WEST SHORE LAKE PONTCHARTRAIN
HURRICANE AND STORM DAMAGE RISK REDUCTION STUDY
INTEGRATED DRAFT FEASIBILITY REPORT
AND
ENVIRONMENTAL IMPACT STATEMENT

ENGINEERING
APPENDIX B

Contents

General

The Study area is located west of the Bonnet Carre Spillway between the Mississippi River and Lakes Pontchartrain and Maurepas in Southeast Louisiana. The project's purpose is to provide hurricane and storm damage risk reduction to developed areas of St. Charles, St. John the Baptist and St. James Parishes. Three alternatives (levee alignments) were evaluated (each with several features, including levees, floodwalls, floodgates and pumping stations) in order to select the best approach to reduce hurricane/tropical storm surge (hereafter "storm surge") in communities throughout the study area. Each alternative also evaluated environmental measures designed to protect and/or minimize the impacts to nearby wetlands and transportation evacuation routes (such as I-10 and U.S. 61) located in the study area. Figure 1 displays the 3 alternative alignments under consideration.

Information provided herein is based on modeling for a 100-year level of protection in the Baseline Year of 2020. This is also known as the base year and is part of a 50 year planning horizon that the Corps designs projects on. 2020 was decided as the base year for economic and hydraulic conditions since it is possible that the proposed levee could be designed and constructed by 2020 were funding and authority available to do so. All information is subject to change based on further evaluation conducted during feasibility level of design and analysis. A description of each alternative follows.

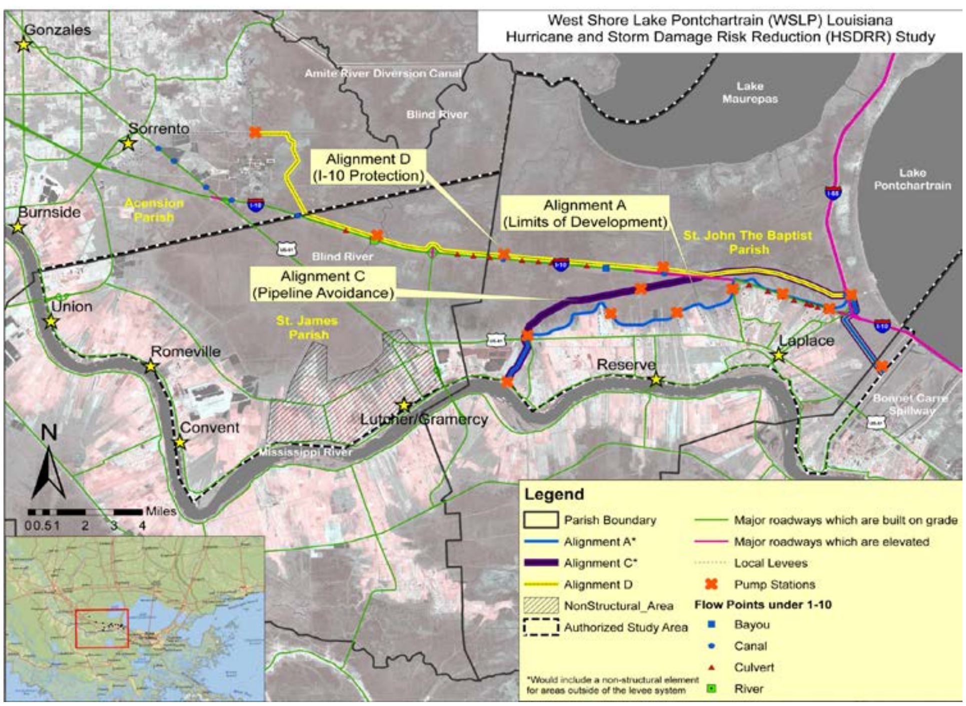

Figure 1: The Three Alternative Alignments

Alternative A

Alternative A starts at the Upper Guide Levee of the Bonnet Carre Spillway in St. Charles Parish, LA (north of the transmission and pipeline corridors), extends west around the I-10/I-55 interstate interchange and ends at the Mississippi River Levee just west of the Hope Canal in St. John the Baptist Parish, LA, a distance of 20.41 miles. The earthen levee generally follows the wet/dry interface. The following information is based on modeling for a 100-year level of protection in the Baseline Year of 2020 for a project life of 50 years and is subject to change based on further evaluation conducted during feasibility.

The top of levee elevation (net elevation) for this alignment ranges from El. 13.5 NAVD88 on the eastern reaches of the levee near the Bonnet Carre Spillway and gradually tapering to El. 7.0 NAVD88 as the levee moves west across the project .

Floodwalls

Ten Floodwalls (T-type walls), comprising a total of 4,774 linear feet, range from 10 ft. to 19 ft. in height; the top of wall design elevation is El. 17.0 NAVD88. The floodwalls, for the most part, are located where the alignment runs under I-10 and the I-10/I-55 interchange.

Floodgates

Nine Floodgates, comprising a total of 1,218 linear feet, range from 10 ft. to 19 ft. in height; the top of gate design elevation is El. 17.0 NAVD88. The floodgates, for the most part, are located along the alignment, usually where canals and roads are. Additionally, two 25-ft. wide railroad swing gates (each 11 ft. high) are included for those instances where the levee crosses the railroad.

Drainage Structures

Gravity Drainage Structures (with sluice gates), comprising a total of 240 linear feet, range from 20 ft. to 29 ft. in width. These are located near proposed pumping stations.

Pumping Stations

There are 8 pumping stations located along the alignment. The different sizes (which assumes there is no storage capacity available) are as follows:

2 at 240 cfs each

1 at 328 cfs

1 at 400 cfs

2 at 460 cfs each

1 at 656 cfs

1 at 787 cfs

Pumping stations are located at the various canals that cross the alignment, such as the Hope, Mississippi Bayou, Reserve Relief, Ridgefield, Vicknair and Montz Canals. It is generally expected that the gates would be closed, and the pumps would be operated during storm surge. Pumping would continue until the water level returns to existing natural water level conditions (currently estimated to be El. 2.0 NGVD), at which time the operation of the pumps would be discontinued and the gates would be opened.

Pipeline Relocations

There are numerous pipeline relocations involved in this alignment. The diameters of the various pipelines are as follows:

6 in. and less	18 pipelines
12 in. and less (but greater than 6 in.)	40 pipelines
24 in. and less (but greater than 18 in.)	11 pipelines
Greater than 24 in.	1 pipeline

<u>Alternative C (TSP)</u>

Alternative C starts at the Upper Guide Levee of the Bonnet Carre Spillway in St. Charles Parish, LA (north of the transmission and pipeline corridors), extends west around the I-10/I-55 interstate interchange and ends at the Mississippi River Levee just west of the Hope Canal in St. John the Baptist Parish, LA, a distance of 18.27 miles. The following information is based on modeling for a 100-year level of protection in the Baseline Year of 2020 for a project life of 50 years and is subject to change based on further evaluation conducted during feasibility.

The top of levee elevation (net elevation) for this alignment ranges from El. 13.5 NAVD88 on the eastern reaches of the levee near the Bonnet Carre Spillway and gradually tapering to El. 7.0 NAVD88 as the levee moves west across the project area.

Floodwalls

Nine Floodwalls (T-type walls), comprising a total of 5,304 linear feet, range from 10 ft. to 19 ft. in height; the top of wall design elevation is El. 17.0 NAVD88. The floodwalls, for the most part, are located where the alignment runs under I-10 and the I-10/I-55 interchange.

Floodgates

Five Floodgates, comprising a total of 288 linear feet, range from 15 ft. to 19 ft. in height; the top of gate design elevation is El. 17.0 NAVD88 The floodgates, for the most part, are located along the alignment, usually where canals and roads are. Additionally, two 25-ft. wide railroad swing gates (each 11 ft. high) are included for those instances where the levee crosses the railroad.

Drainage Structures

Gravity Drainage Structures (with sluice gates), comprising a total of 208 linear feet, range from 25 ft. to 29 ft. in width. These are located near proposed pumping stations.

Pumping Stations

There are 4 pumping stations located along the alignment. The different sizes (which assumes there is no storage capacity available) are as follows:

1 at 200 cfs

1 at 400 cfs

1 at 450 cfs

1 at 1,100 cfs

Pumping stations are located at the various canals that cross the alignment, such as the Montz, Reserve Relief and Ridgefield Canals, as well as a local canal near Baseline Station 933+00. It is generally expected that the gates would be closed, and the pumps would be operated during storm surge. Pumping would continue until the water level returns to existing natural water level conditions (currently estimated to be El. 2.0), at which time the operation of the pumps would be discontinued and the gates would be opened.

Pipeline Relocations

There are numerous pipeline relocations involved in this alignment. The diameters of the various pipelines are as follows:

6 in. and less	14 pipelines
12 in. and less (but greater than 6 in.)	16 pipelines
24 in. and less (but greater than 18 in.)	5 pipelines
Greater than 24 in.	1 pipeline

Access Routes and Staging Areas

Access routes and staging areas have not been determined at this time, but potential access routes and staging areas will be identified during the feasibility-level design of the tentatively selected plan (TSP) alignment. During the P.E.D. phase of the project, these routes and staging areas will be finalized.

Borrow Sources

Borrow material for this project would come from the Bonnet Carré Spillway or alternative borrow sources not yet identified. Potential borrow pits will be identified during the feasibility-level design of the TSP alignment. During the P.E.D. phase of the project, , identification and environmental clearance of these pits will be finalized and right of way drawings will be prepared in anticipation of submitting a request to the NFS to obtain the necessary real estate rights and interests.

<u>Alternative D</u>

Alternative D starts at the Upper Guide Levee of the Bonnet Carre Spillway in St. Charles Parish, LA (north of the transmission and pipeline corridors), extends west around the I-10/I-55 interstate interchange, continues west along I-10 and ends at the Marvin Braud Pumping Station, in the vicinity of Sorrento (within the McElroy Swamp) in Ascension Parish, LA, a distance of 28.28 miles. The following information is based on modeling for a 100-year level of protection in the Baseline Year of 2020 for a project life of 50 years and is subject to change based on further evaluation conducted during feasibility.

The top of levee elevation (net elevation) for this alignment ranges from El. 13.5 NAVD88 on the eastern reaches of the levee near the Bonnet Carre Spillway and gradually tapering to El. 8.0 NAVD88 as the levee moves west across the project area.

Floodwalls

Six Floodwalls (T-type walls), comprising a total of 4,011 linear feet, range from 15 ft. to 19 ft. in height; the top of wall design elevation is El. 17.0 NAVD88. The floodwalls, for the most part, are located where the alignment runs under I-10 and the I-10/I-55 interchange.

Floodgates

Three Floodgates, comprising a total of 306 linear feet, range from 15 ft. to 19 ft. in height; the top of gate design elevation is El. 17.0 NAVD88. The floodgates, for the most part, are located along the alignment, usually where canals and roads are.

Drainage Structures

Gravity Drainage Structures (with sluice gates), comprising a total of 396 linear feet, range from 20 ft. to 29 ft. in width. These are located near proposed pumping stations. For the Bayou Conway area, the required channel size is 24 ft. wide x 12 ft. deep (to convey 1,100 cfs of flow). For the Blind River area, the required channel size is 40 ft. wide x 20 ft. deep (to convey 4,500 cfs of flow).

Pumping Stations

There are 6 pumping stations located along the alignment. The different sizes (which assume there is no storage capacity available) are as follows:

1 at 200 cfs

1 at 400 cfs

1 at 450 cfs

2 at 1,100 cfs each (this includes the Bayou Conway area)

1 at 4,500 cfs (this is for the Blind River area)

Pumping stations are located at the various canals that cross the alignment, such as the Montz, Reserve Relief and Ridgefield Canals, as well as a local canal near approx. Baseline Station 951+00 and the Bayou Conway and Blind River areas. It is generally expected that the gates would be closed, and the pumps would be operated during storm surge. Pumping would continue until the water level returns to existing natural water level conditions (currently estimated to be El. 2.0), at which time the operation of the pumps would be discontinued and the gates would be opened.

Pipeline Relocations

There are numerous pipeline relocations involved in this alignment. The diameters of the various pipelines are as follows:

6 in. and less	7 pipelines
12 in. and less (but greater than 6 in.)	6 pipelines
24 in. and less (but greater than 18 in.)	1 pipeline

There are at least two instances where the pipeline would cross through the floodwall (at approx. Baseline Station 1382+00 and at approx. Baseline Station 1404+00).

Culverts

There are 6 culverts (in addition to the culverts that exist under I-10) that facilitate tidal exchange of water with the wetlands.

Hydraulics and Hydrology

Interior Drainage

The interior drainage analysis for the feasibility study was broken down into two stages:

1) Determine the rough-order-of-magnitude (ROM) capacities of gravity drainage structures and pumps recommended to prevent project induced flooding for each of the proposed alignments (A, C, and D).

2) For the tentatively selected plan (TSP), determine the capacities of gravity drainage structures and pumps using a detailed rainfall-runoff analysis.

For the ROM phase of the analysis, pump and gravity drainage recommendations were determined using an XP-SWMM model completed during the reconnaissance phase of the study for Alignments A and C. Figure 2 depicts the storage basin layout for used in the model. These basins correspond to the sizes and capacities listed in Table 1. Alignment D covers the area of Alignment C in addition to the drainage basins of the Blind River and Bayou Conway. Structures and pumps were sized for Blind and Conway using the HEC-HMS and HEC-RAS modeling suite. The recommendations are also listed in Table 1. All design values are based on a 10-yr, 24-hr rainfall.

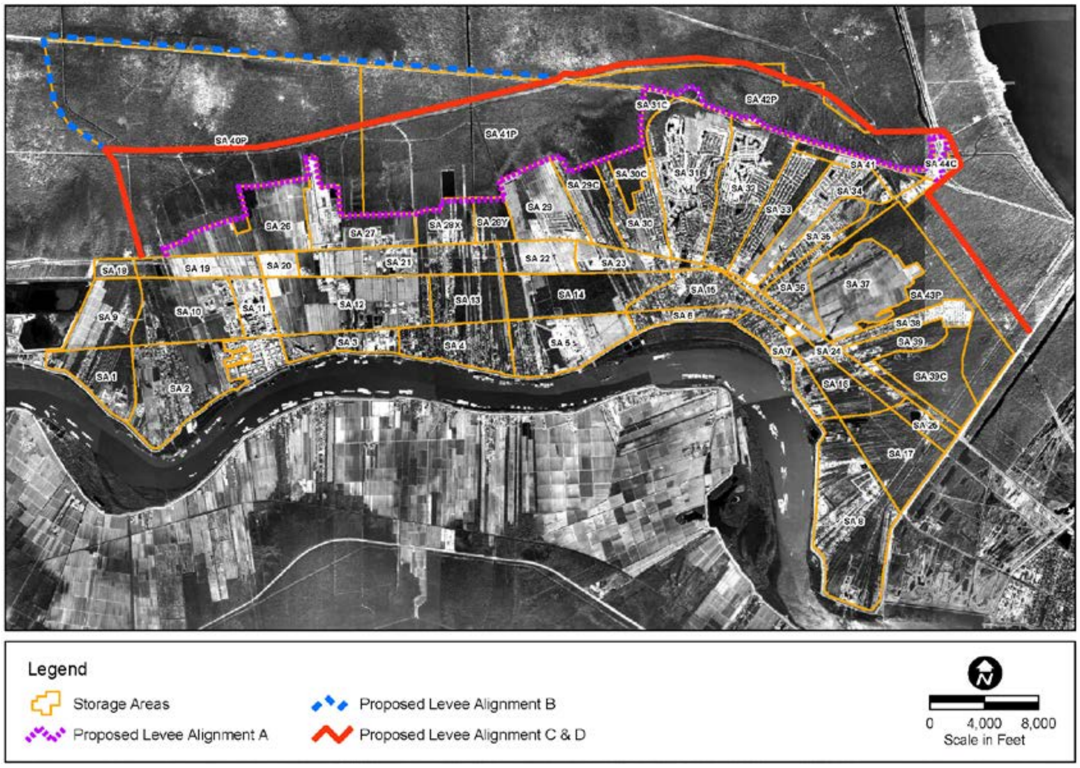

Figure 2: Storage Basin Layout

Table 1: ROM Determinations

Item / Location:	Alignment A	Alignment C and D	Blind River and Bayou Conway (Alignment D only)
Gravity Drain, SA-40P	1 RCBC*, 6' High by 20' Wide	1 RCBC, 6' High by 20' Wide	
Gravity Drain, SA-41P	2 RCBC's, 6' High by 20' Wide	2 RCBC's, 6' High by 20' Wide	
Gravity Drain, SA-42P	2 RCBC's, 6' High by 18' Wide	2 RCBC's, 6' High by 18' Wide	
Gravity Drain, SA-43P	2 RCBC's, 6' High by 18' Wide	2 RCBC's, 6' High by 18' Wide	
Pump Station, SA-40P	480 cfs	450 cfs	
Pump Station, SA-41P	1180 cfs	400 cfs	
Pump Station, SA-42P	920 cfs	200 cfs	
Pump Station, SA-43P	985 cfs	1100 cfs	
Gravity Drain, Blind River			40ft. wide, 20ft. deep rectangular cross section

Gravity Drain, Bayou Conway			24ft. wide, 12 ft. deep rectangular cross section is required
Pump Station, Blind River			1100 cfs
Pump Station, Bayou Conway			4500 cfs

*RCBC - Reinforced Concrete Box Culvert

Detailed interior drainage modeling is being performed on Alignment C as the Tentatively Selected Plan (TSP).

Storm Surge Modeling

State-of-the-Art coastal ocean hydrodynamic analysis methods were used to determine the storm surge and wave results. The modeling system for this study was established by fine-tuning existing models used previously for the Joint Storm Surge (JSS) Analysis in Southern Louisiana for the Louisiana Coastal Protection and Restoration (LACPR) project, as well as the recent flood insurance rate map modernization study conducted by the Federal Emergency Management Agency (FEMA) (USACE 2008a; USACE 2007).

The data gathered from Advanced Circulation (ADCIRC) and the Steady State Spectral Wave (STWAVE) modeling were used to generate surge and wave return values ranging from the 50 year return to the 2000 year return in 50 year increments. A set of 152 hurricane condition storm events were used to develop an existing (2011) condition and future conditions for a 2020 intermediate relative sea level rise (RSLR) and 2070 low, intermediate, and high RSLR as well as alternative alignments intermediate RSLR. The Joint Probability Method, with Optimum Sampling (JPM-OS) was applied for each data set to develop stage frequencies. The resulting levee design heights for the screening level effort for each alignment and for each condition (2011, 2020 and 2070) are shown on the following maps (Figures 3 through11). It should be noted that, for Figures 6 through 11, the notation of "Considering Intermediate Sea Level Rise" on each of these maps refers to Intermediate Relative Sea Level Rise.

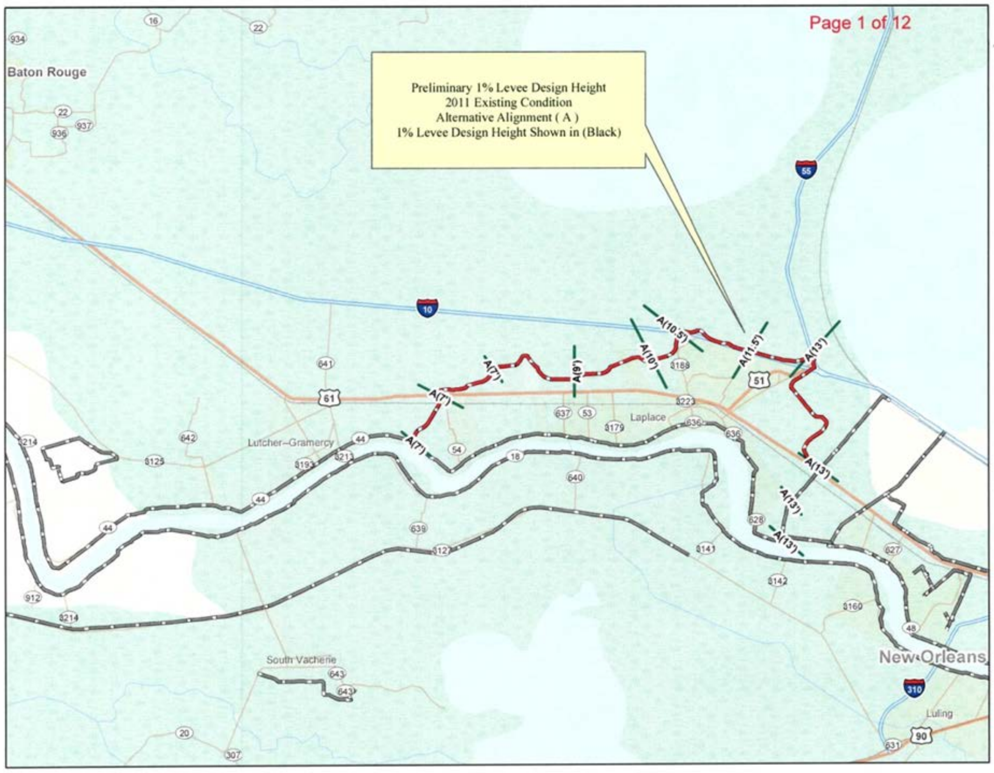

Figure 3: Levee Design Height Existing Conditions Alignment A

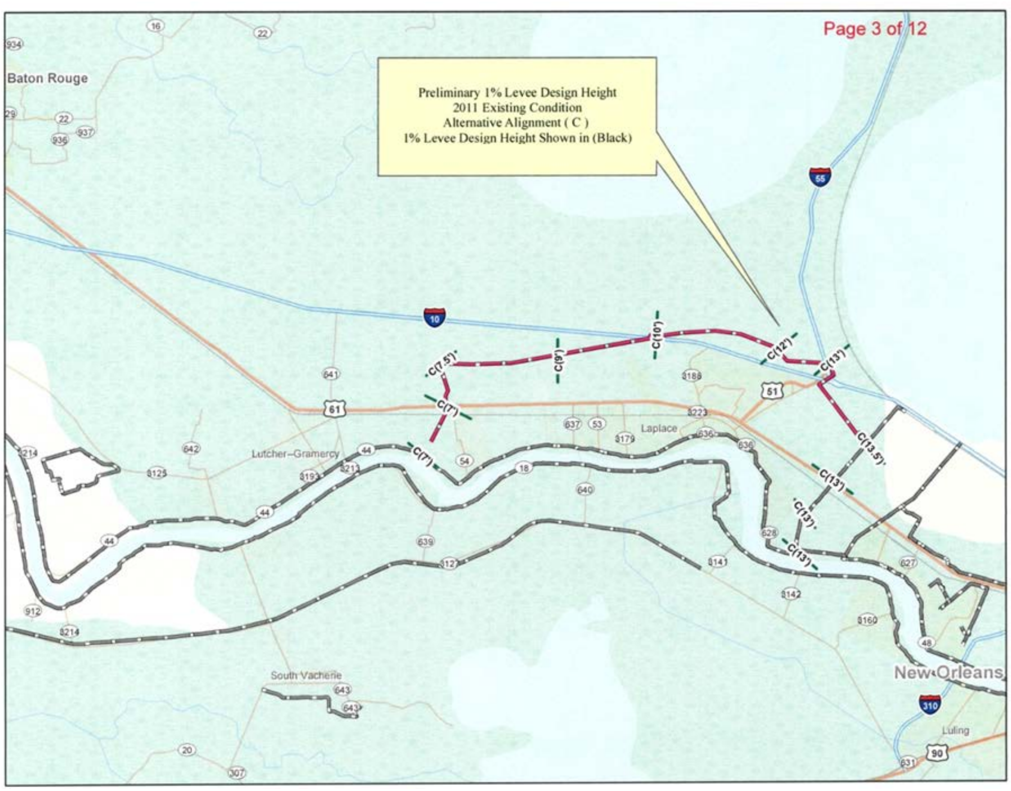

Figure 4: Levee Design Height Existing Conditions Alignment C (TSP)

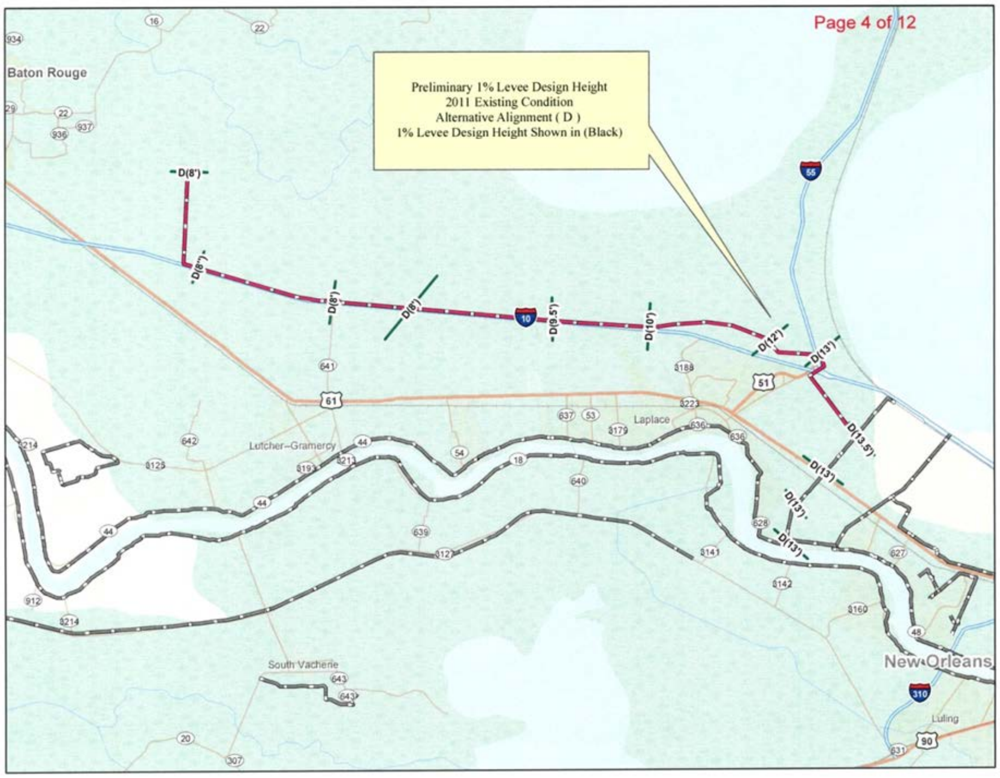

Figure 5: Levee Design Height Existing Conditions Alignment D

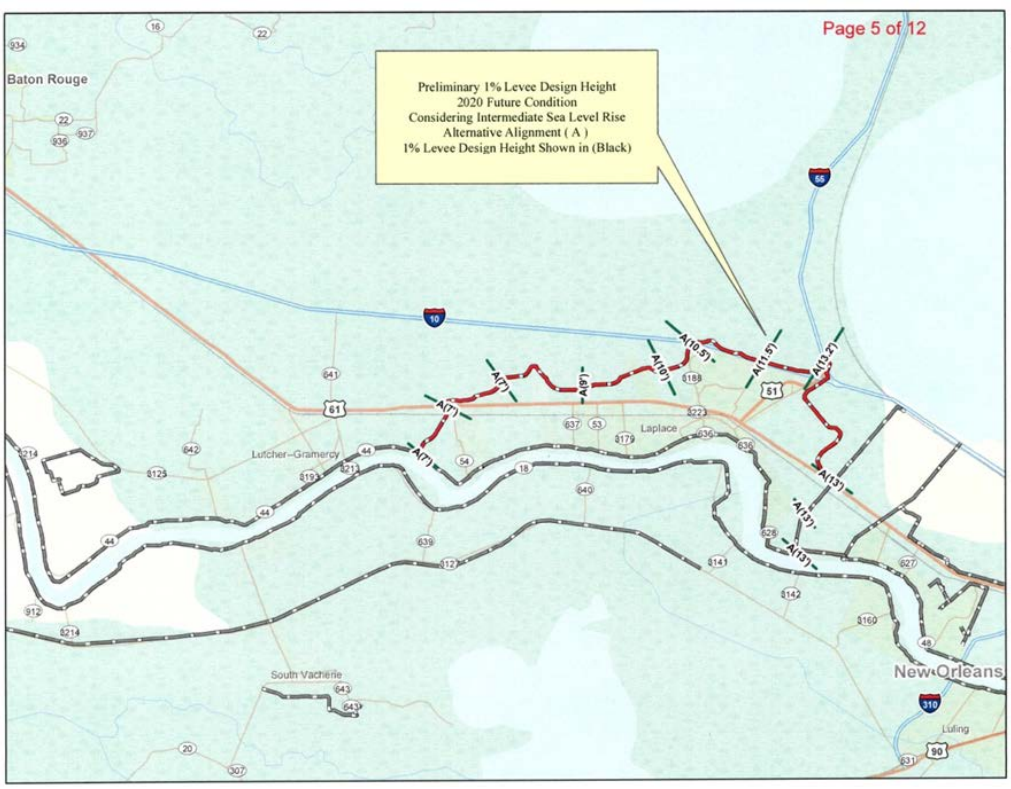

Figure 6: Levee Design Height 2020 Future Condition Alignment A

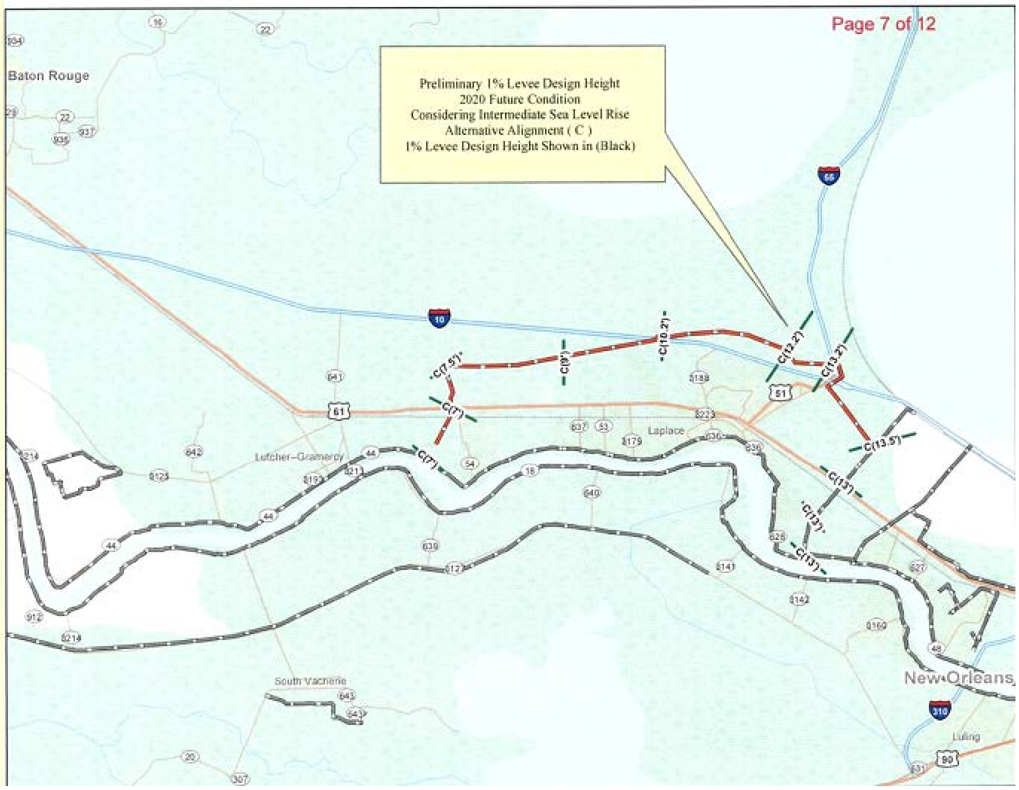

Figure 7: Levee Design Height 2020 Future Condition Alignment C (TSP)

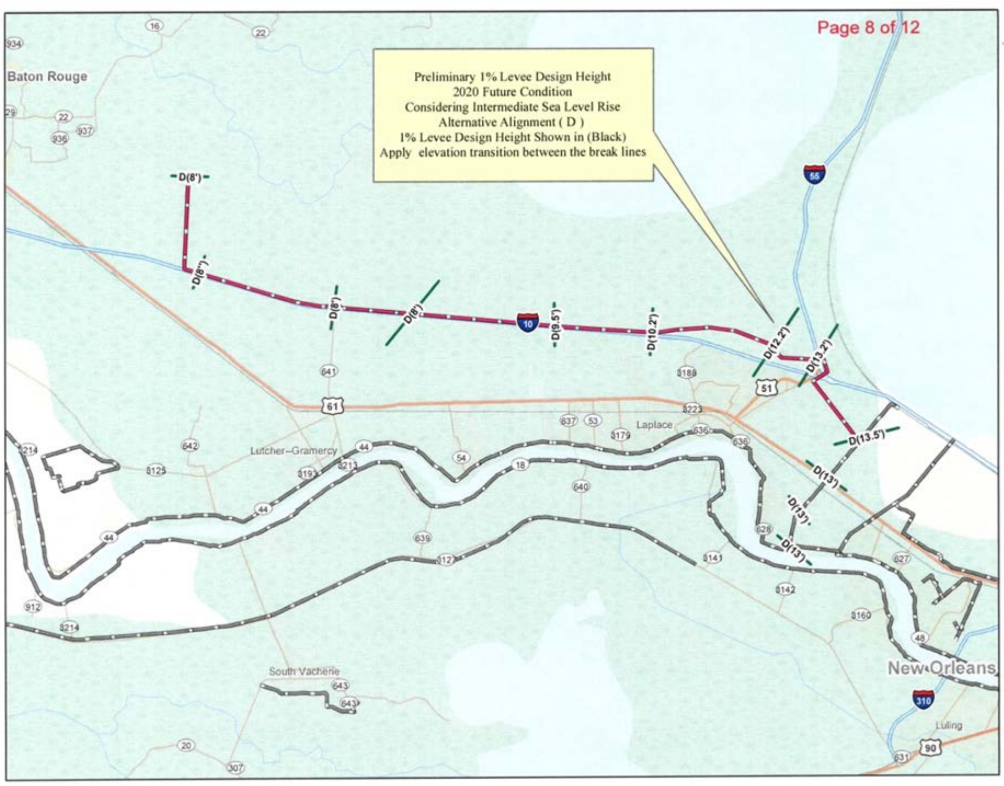

Figure 8: Levee Design Height 2020 Future Condition Alignment D

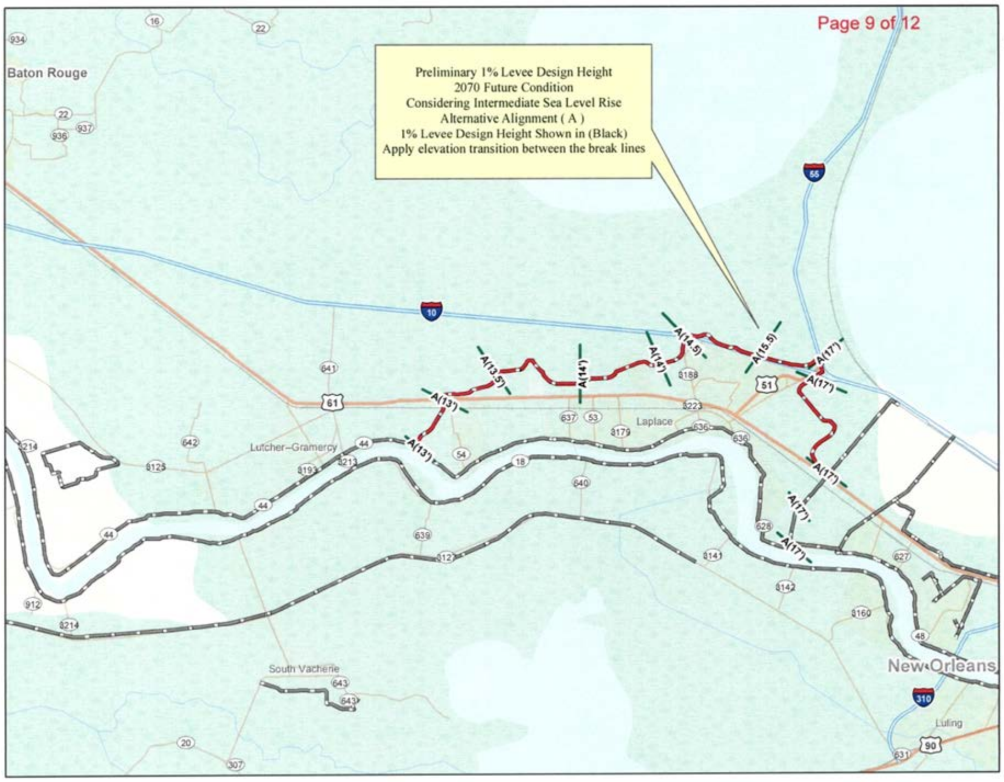

Figure 9: Levee Design Height 2070 Future Condition Alignment A

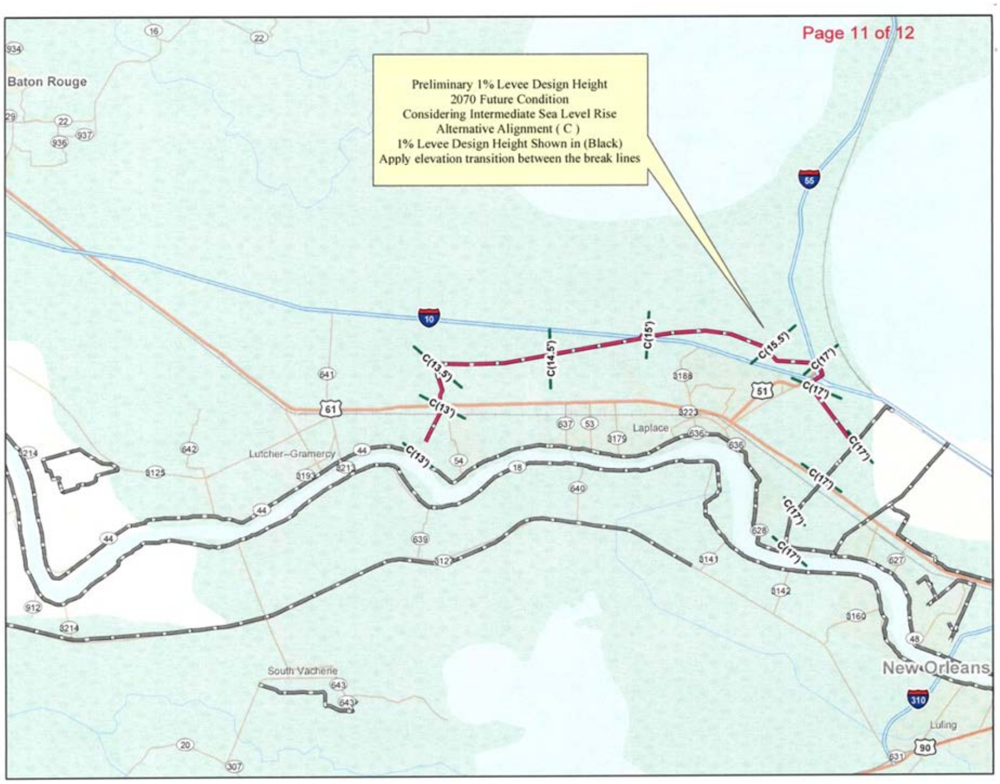

Figure 10: Levee Design Height 2070 Future Condition Alignment C (TSP)

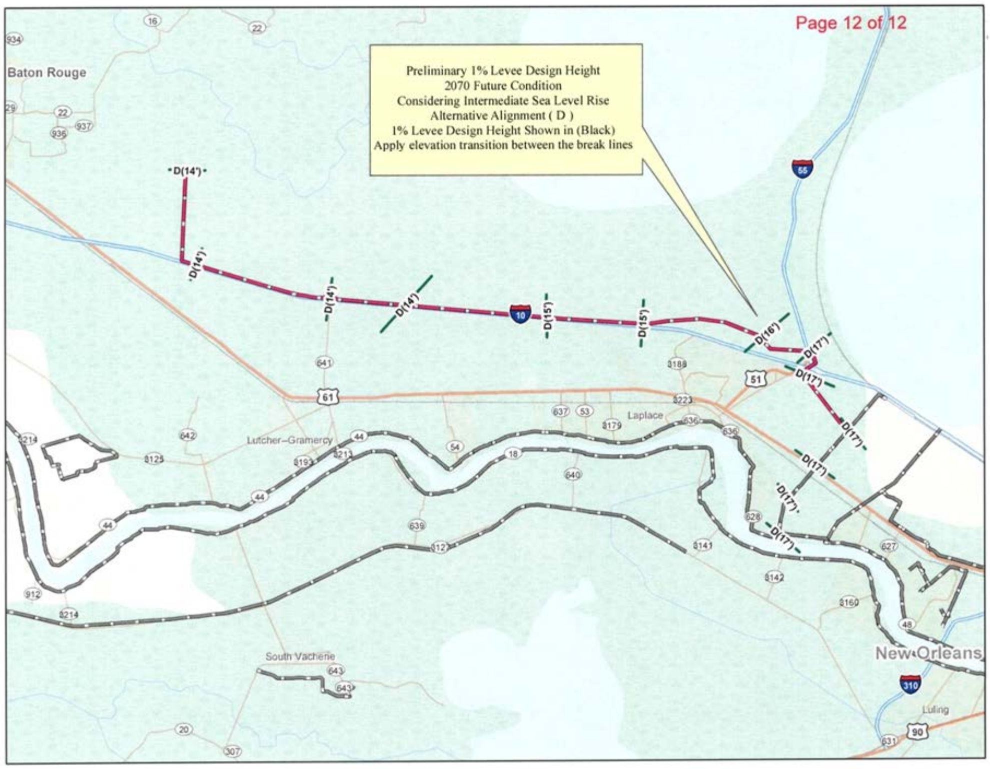

Figure 11: Levee Design Height 2070 Future Condition Alignment D

Additional storm surge modeling (including wave run-up and overtopping) will be performed on Alignment C as the Tentatively Selected Plan (TSP).

Potential Sea Level conditions are represented in the modeling system by application of a relative Sea Level Rise (RSLR) that is consistent with USACE EC 1165-2-211 (2009). Subsidence levels predicted in the study area were incorporated in the ADCIRC initial water level parameter to capture the combined effects of subsidence and local SLR into a single RSLR value. For the 2020 and 2070 simulations, unique RSLR values were added to the 2011 initial water surface elevations (WSE) to determine the initial WSE appropriate for each year and SLR rate. In addition to accounting for RSLR of future conditions, the 2070 scenarios accounted for potential degradation of vegetation in landscapes. SLR changes (as well as salinity intrusion) can cause an associated vegetation degradation and / or loss (this was considered in the ADCIRC modeling). Since these are slow-moving processes, forecasts of 50 years in the future were used, with intermediate RSLR conditions. See Figure 12 for SLR estimates for Years 2011 through 2080.

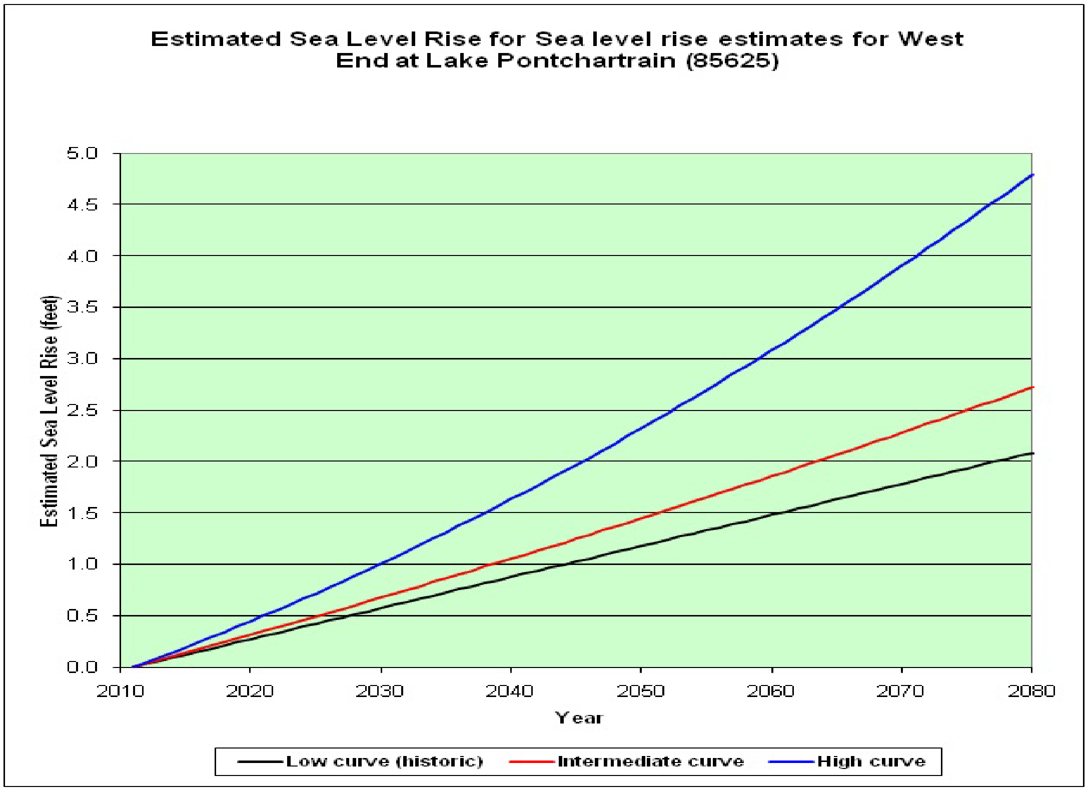

Figure 12: Estimated Sea Level Rise (SLR) for Years 2011 through 2070

Detailed Storm Surge and Wave Analysis (ADCIRC modeling), including SLR assumptions, for the screening level effort (April 2011) is available upon request.

Water Quality

This water resource is significant because of the Clean Water Act, as amended, the Pollution Prevention Act, the Safe Drinking Water Act, and the Water Resources Planning Act, regulations which provide for the protection of U.S. waters for the purposes of drinking, recreation, and wildlife. It also provides for the purposes of restoring and maintaining the chemical, physical, and biological integrity of the Nation's waters. Study area water quality is influenced by basin elevations, surface water budget, land cover and use, coastal and geological processes, and regional weather. The study area is in the southwestern portion of a basin consisting of uplands to the north and estuary to the south, with increasing estuary salinity eastward. The estuary has experienced hydromodification via the construction of canals and embankments. Historical study area water quality is depicted in several references which include the review of data from basin tributaries and estuary lakes and passes. Garrison (1999) provides a statistical summary of general parameters, major ions, nutrients, trace metals, and organic compounds for water quality data collected in Lake Maurepas between 1943 and 1995. Overall, the summary suggests the lake is freshwater, oligotrophic, and does not contain elevated contaminant levels. To determine the most prevalent water quality issues present in the study area, historical Section 305(b) lists were reviewed to determine the most significant causes and sources of subsegment impairment. The most current (2012) 303(d) list for the study area is depicted in Table 2. Ordered by decreasing frequency cited, suspected causes of impairment include non-native aquatic plants, low dissolved oxygen, mercury, elevated turbidity, and fecal coliform, while suspected sources of impairment include wetland habitat modification, introduction of non-native organisms, atmospheric deposition, unknown sources, on-site treatment systems, natural sources, and agriculture.

Table 2: Study Area 2013 303(d) List

Subsegment	Impaired Use for Suspected Cause	Suspected Cause of Impairment	Suspected Source of Impairment	IR Category	TMDL Priority
040401	FWP	Dissolved Oxygen	Wetland Habitat Modification	IRC 5	L
		Mercury	Atmospheric Deposition	IRC 4a	
			Source Unknown	IRC 4a	
		Non-Native Aquatic Plants	Introduction of Non-native Organisms	IRC 4b	
		Turbidity	Wetland Habitat Modification	IRC 4a	
	ONR	Turbidity	Wetland Habitat Modification	IRC 4a	
	PCR	Water Temperature	Natural Sources	IRC 5	L
			Wetland Habitat Modification	IRC 5	L
040403	FWP	Dissolved Oxygen	Agriculture	IRC 5	L
			Wetland Habitat Modification	IRC 5	L
		Mercury	Atmospheric Deposition	IRC 4a	
				IRC 5	L
			Source Unknown	IRC 4a	
				IRC 5	L
		Non-Native Aquatic Plants	Introduction of Non-native Organisms	IRC 4b	
040404	FWP	Dissolved Oxygen	On-site Treatment Systems	IRC 5	L
		Non-Native Aquatic Plants	Introduction of Non-native Organisms	IRC 4b	
	PCR	Fecal Coliform	On-site Treatment Systems	IRC 5	H
040602	FWP	Non-Native Aquatic Plants	Introduction of Non-native Organisms	IRC 4b	

Both historical 305(b) and current 303(d) lists suggest primary study area water quality problems relate to hypoxia. As a further to this suggestion, in 2011 a TMDL report was prepared for the lower Amite River watershed (located just north of subsegments partially included in the study area) to address organic enrichment and low dissolved oxygen. Long-term water quality monitoring in the study area was conducted by the Louisiana Department of Environmental Quality (LDEQ). Water quality trends in the study area based on this water quality assessment would be expected to continue. In particular, low dissolved oxygen conditions in the Maurepas Swamps and increasing marine influence in the northern study area are expected to persist, while the historically most common suspected causes of impairment within the study area would continue to generate water quality problems in competition with management efforts to eliminate impairments. With project water quality is addressed in the EIS.

Climatology

Temperature

Records of temperature are available from "Climatological Data" for Louisiana, published by the National Climatic Data Center. The study areas can be described by using the normal temperature data observed at the Hammond, and Donaldsonville stations. These stations are shown in Table one below with the monthly and annual mean normals which are based on the period of 1991-2011. The average annual mean normal temperature is 59.4^{o}F, with monthly mean temperature normal varying from 81.9^{o}F in July to 48.7^{o}F in December.

Precipitation

Records of precipitation are available from "Climatological Data" for Louisiana, published by the National Climatic Data Center. Two stations in the Louisiana study have been used to show the rainfall data for the areas of Donaldsonville and Ponchatoula/Hammond. Both stations have normal precipitation records which are based on the period of 1991-2011. The average annual normal rainfall of the two stations is 58.14 inches. The wettest normal month is June with a monthly average of 6.48 inches. October is the driest normal month averaging 4.11 inches and Donaldsonville has the greatest day with 24.49 inches of rain falling in June 2001.

Geotechnical

Engineering included the preparation of earthwork stability templates, settlement and lift schedule predictions, preparation of schematic alignment layouts, schematic pump station layouts, and scoping level project cost estimates for the elimination of alternatives to determine a tentatively selected plan. Schematic earthwork templates and settlement and lift schedule predictions were also performed.

The process to complete the scoping level engineering started with the geotechnical evaluation of the different alignments. The geotechnical evaluation consisted of reviewing existing soil boring data, preparation of earthwork stability templates, T-Wall analysis, settlement predictions, additional lifts, and secondary settlement predictions.

Geotechnical data was used to develop soil design parameters for the proposed alignments. At the time of the geotechnical report, four alternative alignments (reduced to three in August 2012) were being considered for the project. These alignments are denoted as Alignments A, C and D. Eighty three borings have been utilized for this screening study, with 23 geologic reaches and eleven soil reaches being developed. The alignments and reaches, as well as the developed soil design parameters, are shown in tabular and graphical form in the Draft Geotechnical Report Appendix I from March 2012 (which is available upon request).

Of the 83 borings furnished, 32 borings are located on Alignment A from its western limit at Hope Canal to its intersection with I-10 west of Highway 3188. These 32 borings comprise Soil Reaches 1 through 5. An additional 17 borings are located on the portion of Alignment A which coincides with I-10 from Highway 3188 to just west of the intersection with I-55 and comprise Soil Reaches 6 and 7. Thus, over half of the available data and selected reaches coincide with Alignment A.

The proposed alignments from the I-55 interchange to the St. Charles Parish line vary among the furnished drawings. For the purposes of this study, Alignment A is referenced as Alignment A in the geologic descriptions and reaches. Alignments C and D should be considered to coincide with Reach A in this area. Soil Reaches 8 through 10 were developed from the 27 borings in this area. However, as noted, these borings may not coincide with any or all of the current alignments.

Two of the available borings were utilized to define Soil Reach 11 at Mississippi Bayou. The remaining three borings were included with Soil Reach 1, but these borings coincide with Alignment C along the western side of the project.

Geotechnical data is not available for the portions of Alignments C and D which did not coincide with Alignment A at the time of this study. It has been projected that anticipated geologies at these locations are based on available data and information.

It should be noted that the geotechnical investigation was limited for this preliminary screening phase and did not include any exploration. The alignment chosen for the tentatively selected plan (TSP), Alignment C, will require additional geotechnical data collection based on USACE's current policies and procedures for completing a feasibility study.

Methodology and Assumptions. The analyses consider the HSDRRS design guidelines dated 23 October 2007, with the geotechnical section as updated on 12 June 2008, although the scope does not include all cases required by this guideline. Required factors of safety and design cases are based on these guidelines. The HSDRRS design guidelines have been updated since issuance of the draft report. The scope of this study only includes an evaluation of Q-case parameters assuming eventual use of S-case parameters will be less restrictive.

Water Levels. Hydraulic design criteria were selected based on GFI in the form of preliminary hydrographic survey maps. The levees were evaluated using the water levels furnished for the future conditions anticipated for the year 2020. To include structural superiority, the floodwall analyses are based on water levels projected for the year 2070.

The scope of this alternative alignment screening level study included stability analyses by Spencer's Method for water at the project grade level (PGL), still water level (SWL) and low water level (LWL) at the levees. The scope did not include consideration of the Top of Levee (TOL), as this was not considered a critical design case for this alternative alignment screening level study. The scope for this study also did not include an evaluation of stability by the Method of Planes (MOP) analyses. Stability analyses for the structures only considered extreme water level (EWL) and SWL.

Stability Analyses. Stability of earthen levees for the 11 soil design reaches were evaluated. Five of these reaches were also evaluated with geotextile reinforcement to reduce the size of the berms. Nine structures (T-walls and gates) were also evaluated.

Levee Stability. The earthen levees generally consist of a 10-ft levee crown with 3 horizontal on 1 vertical (3H:1V) side slopes. Substantial stability berms on the flood side and protected side are required for Soil Reaches 6 through 10. For these reaches, the berms can be reduced with the addition of geotextile reinforcement. A tabular summary of the results along with a plate of the governing stability analysis results are provided in the Draft Geotechnical Report Appendix I from March 2012 (which is available upon request).

Structure Stability. The T-walls and gates are located within Soil Design Reaches 1, 8 and 11. The majority of the cases analyzed indicate the presence of an unbalanced load. A tabular summary of all the results along with a plate of the governing analyses are included in the Draft Geotechnical Report Appendix I from March 2012 (which is available upon request). In addition to stability analyses, estimates of allowable pile load capacity were also computed for each soil reach where structures will be located.

Underseepage Analysis for Levees. With large stability berms required for several levees and considering a predominantly clay foundation, levee underseepage potential is not a significant design concern for most of the design soil reaches. However, Soil Reach 11 identified channel fill that will require either a cutoff, relief wells or seepage berms. Detailed underseepage analyses will be required during final design of the TSP to meet the HSDRRS design guidelines. The final field investigation should consider the estimated locations of abandoned distributaries and channel fill. Additional measures may be required to ensure adequate factors of safety are maintained.

Underseepage Analysis for Structures. Underseepage of pile-supported T-walls was evaluated using the Lane's Weighted Creep Ratio (LWCR) method to establish the tip elevations for the sheet pile cutoff wall. The flow path was assumed only to be the penetration of the sheet pile and horizontal contacts were not assumed. The sheet pile tip embedments are governed by seepage instead of the HSDRRS requirement of 5 feet of penetration below the critical failure plane (for unbalanced load cases).

Settlement Analyses. Settlement analyses were performed for Soil Reaches 1, 4, 6 and 10. An evaluation of the time-rate of consolidation settlement was not conducted; however, estimates for lift construction are available.

In general, settlement parameters for all reaches considered the surficial natural levee deposits and underlying Pleistocene deposits as precompressed. In addition, based on the available data, the swamp deposits were modeled to have an over consolidation ratio (OCR) between 3 and 10 in Soil Reaches 1 and 4 and between 1 and 2 in Soil Reaches 6 and 10. The interdistributary clays were typically modeled as normally consolidated. These values were based on the available boring data and correlations of moisture content to compression ratio (CR) values developed in the region. The parameters generally only consider the stress history at the available boring locations. The stress history at alignments away from the boring data was not assumed.

The higher OCR values in the swamp deposits may only be applicable to previously developed areas in Alignment A. Thus, even in Soil Reach 1, additional lifts may be needed to maintain the levee height in previously undeveloped areas along Hope Canal and along Alignment C. Due to the shallow depth of the Pleistocene interface on the western side of the project, additional fill height would be anticipated to be low. However, moving eastward along the project as the Pleistocene interface increases in depth, the potential for lift construction would increase. Further, it appears current alignments diverge from developed areas east of the I-10/I-55 interchange, increasing this potential even further.

Based on the parameters developed for Soil Reaches 1 and 4, a minimum of 1.5-ft overbuild was assumed in all of the levee stability analyses. The overbuild height for Soil Reach 1 did not require consideration of submergence. Submergence was considered for Soil Reach 4. Settlements greater than 1.5 feet were computed for Soil Reaches 6 and 10 where larger berms and/or greater fill heights would be required. Thus, lift construction will be required for these reaches to maintain the design grade.

The greatest levee height and greatest settlement were computed for Soil Reach 10. This soil reach also has the deepest Pleistocene interface. For Soil Reach 10, an overbuild height of 2.6 feet was computed. It was estimated an additional 3 inches of settlement would occur for this overbuild once the initial levee is fully consolidated. This resulted in a total overbuild of approximately 3 feet. It was determined that only one additional lift thickness be assumed and this lift may be considered as 1.5 feet with an initial overbuild of 1.5 feet. It was also decided that this lift schedule be assumed for Soil Reaches 8, 9 and 10. Based on calculations for Soil Reach 6, it was estimated the overbuild would need to be increased from 1.5 feet to 2.5 feet. Thus, a 1-ft lift thickness beyond the initial 1.5-ft overbuild should be assumed. This lift thickness was applied to Soil Reaches 6 and 7. No lift schedule is deemed necessary for Soil Reaches 1 through 4 and 11 on Alignment A.

The furnished hydraulic data is based on a design year of 2020. The design levee heights were considered to occur from 2012 to 2020. This is a relatively short design period. Therefore, only one construction lift was assumed to be feasible. It was determined that this lift be estimated to occur halfway through the design period or four years into the eight-year design. Given the limited data for this screening study, only assumed time-rate of settlement parameters could be developed. However, even these assumptions would not address the stress history and time-rate away from the boring locations. For alignments within previously undeveloped areas, an additional lift or increased lift thickness may be required.

Additional detailed geotechnical data and analyses (including updated information from May 2013) is available upon request.

Datum and Topography

The furnished soil borings and the soil parameter plots are referenced to NGVD. These elevations were reduced by 1 foot for conversion to the NAVD88 datum. Water levels were provided in NAVD88. All the analyses for this feasibility report reflect the NAVD88 datum. Topographic survey data was not obtained for the alternative alignments. Review of available Lidar data indicated average grade at Elevation 1.0 NAVD88 should be used for the analyses of the levees. While the ground elevation varies along the length of each alignment, the assumed ground elevation of 1.0 NAVD88 was appropriate for the majority of the alignment and conservative for the areas of higher ground elevation. With the exception of furnished gate elevations, average grade at Elevation 1.0 was also used for the typical T-wall analyses.

Civil/Structural Design

Three alternatives were evaluated for scoping level engineering: Alignment A, Alignment C and Alignment D. Prior to the scoping level engineering, the alignments consisted of non-dimensional generalized locations on large scale mapping. The purpose of the scoping level engineering was to refine the generalized alignment locations into levee cross sections coordinated with existing topography features (streams, channels, wetlands, etc.) and existing infrastructure (highways, pipelines, utilities, etc.).

After the levee templates were completed, it was decided to apply the design templates to Alignments A, C and D.

A set of standard details was prepared to provide a schematic elevation view of the typical pump station T-Wall, Interstate T-Wall, Roadway/Railroad Floodgate T-Wall and Pipeline T-Wall. These typical elevations included clearance recommendations from the geotechnical engineers to ensure the new construction would not adversely impact existing infrastructure. Drawings showing the typical elevations are available upon request.

The pump station flow rates and gravity drainage gate sizes were computed. These pump station flow rates and gravity drainage gate sizes were based upon hydrologic units defined in the existing SWMM model. If multiple drainage outfalls existed in the hydrologic unit, the projected pump station flows and gravity drainage gate sizes were divided based upon the percentage of the outfall's contributory area in the delineated hydrologic unit. The pump stations were grouped into twelve types based upon the pump and gate sizes. Typical Floor Plans were developed for each pump station type. These typical floor plans and a typical elevation through the station are available upon request.

A "smoothed" version of **Alignment A** (Figure 1) was used in order to minimize the encapsulation of wetlands in the protection system. Alignment A begins at the Upper Guide Levee of the Bonnet Carre' Spillway and travels westerly parallel to an existing pipeline corridor, around the Interstate 10/Interstate 55/US Highway 51 interchange, then follows Interstate 10 to the LA 3188 (Belle Terre Boulevard) interchange, then southerly and westerly paralleling the wetland wet/dry line to Mt. Airy where it terminates at the Mississippi River levee. The "smoothed" alignment was placed on the DOQQ base map and adjusted in a few minor locations. These locations included the Interstate 10 crossing east of the LaPlace interchange, the Interstate 55 crossing north of the US Highway 51 entrance ramp, the Interstate 10 crossing west of the Belle Terre interchange, and the existing water tower adjacent to the Belle Terre interchange. The modifications at the Interstate crossings were performed to cross the elevated structures with a ninety degree crossing that will ultimately be passed between existing bridge bents with a T-Wall. The Interstate 55 crossing was moved north to include the entrance/exit ramps from US Highway 55 and provide access for evacuation and recovery.

The top of levee elevation (net elevation) for this alignment is El. 13.5 NAVD88 (based on providing 100-Year protection in the Baseline Year of 2020), then decreases to El. 13.2 NAVD88 (at approx. Baseline Station 421+00), then decreases to El. 11.5 NAVD88 (at approx. Baseline Station 552+00), then decreases to El. 10.5 NAVD88 (at approx. Baseline Station 614+00), then decreases to El. 10.0 NAVD88 (at approx. Baseline Station 700+00), then decreases to El. 9.0 NAVD88 (at approx. Baseline Station 821+00) and finally decreases to El. 7.0 NAVD88 (at approx. Baseline Station 1013+00). The levee design, which involves the placement (in 2 lifts, 5 years apart) of approx. 3.1 million cubic yards of compacted and uncompacted clay fill, on top of 3.7 million square yards of geotextile fabric (with a 70-ft. width) along with a 100-ft. base width, 3:1 side slopes and 10-ft. crown width, creates a footprint of 411 acres. An aggregate limestone road (6 ft. wide x 8 in. thick) sits on top of the levee crown, a total of 29,615 cubic yards.

The design levee templates were placed along the proposed Alignment A at the defined soil and hydraulic reaches and based upon the recommended offsets for future maintenance activities, impacts to existing pile supported structures, offsets for stability from potential excavations (pipeline rights-of-way) and existing drainage features. Special attention was made to locate the right-of-way limits for the proposed levee sections to coincide with the existing rights-of-way from highways, pipelines etc. to avoid remainder parcels that were nonfunctional to the original owner. After the earthen embankments were placed on the base map and transitions performed from template section to template section, Alignment A was evaluated for specialty locations such as pump stations, T-Walls, gates, ramps, and pipeline crossings. The typical elevation details described above were utilized at appropriate locations and widths adjusted based upon the pump station size, Interstate crossing width, roadway/railway width, number of pipelines, etc. Alignment A was approximately 107,800 feet (20.41 miles) long and included 4,774 feet of T-Wall, 240 feet of drainage gates, 1,218 feet of roadway gates, two railway gates, seventy pipeline crossings, and eight pump stations. Schematic plans and typical levee sections (first and second lifts) were developed for Alignment A with levee template section, pump station, gate, T-Wall and pipeline crossings annotated. These schematic plans and typical levee sections are available upon request.

Alignment C (the TSP) begins at the Upper Guide Levee of the Bonnet Carre' Spillway and travels westerly parallel to an existing pipeline corridor, around the Interstate 10/Interstate 55/US Highway 51 interchange, then follows the existing pipeline corridor to Interstate 10/LA 3188 (Belle Terre Boulevard) interchange, then southerly and westerly paralleling the existing pipeline corridor to Mt. Airy where it terminates at the Mississippi River levee. Alignment C was developed to minimize the number of pipeline crossings.

The top of levee elevation (net elevation) for this alignment is El. 13.5 NAVD88 (based on providing 100-Year protection in the Baseline Year of 2020), then decreases to El. 13.2 NAVD88 (at approx. Baseline Station 304+00), then decreases to El. 12.2 NAVD88 (at approx. Baseline Station 354+00), then decreases to El. 10.2 NAVD88 (at approx. Baseline Station 612+00), then decreases to El. 9.0 NAVD88 (at approx. Baseline Station 722+00), then decreases to El. 7.5 NAVD88 (at approx. Baseline Station 905+00) and finally decreases to El. 7.0 NAVD88 (at approx. Baseline Station 968+00). The levee design, which involves the placement (in 2 lifts, 5 years apart) of approx. 3.1 million cubic yards of compacted and uncompacted clay fill, on top of 3.4 million square yards of geotextile fabric (with a 70-ft. width) along with a 100-ft. base width, 3:1 side slopes and 10-ft. crown width, creates a footprint of 856 acres. An aggregate limestone road (6 ft. wide x 8 in. thick) sits on top of the levee crown, a total of 26,124 cubic yards. A conveyance canal is situated along the entire levee (with a bottom depth elevation of El.-10 ft. NAVD88).

The design levee templates were placed along the proposed Alignment C at the defined soil and hydraulic reaches and based upon the recommended offsets for future maintenance activities, impacts to existing pile supported structures, offsets for stability from potential excavations (pipeline rights-of-way) and existing drainage features similar to Alignment A. There was a section of Alignment C from the Interstate 10/LA 3188 (Belle Terre Boulevard) interchange to the Mt. Airy community where there were no soil boring data and design levee templates were not developed. The other alignment's design levee templates that were in the closest proximity of the required hydraulic reach defined were used. Special attention was made to locate the right-of-way limits for the proposed levee sections to coincide with the existing rights-of-way from highways, pipelines etc. to avoid remainder parcels that were nonfunctional to the original owner. Once all the required design levee templates were selected for the hydraulic reaches, the levee sections were transitioned together similar to Alignment A. Alignment C was evaluated for specialty locations such as pump stations, T-Walls, gates, ramps and pipeline crossings.

Alignment C was approximately 96,500 feet (18.27 miles) long and included 5,304 feet of T-Wall, 2080 feet of drainage gates, 288 feet of roadway gates, two railway gates, thirty-six pipeline crossings, and four pump stations. Schematic plans and typical levee sections (first and second lifts) were developed for Alignment C with levee template section, pump station, gate, T-Wall and pipeline crossings annotated. These schematic plans and typical levee sections are available upon request.

Alignment D begins at the Upper Guide Levee of the Bonnet Carre' Spillway and travels westerly parallel to an existing pipeline corridor, around the Interstate 10/Interstate 55/US Highway 51 interchange, then follows the existing pipeline corridor to Interstate 10/LA 3188 (Belle Terre Boulevard) interchange, then westerly paralleling the Interstate 10 right-of-way approximately to the St James/Ascension Parish line, then turns northerly through the McElroy Swamp to the New River Canal, then westerly to the Marvin Braud Pump Station levee. Alignment D was developed to provide flood protection to the maximum number of communities in St Charles, St. John the Baptist, St. James, and Ascension Parishes and protect the Interstate 10 corridor. Alignment D also minimizes the number of pipeline crossings.

The top of levee elevation (net elevation) for this alignment is El. 13.5 NAVD88 (based on providing 100-Year protection in the Baseline Year of 2020), then decreases to El. 13.2 NAVD88 (at approx. Baseline Station 305+00), then decreases to El. 12.2 NAVD88 (at approx. Baseline Station 354+00), then decreases to El. 10.2 NAVD88 (at approx. Baseline Station 600+00), then decreases to El. 9.5 NAVD88 (at approx. Baseline Station 750+00) and finally decreases to El. 8.0 NAVD88 (at approx. Baseline Station 940+00). The levee design, which involves the placement (in 2 lifts, 5 years apart) of approx. 3.8 million cubic yards of compacted and uncompacted clay fill, on top of 3.1 million square yards of geotextile fabric (with a 70-ft. width) along with a 100-ft. base width, 3:1 side slopes and 10-ft. crown width, creates a footprint of 1,181 acres. An aggregate limestone road (6 ft. wide x 8 in. thick) sits on top of the levee crown, a total of 36,880 cubic yards. A conveyance canal is situated along the entire levee (with a bottom depth elevation of El.-10 ft. NAVD88).

The design levee templates were placed along the proposed Alignment D at the defined soil and hydraulic reaches and based upon the recommended offsets for future maintenance activities, impacts to existing pile supported structures, offsets for stability from potential excavations (pipeline rights-of-way) and existing drainage features similar to Alignments A and C. There was a section of Alignment D from the Interstate 10/Hope Canal crossing to the Marvin Braud levee where there were no soil boring data and design levee templates were not developed. The other alignment's design levee templates that were in the closest proximity of the required hydraulic reach defined were used. Special attention was made to locate the right-of-way limits for the proposed levee sections to coincide with the existing rights-of-way from highways, pipelines, etc. to avoid remainder parcels that were nonfunctional to the original owner. Once all of the required design levee templates were selected for the hydraulic reaches, the levee sections were transitioned together similar to Alignments A and C. Alignment D was evaluated for specialty locations such as pump stations, T-Walls, gates, ramps and pipeline crossings.

Alignment D was approximately 149,300 feet (28.28 miles) long and included 4,011 feet of T-Wall, 396 feet of drainage gates, 306 feet of roadway gates, no railway gates, fourteen pipeline crossings, and six pump stations. Schematic plans and typical levee sections (first and second lifts) were developed for Alignment D with levee template section, pump station, gate, T-Wall, and pipeline crossings annotated. These schematic plans and typical levee sections are available upon request.

Quantities. Quantities were computed for clearing and grubbing, geotextile, earthwork, aggregate roadway, turf establishment, T-Walls, drainage gates, roadway gates, railroad gates, pump stations and pipeline relocations.

Clearing and grubbing was based upon the proposed levee right-of-way limits denoted on the typical levee sections for the length of the reach and converted to acres. Geotextile was based upon the proposed width denoted on the typical levee sections for the length of the reach and converted to square yards. Earthwork was computed by end area denoted on the typical levee sections for the length of the reach. To determine the end area for each typical levee section, the average groundline elevation along the alignment centerline was computed. LIDAR data from the Louisiana State University Atlas Database was loaded into ArcGIS and the EZProfiler extension was used to obtain x, y, z, coordinates in Louisiana State Plane Coordinate System. The EZProfiler parameters were set to obtain coordinates and elevations every 45 feet along the alignment since the LIDAR data had 15 feet by 15 feet pixels. The EZProfiler dumped the coordinate and elevation data into an Excel spread, where the groundline elevation was averaged. The average groundline elevation was included in the levee typical section and the end areas were computed for each individual reach. After the end areas were computed, the length of the earthen levee segments were multiplied by the end area and ten by a 1.25 consolidation factor before converting into cubic yards. The 1.25 consolidation factor was used to account for consolidation and compaction of underlying existing soils as the new earthwork lifts are performed. Turf establishment quantities were set equal to the clearing and grubbing limits and converted to acres. Aggregate road surfacing was computed from the levee segment length and a section 6 feet wide and 8 inch deep then converted to cubic yards. T-Walls, Drainage Gates, and Roadway Gates were tabulated by length and incremental wall heights. An incremental wall height of 5 feet was set as the criteria. Railroad gates were measured per each. Pipeline relocations were measured per each and the incremental pipeline size. Incremental pipeline sizes were set at less than or equal to 6 inches, greater than 6 inches up to 12 inches, greater than 12 inches up to 18 inches, greater than 18 inches up to 24 inches and greater than 24 inches. All quantities for Alignments A, C and D were computed in the same manner.

Relocations

An ArcGIS State of La. Oil Spill Response Database was used to identify the pipeline locations for each alignment. This database contained not only the shapefiles of the pipelines but in most instances the owner, size, type and the carried material. This data was used for each of the three alignments. The assumption for each alignment was that a pipeline floodwall would be required wherever a pipeline crossed the levee footprint. The pipeline would cross through the pipeline floodwall. It was decided that the existing carrier line would remain in operation while a bypass line would be constructed through a sleeve in the T-wall cutoff piles. When the bypass would be complete and in place, the switch over-tie in with the existing line then would follow. A unit cost for the different pipe size ranges was used (unit costs were furnished by USACE). See below.

Pipeline Relocations

Description	Estimated Quantity (Q)	Units	Unit Cost (UC)
≤6" Diameter	14	Each	$515,000
>6" to ≤12" Diameter	16	Each	$700,000
>18" to ≤24" Diameter	5	Each	$1,550,000
> 24" Diameter	1	Each	$1,920,000

Detailed information (including identification of pipeline owners, sizes and product carried through the line) is available upon request.

Cost Estimates

After each alignment's quantities were finalized, cost estimates were prepared for each alignment. For each item, the item description, item quantity, unit of measure, unit cost, item cost, contingency and total item cost was tabulated in an Excel spreadsheet; the same information was later prepared in MII MCACES format. Since the unit of measure for the pump stations was set by the cubic feet per second (cfs) flow rate of each type of pump station, separate quantities and costs were computed for each type of pump station. Separate tabs for each pump station were created in the Excel spreadsheet (and subsequently shown in the MII MCACES format for each alignment). The cost for each pump station was divided by the flow rate to determine the unit cost. All cost estimates for Alignments A, C and D were computed in the same manner. See Table 2 below for Estimated Cost Summary of each alignment.

Table 3: Estimated Total Cost (For Each Alignment)

Item	Alignment A	Alignment C (TSP)	Alignment D
Levees & Floodwalls	$335,898,670	$334,156,997	$339,508,346
Pump Stations	$132,162,500	$112,687,500	$166,437,500
Pipeline Relocations	$70,300,000	$35,100,000	$11,693,750
Real Estate	$3,849,000	$3,283,000	$2,434,000
Direct Habitat Impacts	$17,000,791	$35,710,811	$43,323,364
Indirect Mitigation Costs (15%)	$23,123,679	$54,655,968	$327,687,626
Non-Structural Measures (Year 2070)	$305,256,794	$305,256,794	$0
TOTAL COST (Including Non-Structural Measures)	**$887,591,434**	**$880,851,070**	**$891,084,586**

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