excluded from consideration in this general reevaluation study.

Within the Final Array, consideration was given to various permutations for depths in both the lower Mississippi from RM 13.4 AHP to RM 22 BHP and the crossings. Those additional permutations are listed below. These additional alternatives consider deepening the the lower Mississippi to 50 ft MLLW, and deepening the crossings to depths of 45 ft and 48 ft LWRP.

- **Alternative 3a**: This alternative considers a depth of 45 ft LWRP for the 12 actively maintained crossings and a depth of 50 ft MLLW in the Lower Mississippi River from RM 13.4 AHP to RM 22 BHP;

- **Alternative 3b**: This alternative considers a depth of 48 ft LWRP for the 12 actively maintained crossings and a depth of 50 ft MLLW in the Lower Mississippi River from RM 13.4 AHP to RM 22 BHP.

3.9 Cost Estimates

Cost estimates were developed for both the first construction cost and the annual maintenance cost both within the crossings and in the lower Mississippi. Construction cost estimates assumed the continuation of current dredging practices. First construction cost and annual maintenance cost were not developed for the portions of the river that are naturally deep, and would not require construction or maintenance.

3.9.1 First Construction Cost

For both the crossings and the lower Mississippi, the construction and disposal methods used in Phase I and Phase II of the project to deepen the portions of the MRSC to the current depths were used to develop the first construction cost for each alternative in the final array. Based on the construction duration required to construct the MRSC to the current depths, a duration of 4 years was used for first construction of all alternatives. First construction cost estimates were developed based on the estimated quantity of dredge material that would be removed under each alternative.

For the lower Mississippi from the current project depth of 48 ft MLLW to 50 ft MLLW, deepening would be required between approximate Mile 6 AHP and approximate Mile 22.1 BHP. Costs were based on the assumption that this work would be accomplished using two (2) hydraulic cutterhead dredge 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 cutter head dredging work, all dredge material would be utilized in a beneficial manner, within the limits of the Federal Standard, 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 RM 19.5 BHP to 22.1 BHP would be performed via mobile hopper dredge(s) versus stationary cutter head dredges as this area is located within the Gulf

entrance. For the hopper dredging work, all material would be dredged and hauled to the EPA approved Ocean Dredge Material Disposal Sites (ODMDS) adjacent to and west of the Gulf entrance channel between Approximate Miles 20.4 BHP and 23.1 BHP.

While there are numerous crossing locations between New Orleans and Baton Rouge, only 12 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. These 12 crossings include: Baton Rouge Front, Red Eye, Sardine Point, Medora, Granada, Bayou Goula, Alhambra, Philadelphia Point, Smoke Bend, Richbend, Belmont, and Fairview.

The crossings are currently maintained to 45 ft below the LWRP and would be deepened, if deepening was deemed justified, to either 48 ft or 50 ft below the LWRP based on the alternative considered. Construction would be accomplished via contract and/or Government dustpan dredge(s) consistent with the method of construction already utilized to deepen and maintain 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 fall out into deeper holes within the river.

Table 3-3 provides a breakdown of the first construction cost for each of the alternatives in the final array. Because the lower Mississippi is currently at a depth of 48’ ft MLLW, there is no first construction cost for this reach for Alternative 2. For purposes of cost estimating, the reach identified as “Southwest Pass” in the tables extends from RM 13.4 AHP to RM 18 BHP The reach identified as the Bar Channel extends from RM 18 BHP to 22BHP. These reaches were divided based on the type of dredge used and the disposal method, both of which result in a different cost per cubic yard of dredge material.

The first construction cost for all alternatives also include estimates for relocation and real estate requirements, refer to Chapter 5 for additional information on these estimates.

Table 3-3 First Construction Quantities and Cost

Alternative 1		
	Construction Quantities (CY)	Construction Cost
Total	None	None
Alternative 2		
	Construction Quantities (CY)	Construction Cost
Crossings	5,467,000	$88,700,000
Southwest Pass	N/A	
Bar Channel	N/A	
Total	5,467,000	
Alternative 3		
	Construction Quantities (CY)	Construction Cost
Crossings	8,588,600	$180,600,000
Southwest Pass	18,281,000	
Bar Channel	1,619,000	
Total	28,488,600	
Alternative 3a		
	Construction Quantities (CY)	Construction Cost
Crossings	N/A	$80,000,000
Southwest Pass	18,281,000	
Bar Channel	1,619,000	
Total	19,900,000	
Alternative 3b		
	Construction Quantities (CY)	Construction Cost
Crossings	5,467,000	$169,000,000
Southwest Pass	18,281,000	
Bar Channel	1,619,000	
Total	25,367,000	

3.9.2 Annual Operation and Maintenance Cost

Comparison of alternatives for economic analysis is based on the incremental difference between current annual Operation and Maintenance (O&M) cost, and anticipated O&M cost for each alternative. For this phase of the study, the Engineer Research and Development Center (ERDC) was tasked with developing a 1D model to determine the annual maintenance dredging quantities that could be anticipated within the 12 actively maintained crossings, as well as the lower Mississippi River reach between RM 13.4 AHP to RM 22 BHP under each of the alternatives. O&M costs were developed based on both the results of the 1D model as well as on historic dredging practices. (Refer to the Engineering Appendix C, for detailed information on development of the quantities.)

CEMVN and ERDC both agreed that shoaling and maintenance dredging needs within the lower portion of the Mississippi River, from Venice, Louisiana (Mile 13.4 AHP) to the Gulf entrance channel (Mile 22 BHP), would remain essentially the same as currently exists in these locations. For this reason, the dredging needs for both the 48 ft and 50 ft MLLW alternative channel depths in this reach were based on average annual quantities obtained from historical dredging performed within this reach of the MRSC. Because the annual dredge quantities in this reach would essentially remain the same as the current project, there is no cost difference in estimated annual O&M cost for this reach. In addition, there are no annual maintenance requirements for the reaches between RM 13.4 AHP to RM 115 AHP. Although New Orleans Harbor does require annual O&M, because it is excluded from the scope of this evaluation, there would be no change in the O&M cost.

The only locations within the project area that would have an increase in quantity of dredge material, and therefore an incremental increase in cost would be the 12 crossings that are currently maintained between RM 115 AHP to RM 232.4 AHP. Table 3-4 provides a comparison of annual OMRR&R dredge quantities for the 12 crossings for the alternative depths of 48 ft and 50 ft LWRP. The table provides the estimated annual OMRR&R cost, and the difference in the estimated annual cost from the current OMRR&R cost based on a 5 year average of recent operations expenditures for the crossings.

Table 3-4 Incremental OMRR&R Quantities and Cost

Alternative 1:			
	Current OMRR&R Quantities (CY)	Current OMRR&R Expenditures	Incremental Cost Increase
Crossings	19,419,180	$23,969,413	N/A
Alternative 2			
	OMRR&R Quantities	OMRR&R Cost	Incremental Cost Increase
Crossings	38,397,000	$124,308,045	$100,300,000
Alternative 3			
	OMRR&R Quantities	OMRR&R Cost	Incremental Cost Increase
Crossings	48,377,000	$155,451,482	$131,400,000
Alternative 3a			
	Current OMRR&R Quantities (CY)	Current OMRR&R Expenditures	Incremental Cost Increase
Crossings	19,419,180	$23,969,413	N/A
Alternative 3b			
	Current OMRR&R Quantities (CY)	Current OMRR&R Expenditures	Incremental Cost Increase
Crossings	38,397,000	$124,308,045	$100,300,000

The quantities shown in Table 3-4 reflect the quantity for the neat line quantity (dredge quantity to obtain the required depth) plus advance maintenance. To estimate the total OMRR&R cost for dredging of the crossings, the quantity was increased by 20% to account for over depth. In addition, the OMRR&R includes estimates for Preliminary Engineering and Design (6%); and Construction Supervision and Administration (8%). A risk-based contingency was added to each line item. The current OMRR&R expenditures are based on a 5-year average of actual expenses as recorded by O&M. This reflects a cost of $1.25 per cubic yard for dredge material when using a hopper dredge. The estimated cost for the alternatives used a more conservative cost of $1.95 per a cubic yard based on using a dustpan dredge.

While Table 3-4 reflects the incremental difference in OMRR&R for the comparison of alternatives, it should be noted that the table does not reflect the full OMRR&R budget required to maintain MRSC. Table 3-4 only reflects the incremental cost required to dredge the crossings under each alternative. The OMRR&R budget is estimated at $200 million annually and includes

funding for: dredging of lower Mississippi; dredging of the New Orleans Harbor Access Area and Hopper Dredge Disposal Area; repair of foreshore rock, jetties, and pile dikes in Southwest Pass; and annual implementation of the saltwater sill barrier. The incremental cost shown in Table 3-4 would be in addition to the present $200 million annual OMRR&R budget.

Comparison of alternatives considered the frequency of implementation for the sill for salt-water intrusion impact. However, the evaluation determined that there would be limited, if any change in the frequency of construction of the sill for all of the alternatives. Therefore, this was not used for comparison of alternatives.

Additional information on the development of quantities and cost for both construction and OMRR&R can be found in the Engineering Appendix (Appendix B).

3.10 Summary of Accounts and Comparison of Alternatives

To facilitate the evaluation and display of effects of the alternative plans there are four Federal Accounts to consider:

(1) The national economic development (NED) account displays changes in the economic value of the national output of goods and services.

(2) The environmental quality account displays non-monetary effects on ecological, cultural, and aesthetic resources including the positive and adverse effects of ecosystem restoration plans.

(3) The regional economic development (RED) account displays changes in the distribution of regional economic activity (e.g., income and employment).

(4) The other social effects account displays plan effects on social aspects such as community impacts, health and safety, displacement, energy conservation and others.

The NED account is required. Other information that is required by law or that will have a material bearing on the decision-making process should be included in the other accounts, or in some other appropriate format used to organize information on effects. The Federal objective is to determine the project alternative with maximum net economic benefits while protecting or minimizing impacts to the environment. The alternative plan that reasonably maximizes net economic benefits consistent with protecting the Nation's environment, the NED plan, shall be selected. Display of the NED and environmental quality accounts is required. Display of the regional economic development (RED) and other social effects accounts is discretionary. Although not reflected in this analysis, there are real and tangible benefits to be gained in the region upriver from Baton Rouge by deepening the channel. RED (regional economic development) benefits come in the

form of efficiencies that are separate from the transportation cost savings used by USACE to evaluate a project. Although RED may be used to further describe alternatives, and independent studies exist that point to real and tangible benefits to be gained, these are not considered in the NED decision process.

Consideration of the NED and other social effects is provided in the Economics Appendix D.

Environmental Quality impacts are described in Chapter 4 and no significant impacts were identified for any alternative. In fact, due to the anticipated incidental benefits from beneficial use of dredged material within the Federal standard, the NED plan is anticipated to have a net beneficial environmental impact. Therefore, the comparison and selection of alternatives is based on the NED plan. The NED plan is the alternative that provides the greatest net benefits to the Nation.

3.11 Comparison of Alternatives

Table 3-5 provides a comparison of each alternative considering the first construction cost, the incremental annual OMRR&R cost, the total average annual cost, and the total average benefits used to calculate the net benefits.

Table 3-5 Economic Comparison of Final Array of Alternatives

Channel Alternative	Alternative 2	Alternative 3	Alternative 3a	Alternative 3b
First Cost of Construction	$ 88,663,029	$ 183,076,433	$ 82,218,030	$ 170,881,059
Interest During Construction	$ 3,897,405	$ 8,047,583	$ 3,614,099	$ 7,511,505
Total Investment	$ 92,560,434	$ 191,124,016	$ 85,832,129	$ 178,392,564
Average Annual Const. Cost	$ 3,512,491	$ 7,252,791	$ 3,257,165	$ 6,769,656
Average Annual Increm. O&M	$ 100,007,021	$ 131,446,950	$ -	$ 100,007,021
Total Average Annual Cost	$ 103,519,512	$ 138,699,741	$ 3,257,165	$ 106,776,677
Total Average Annual Benefits	$ 105,900,338	$ 147,604,765	$ 10,973,375	$ 116,873,779
Net Excess Benefits	**$ 2,380,826**	**$ 8,905,025**	**$ 7,716,210**	**$ 10,097,102**
B/C Ratio	**1.02**	**1.06**	**3.37**	**1.09**

Alternative 1 (No Action): No NED benefits are associated with the No Action Alternative.

Alternative 2 (48 ft depth for the Crossings and Lower Mississippi): Alternative 2 has a positive B/C ratio and provides NED benefits however these are not as great as Alternatives 3, 3a, and 3b, all of which include deepening of the lower Mississippi from RM 13.4 AHP to RM 18 BHP to a depth of 50 ft. This indicates that there are NED benefits associated with deepening the lower Mississippi from its current depth of 48 ft to 50 ft, which reduces transportation cost savings for ships to reach the Port of Plaquemines and the Port of New Orleans.

Alternative 3 (50 ft depth for the Crossings and the Lower Mississippi): Alternative 3 has a positive B/C ratio and provides NED benefits greater than Alternative 2. While alternative 3 has very good NED benefits, and its B/C ratio is above 1, the B/C is not as great as alternatives 3a and 3b.

Alternative 3a (45 ft depth for the Crossings and 50 ft for the Lower Mississippi): Alternative 3a has the highest B/C ratio and provides NED benefits greater than Alternative 2. However, the net excess benefits are not as great as Alternative 3 or 3b. Since this alternative only includes construction in the lower Mississippi from RM 13.4 AHP to RM 22 BHP, it shows there are benefits to be gained from deepening this reach to 50 ft. Since this alternative includes no construction or increase in O&M in the crossings, this indicates that cost for the crossings is significantly impacting the B/C ratio.

Alternative 3b (45 ft depth for the Crossings and 50 ft for the Lower Mississippi): Alternative 3b has a positive B/C ratio and provides the greatest net net excess benefits. A comparison of Alternative 3b and Alternative 3a, which includes no deepening of the crossings, indicates that there is benefit to be gained by deepening the crossings to some amount, but the cost of construction and incremental O&M, significantly reduce the B/C ratio.

3.12 Optimization of Alternatives

Based on the comparison of Alternative 3b and 3a, it is discernible that there are benefits to be gained by deepening the crossings to reduce transportation cost for ships traveling to the Port of South Louisiana and the Port of Baton Rouge. However, the cost of construction and the annual incremental increase in OMRR&R is significantly influencing the B/C ratio.

With the understanding that there were opportunities to be gained from varying the depths in the crossings from those implemented in the lower Mississippi reach, a more detailed analysis of the reaches of the river and the various ports serviced by each crossing was conducted. There are three crossings actively maintained that are within the footprint of the Port of South Louisiana: Fairview;

Belmont; and Richbend. There are nine actively maintained crossings that are within the footprint of the Port of Baton Rouge: Smoke Bend; Philadelphia; Alhambra; Bayou Goula; Granada; Medora; Sardine; Red Eye; and Baton Rouge Front (refer to Figure 3-2).

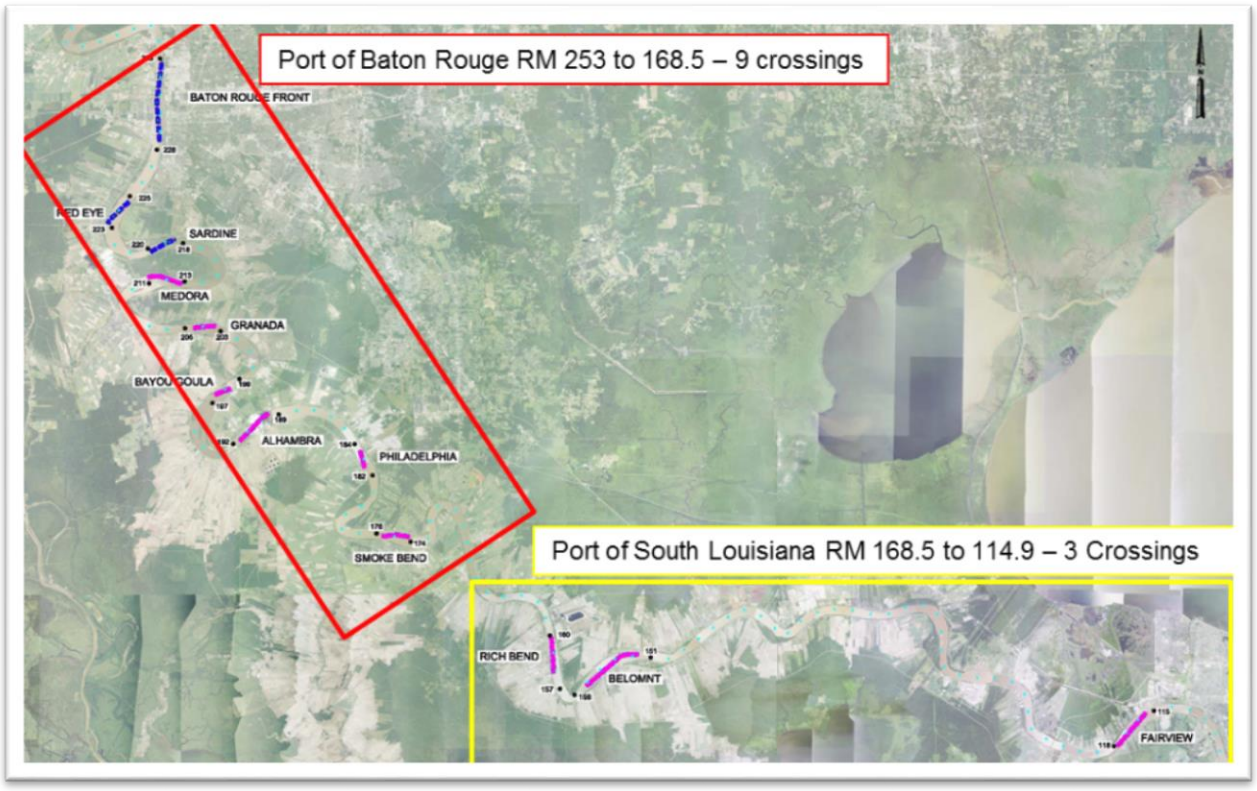

Figure 3-2 Crossing by Port

In order to optimize the final array, additional alternatives were developed that would allow for comparison of the NED benefit and B/C ratio for deepening the river through the Port of South Louisiana to a depth of 48 ft and 50 ft LWRP. This was compared to deepening the full channel (through the Port of Baton Rouge) to depths of 48 ft and 50 ft LWRP. These additional alternatives are defined as:

- **Alternative 2a**: The alternative considers a depth of 48 ft LWRP for the 3 crossings located within the footprint of the Port of South of Louisiana and a depth of 48 ft MLLW in the Lower Mississippi River from RM 13.4 AHP to RM 22 BHP. The 9 crossings located within the footprint of the Port of Baton Rouge would remain at 45 ft LWRP.

- **Alternative 3c**: The alternative considers a depth of 48 ft LWRP for the 3 crossings located within the footprint of the Port of South of Louisiana and a depth of 50 ft MLLW in the

Lower Mississippi River from RM 13.4 AHP to RM 22 BHP. The 9 crossings located within the footprint of the Port of Baton Rouge would remain at 45 ft LWRP.

- **Alternative 3d**: The alternative considers a depth of 50 ft LWRP for the 3 crossings located within the footprint of the Port of South of Louisiana and a depth of 50 ft MLLW in the Lower Mississippi River from RM 13.4 AHP to RM 22 BHP. The 9 crossings located within the footprint of the Port of Baton Rouge would remain at 45 ft LWRP.

(Note the nomenclature for the alternatives is based on the depth of the lower Mississippi River reach from RM 13.4 AHP to RM 22 BHP, 48 ft for Alternative 2 and 2a, and 50 ft for alternative 3, and 3a through 3d).

Table 3-6 provides a comparison of the first construction cost, incremental O&M cost, Net Excess Benefits, and B/C ratio for each of the newly defined alternatives as well as Alternatives 2 and 3. Alternative 3a is not included in table 3-6, as it did not provide greater net excess benefits when compared to alternative 3b, therefore this alternative was not carried forward in the evaluation.

The optimization of the final array of alternatives identified that Alternative 3d yielded the greatest net excess benefits.

Table 3-6 Optimization of Alternatives

Channel Alternative	Alternative 2	Alternative 2a	Alternative 3	Alternative 3b	Alternative 3c	Alternative 3d
First Cost of Construction	$88,663,029	$5,551,980	$183,076,433	$170,881,059	$87,770,010	$88,971,120
Interest During Construction	$3,897,405	$244,051	$8,047,583	$ 7,511,505	$3,858,151	$3,910,948
Total Investment	$92,560,434	$5,796,031	$191,124,016	$ 178,392,564	$91,628,160	$92,882,068
Average Annual Const. Cost	$3,512,491	$219,948	$7,252,791	$ 6,769,656	$3,477,113	$3,524,697
Average Annual Increm. O&M	$100,007,021	$13,443,710	$131,446,950	$ 100,007,021	$13,443,710	$18,126,110
Total Average Annual Cost	$103,519,512	$13,663,658	$138,699,741	$ 106,776,677	$16,920,824	$21,650,806
Total Average Annual Benefits	$105,900,338	$84,519,999	$147,809,587	$ 116,873,779	$95,023,734	$118,436,481
Net Excess Benefits	**$2,380,826**	**$70,856,340**	**$9,109,847**	**$ 10,097,102**	**$78,102,911**	**$96,785,675**
B/C Ratio	**1.02**	**6.19**	**1.07**	**1.09**	**5.62**	**5.47**

3.13 Identifying the Tentatively Selected Plan

Alternatives 1 through 3 as described above were reviewed and approved by the CEMVN vertical team (i.e., Division and HQ) and local sponsor at the designated Alternatives Milestone meeting on July 6, 2016 at CEMVN. The three original alternatives (1, 2, 3) were carried forward for evaluation in the draft SEIS, while economics and cost/benefits analysis for this study were also being developed concurrently. It was recognized that the original alternatives represented the maximum environmental impacts; all additional alternatives reduced the maximum impacts from the three original alternatives. For that reason, the other alternatives 2a, 3a, 3b, and 3c were developed, analyzed, and screened based on economic analysis only. The economic analysis screened alternatives 2a, 3a, 3b, and 3c from further consideration based on their respective net excess benefits. The draft EIS was reinitiated to include alternative 3d, with the original alternatives, in the consideration for a selection of a TSP.

Although the project is authorized to a depth of 55 ft for the full channel (through the Port of Baton Rouge), the economic and environmental analysis indicates that the increment with the greatest net excess benefits is alternative 3d. The Tentatively Selected Plan (TSP) for the next phase of construction is Alternative 3d. This alternative is to deepen the MRSC to a depth of 50 ft LWRP for the 3 crossings located within the footprint of the Port of South of Louisiana (refer to Figure 3-2) and to a depth of 50 ft MLLW in the Lower Mississippi River from RM 13.4 AHP to RM 22 BHP (Refer to Figure 3-1). The 9 crossings located within the footprint of the Port of Baton Rouge would remain at 45 ft LWRP. Further deepening of the channel through the Port of Baton Rouge may be implemented in a future construction phase as additional increments become economically justified to achieve the fully authorized project.

3.14 Additional Plan Formulation and TSP Confirmation

After release of the draft report, and upon consideration of the public comments, Independent External Peer Review, and Agency Technical Review comments, and the development of feasibility level design, to include evaluation of training works, sea level rise and further refinement of relocation and real estate needs, further plan formulation may be warranted to confirm and further optimize the TSP.