

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

**PLAN FORMULATION
APPENDIX E**

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INTRODUCTION

This appendix provides supplemental plan formulation information on the West Shore Lake Pontchartrain, Louisiana Hurricane and Storm Damage Risk Reduction Feasibility study. It supplements the information in Chapter 3 of the main report and includes tables and maps used in the development, screening, and evaluation of management measures and alternative plans.

Per the study authority, as identified in Chapter 1, the study area includes portions of St. Charles, St. John the Baptist, and St. James Parishes. It is bounded on the east by the Bonnet Carré Spillway upper guide levee, on the north by Lakes Pontchartrain and Maurepas, on the west by the Ascension/St. James Parish line, and on the south by the Mississippi River Levee (**Figure 1**).

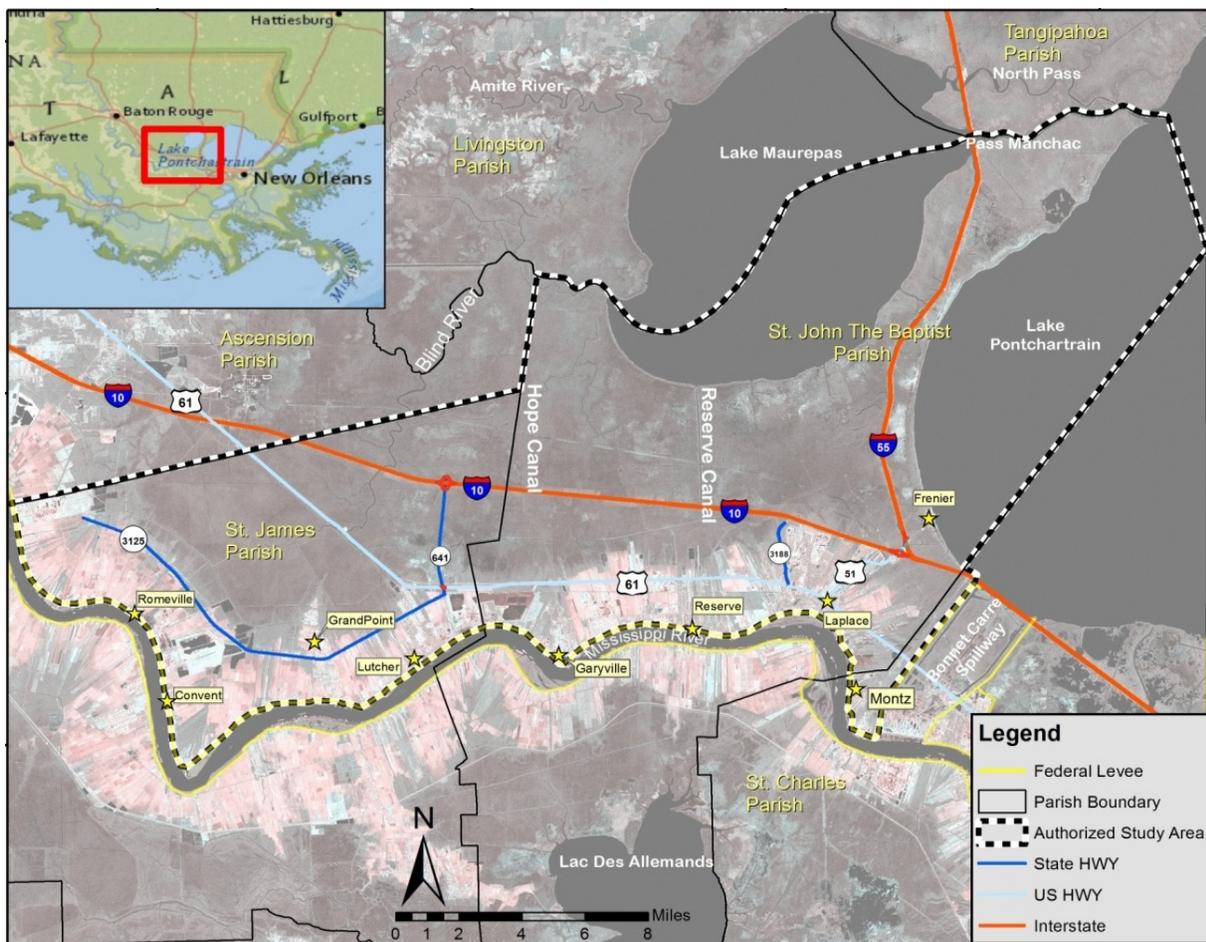


Figure 1: Study Area

The study goals, objectives and constraints are identified in Chapters 1 and 3 of the draft report. They are included as a point of reference for understanding details of the screening process (**Table 1**).

Table 1: Objectives and Constraints

OBJECTIVES	CONSTRAINTS
1. Reduce hurricane storm surge related damages through 2070.	1. Minimize impacts to wetlands.
2. Reduce risk to residents’ life and health by decreasing flooding to the maximum extent practical.	2. Minimize impacts to the Small Diversion at Convent/Blind River project and River Reintroduction into Maurepas Swamp Project.
3. Increase public awareness of hurricane risks in developed flood prone areas.	3. No loss of flood protection from existing flood damage risk reduction projects.
4. Enhance public awareness of the risk to life and property of development in flood prone areas.	4. Minimize impacts to the Maurepas Swamp Wildlife Management Area and surrounding wetlands.
5. Reduce the risk of damage and loss of critical infrastructure, specifically the I-10/I-55 hurricane evacuation routes.	5. Minimize infrastructure impacts (pipelines, highways, hospitals, schools, fire stations, and police stations).

MANAGEMENT MEASURES

Measures considered for this study are outlined in **Chapter 3, Section 3.3**. This section provides additional information about those measures that were evaluated and removed from further consideration during the planning process. As discussed in Chapter 3, these measures were screened and evaluated based on their ability to meet the planning objectives while avoiding the study constraints (see **Table 1**). Additional criteria of effectiveness and efficiency were used.

Cypress Reforestation: This measure would enhance and/or restore cypress forest on the Maurepas Landbridge and in the Maurepas Swamp to reduce surge heights. The measure did not meet objectives to reduce the risk of damages to structures and to residents’ life and health. Structures would still be damaged from the increased still water levels during storms. Consequently, the measure was screened because it was ineffective. **Figure 2** demonstrates the storm surge flow through cypress vegetation.

Seawall: This measure would construct a seawall along the rim of Lakes Maurepas and Pontchartrain. This measure would have adverse impacts to the existing environmental systems and drainage system. This measure would enclose the Maurepas Swamp and would stop water exchanges between Lake Maurepas and the swamp (see **Figure 3**). The mitigation features for this measure would be cost prohibitive. The measure was screened because it was not cost effective.

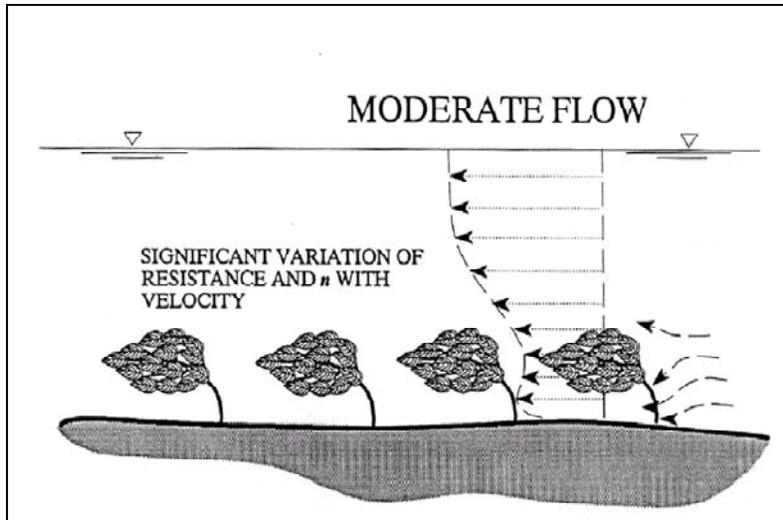


Figure 2: Storm Surge through Vegetation



Figure 3: Seawall Measure

Flood Forecast and Warning: The area has an ample Forecast/Warning System. NOAA, FEMA, and the USACE already take the responsibility for producing the storm surge maps under existing floodplain management authorization.

Floodgates on Tidal Passes: This measure would place a large tide control structure on Pass Manchac, and potentially North Pass, to prevent storm surge from entering the area. It would have adverse impacts to the

environment and drainage system. A control structure would restrict tidal flows under normal conditions and limit the upper basin's ability to drain during storms. The mitigation features would be cost prohibitive (inefficient). Additionally, it would be ineffective due to surge flanking.

Highway/Levee: This measure would raise the I-10 roadbed to serve as a levee to reduce risk of surge damage. Using the roadbed as a levee system would require massive changes to the existing highway system. In addition, future levee lifts would require the highway to be replaced at each event.

Control Structures (Canals and Bayous): Control structures were evaluated as both a stand-alone measure and in combination with other measures. It was removed as a standalone measure because at higher storm surge events, surge heights are higher than the existing banks, making a canal closure alone ineffective (see **Figure 4 and 5**). However portions of the feature were carried forward in combination with other measures.



Figure 4: Canal Drainage Patterns

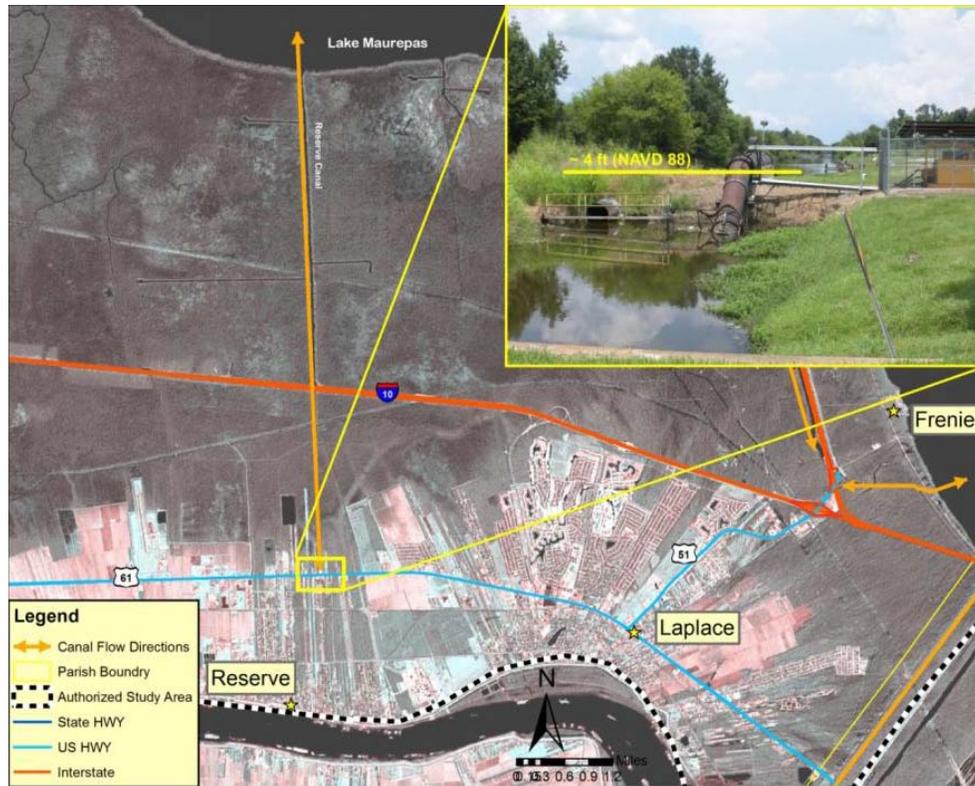


Figure 5: Reserve Canal Cross Section View

INITIAL ARRAY OF ALTERNATIVE PLANS

As discussed in **section 3.4** of the Final Report, structural plans developed from earlier study efforts were incorporated into the plan formulation process as documented in this report. Structural alternative plans typically included an earthen levee with control structures which extend from the west guide levee of the Bonnet Carré Spillway in St. Charles Parish to various points west in the area. **Table 2** outlines the structural plans considered in this study and **Figures 6 through 17** maps the alignments.

Table 2: Initial Array of Structural Plans

Condensed Plan ID	Linkages to Past WSLP efforts
Plan 1: Spillway to Reserve Canal	1987 Reconnaissance Report: Alignment #2 1997 Reconnaissance Report: Alignment 2 1998 Scoping Report: Alignment #2
Plan 2: Spillway to East St. John High School (ESJHS)	1985 Initial Evaluation Report: Alignment #2 1997 Reconnaissance Report: Alignment 1 1998 Scoping Report: Alignment # 1
Plan 3: Spillway to ESJHS (wetland/non-wetland)	1997 Reconnaissance Report: Alignment # 5 1998 Scoping Report: Alignment # 3
Plan 4: Spillway to ESJHS (I-10 Offset)	1997 Reconnaissance Report: Alignment # 5 1998 Scoping Report: Alignment # 1

Plan 5: Spillway to Marathon	1997 Reconnaissance Report: Alignment 2 1998 Scoping Report: Alignment #2 2006 Evaluation of Draft FS Report : USACE Plan A 2007 Screening Assessment: Alignment A
Plan 6: Spillway to Reserve (US-51 Protection)	1985 Initial Evaluation Report: Alignment #4 1997 Reconnaissance Report: Alignment 1A/B 1998 Scoping Report: Alignment # 1
Plan 7: Spillway to Marathon (wetland/non-wetland)	1997 Reconnaissance Report: Alignment 1A/B 1998 Scoping Report: Alignment # 1 2006 Evaluation of Draft FS Report : USACE Plan A 2007 Screening Assessment: Alignment A
Plan 8: Spillway to Ascension Parish/MS River	1985 Initial Evaluation Report: Alignment #3 1997 Reconnaissance Report: Alignment 2A/B 2007 Screening Assessment: Alignment D
Plan 9: Spillway to Hope Canal/MS River	1997 Reconnaissance Report: Alignment # 5 2006 Evaluation of Draft FS Report : USACE Plan A 2007 Screening Assessment: Alignment A
Plan 10: Spillway to Hope Canal/MS River (I-10 Protection)	1985 Initial Evaluation Report: Alignment #3 2006 Evaluation of Draft FS Report : St. John Plan B 2007 Screening Assessment: Alignment B
Plan 11: Spillway to Hope Canal/MS River (Pipeline Avoidance)	1985 Initial Evaluation Report: Alignment #1 1987 Reconnaissance Report: Alignment #1 2006 Evaluation of Draft FS Report : St. John Revised 2007 Screening Assessment: Alignment C
Plan 12: Spillway to Ascension Parish (I-10 Protection)	1985 Initial Evaluation Report: Alignment #3 2007 Screening Assessment: Alignment D

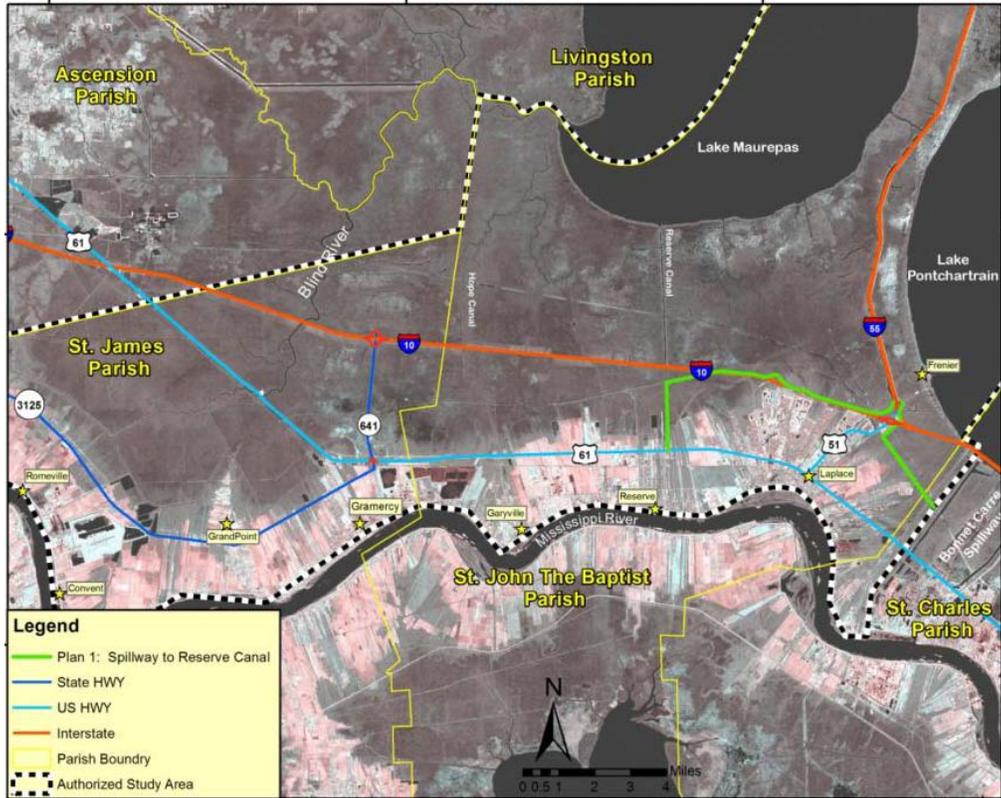


Figure 6: Plan 1 - Bonne Carré Spillway to Reserve Canal

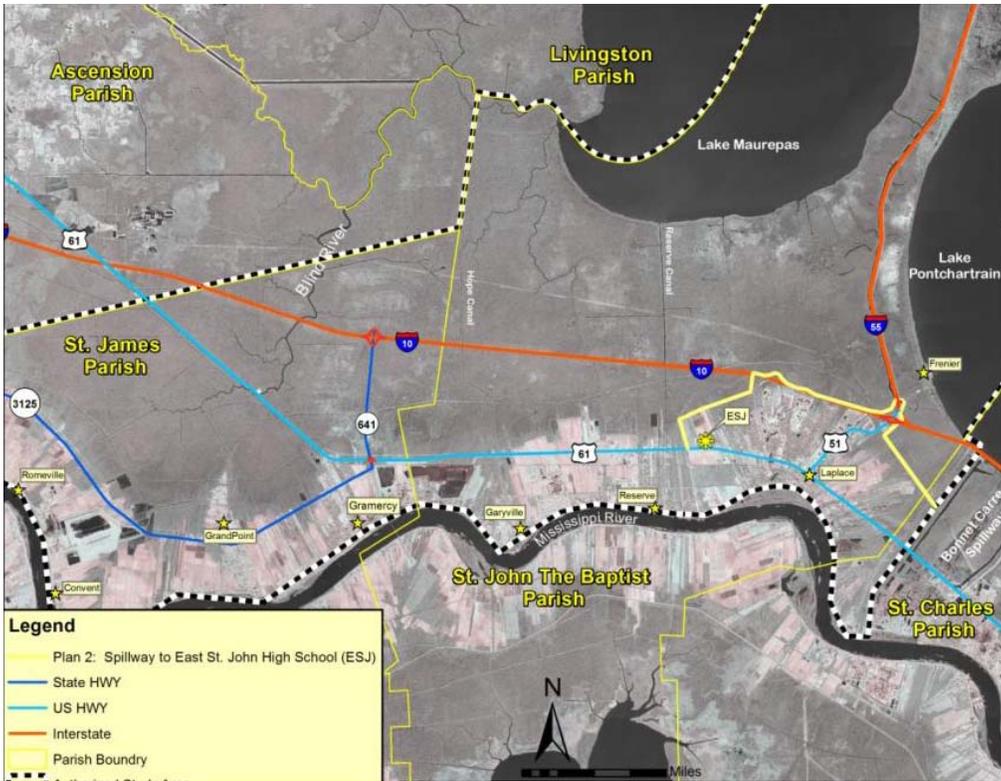


Figure 7: Plan 2 - Bonnet Carré Spillway to ESJHS

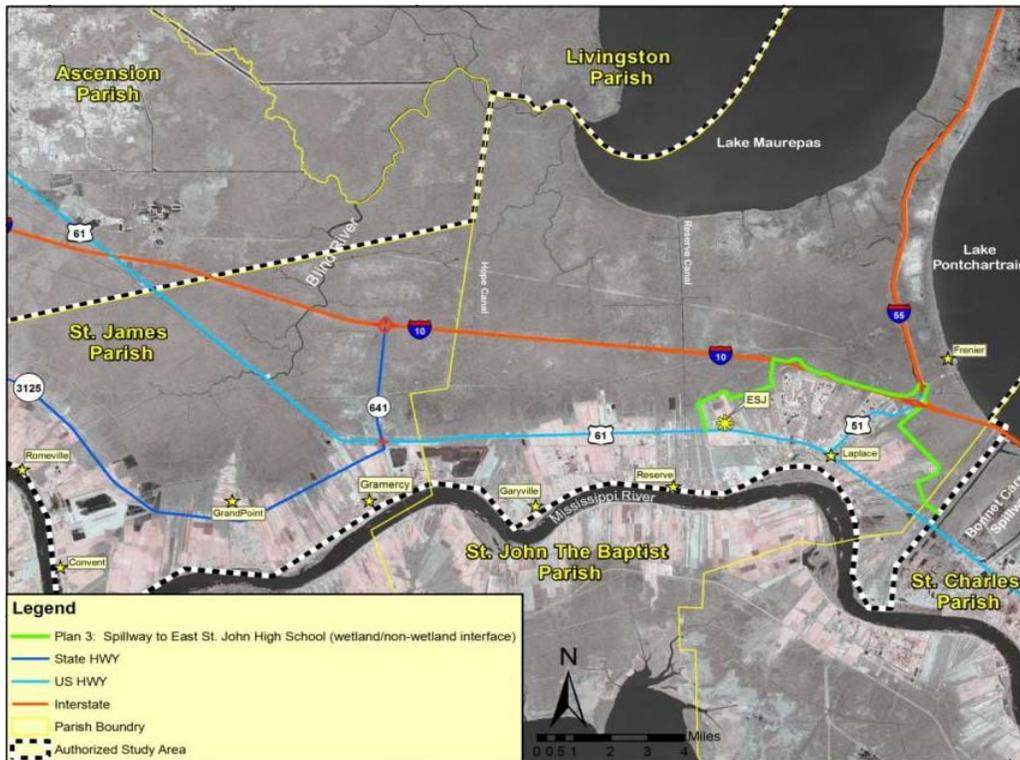


Figure 8: Plan 3 - Bonnet Carré Spillway to ESJHS (wetland interface)

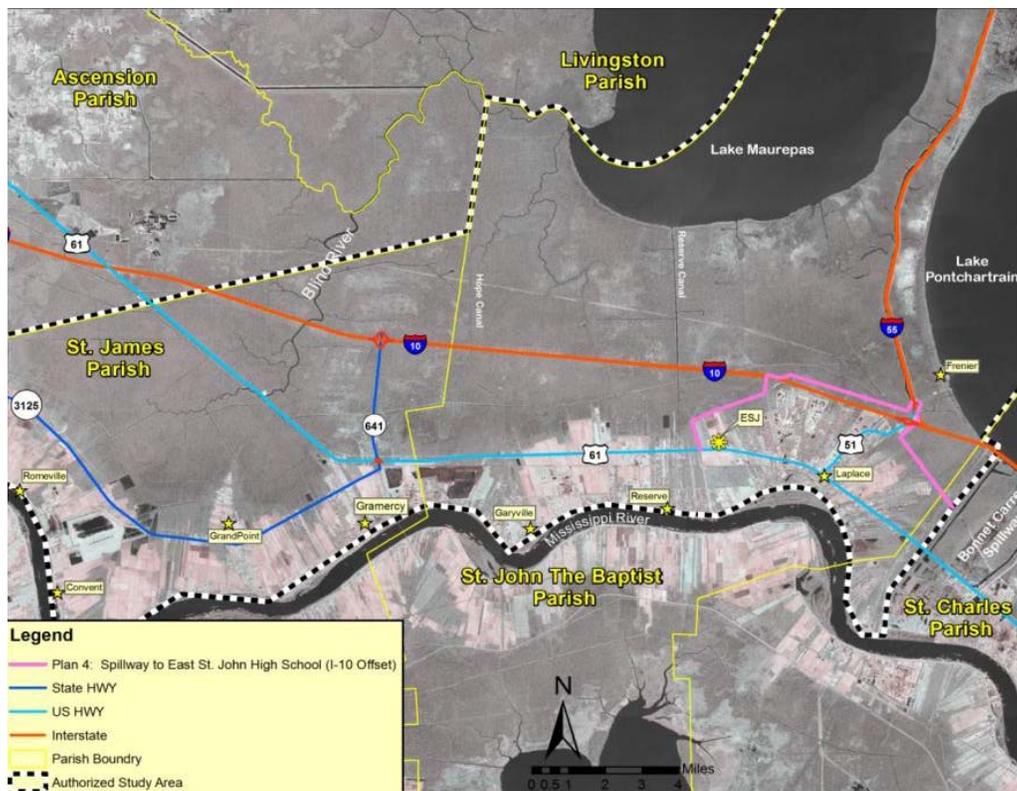


Figure 9: Plan 4 - Bonnet Carré Spillway to ESJHS (I-10 Offset)



Figure 10: Plan 5 - Bonnet Carré Spillway to Spillway to Marathon

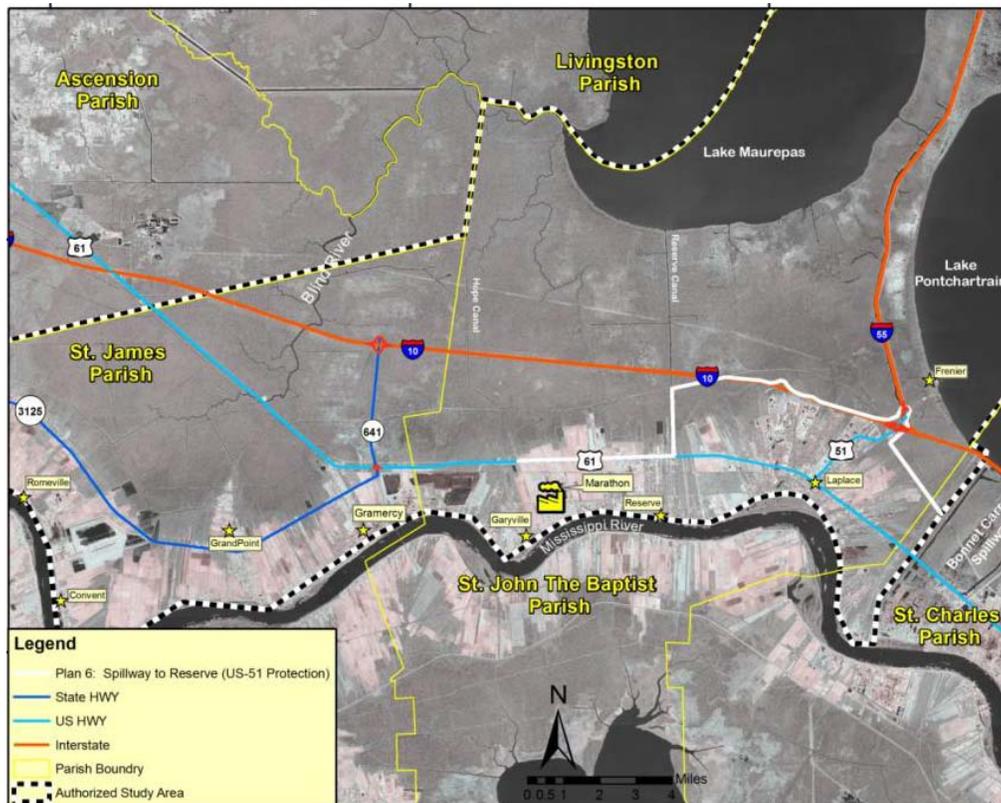


Figure 11: Plan 6 - Bonnet Carré Spillway to Reserve (US-51 Risk Reduction)



Figure 12: Plan 7 - Bonnet Carré Spillway to Marathon (wetland interface)

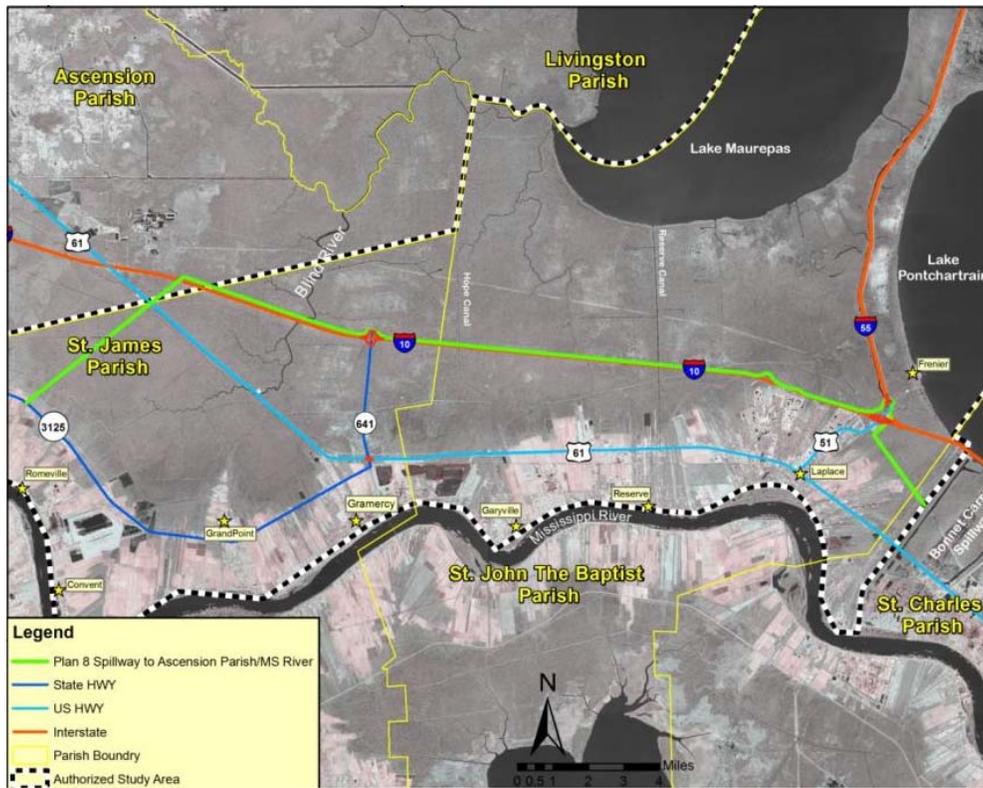


Figure 13: Plan 8 - Bonnet Carré Spillway to Ascension Parish/Mississippi River

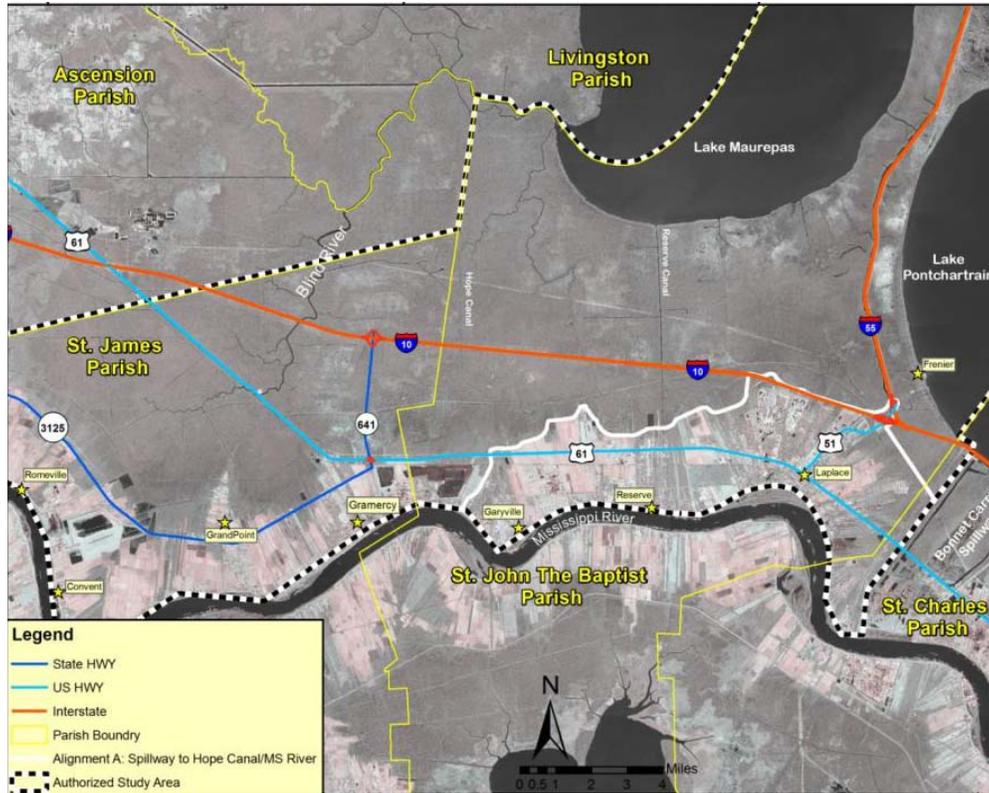


Figure 14: Plan 9 - Bonnet Carré Spillway to Hope Canal/Mississippi River

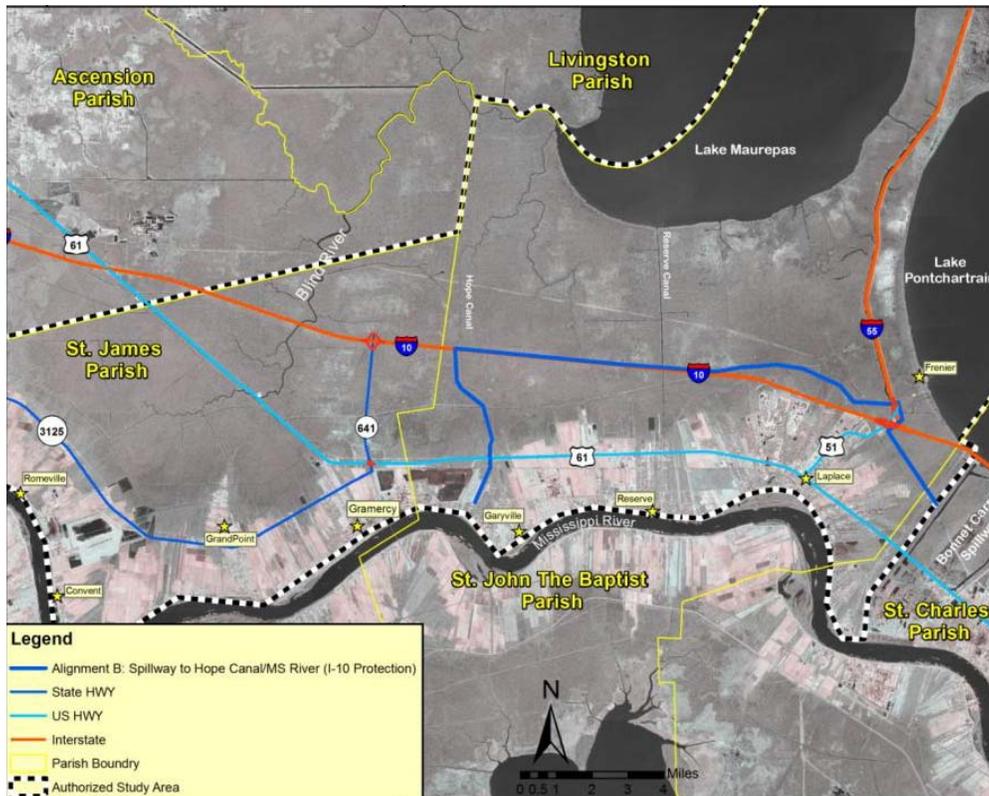


Figure 15: Plan 10 - Bonnet Carré Spillway to Hope Canal/MS River (I-10 Risk Reduction)



Figure 16: Plan 11 - Bonne Carré Spillway to Hope Canal/MS River (Pipeline Avoidance)

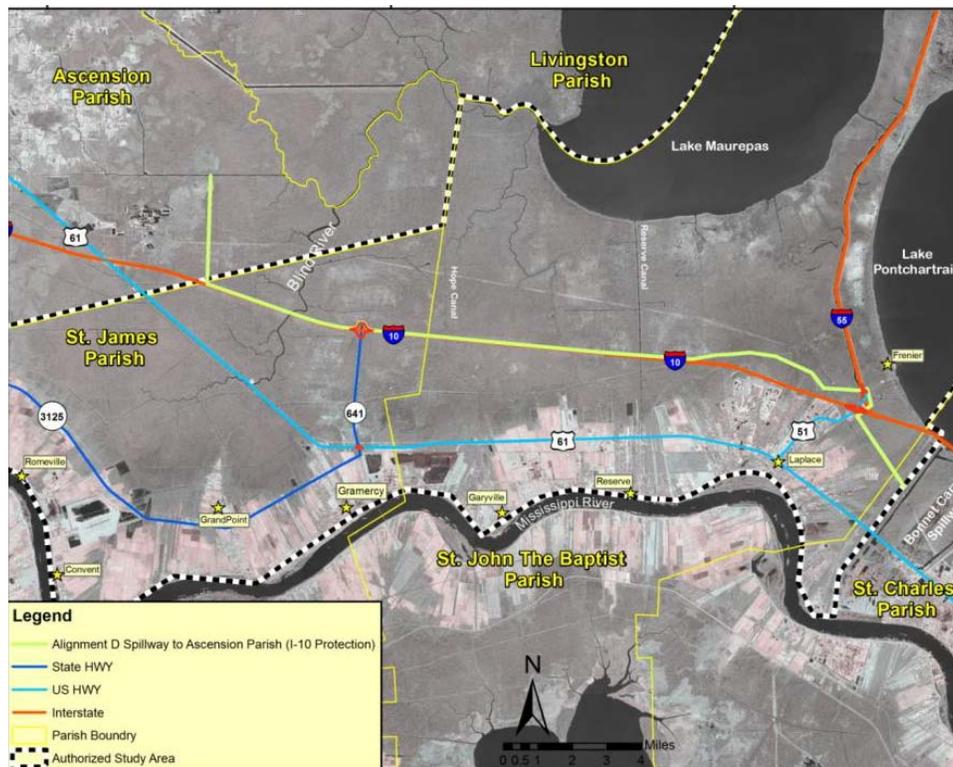


Figure 17: Plan 12 - Bonnet Carré Spillway to Ascension Parish (I-10 Risk Reduction)

To determine the plans to evaluate further, each plan was scored from 5 (high performing) to 1 (low performing) based on how well it met objectives and avoided constraints. Objectives 3 and 4 were not used in the screening of the initial array; do to the fact that all plans would meet Objectives 3 and 4 equally. The scores were totaled and the plans were compared, evaluated and screened. Scores for meeting the objectives and avoiding constraints were developed by reviewing existing available data sources and newly modeled storm surge impacts (**Table 3**).

Table 3: Screening and Ranking of Initial Array Plans against Objectives and Constraints

Condensed Plan ID	Objectives Ranked (5=High, 4=Medium High , 3=Medium, 2=Medium-Low 1=Low)			Avoids Constraint (5=High, 4=Medium High , 3=Medium, 2=Medium-Low 1=Low)					SUM
	#1 Storm damages	#2 Reduce risk to life and health	#5 Reduce the risk of damage and loss of critical infrastructure	#1 Min. impacts to wetlands	#2 Min. impacts to diversion projects	#3 No loss of existing flood protection	#4 Avoid impacts to WMA & wetlands	#5 Min. impacts to critical infrastructure	
Plan 11: Spillway to Hope Canal/MS River (Pipeline Avoidance)	4 Received a 4 due to the fact that under the existing conditions there were significant flooding of structures until you reached Hope Canal. 95% of the FWOP equivalent annual damages would be addressed by this plan.	4 Received a 4 due to the fact that under the existing conditions the plan would prevent surges from flooding of areas which saw depths of flooding greater than 2.5 ft deep. It was assumed that areas that received a greater than 2.5 feet of flooding above the ground would create a hazard to life. Also, the team reviewed the potential for plans to increase water depths outside of the system. Due to the tie in points of the plan there would be limited impacts to structures outside of the plan.	4 Received a 4 due to the fact that under the existing conditions the plan would prevent surges from flooding I-10 and US-61. The Plan did not receive a 5 because these highways would flood in the future west of the plan.	3 Received a 3 due to the fact that it minimized the indirect impacts to the wetlands where possible. The plan did not score higher because there is still ~16 sq miles of wetlands behind the alignment.	3 Received a 3 due to the fact that it would parallel the Hope Canal Diversion and would not interfere with the proposed lateral discharges. The plan did not receive a 4 because the plan would still have to coordinate the design of a drainage structure at Hope Canal.	3 Received a 3 due to the fact that the plan did not risk disruptions to the local drainage patterns northward.	3 Received a 3 due to the fact that it minimized the indirect impacts to the WMA where possible.	5 Received a 5 due to the fact that it avoided a large # of pipelines.	29

Condensed Plan ID	Objectives Ranked (5=High, 4=Medium High, 3=Medium, 2=Medium-Low 1=Low)			Avoids Constraint (5=High, 4=Medium High, 3=Medium, 2=Medium-Low 1=Low)					SUM
	#1 Storm damages	#2 Reduce risk to life and health	#5 Reduce the risk of damage and loss of critical infrastructure	#1 Min. impacts to wetlands	#2 Min. impacts to diversion projects	#3 No loss of existing flood protection	#4 Avoid impacts to WMA & wetlands	#5 Min. impacts to critical infrastructure	
Plan 9: Spillway to Hope Canal/MS River	4 Received a 4 due to the fact that under the existing conditions there were significant flooding of structures until you reached Hope Canal. 95% of the FWOP equivalent annual damages would be addressed by this plan.	4 Received a 4 due to the fact that under the existing conditions the plan would prevent surges from flooding of areas which saw depths of flooding greater than 2.5 ft deep. It was assumed that areas that received a greater than 2.5 feet of flooding above the ground would create a hazard to life. In addition, the team reviewed the potential for plans to increase water depths outside of the system. Due to the tie in points of the plan there would be limited impacts to structures outside of the plan.	4 Received a 4 due to the fact that under the existing conditions the plan would prevent surges from flooding I-10 and US-61. The Plan did not receive a 5 because these highways would flood in the future west of the plan.	5 Received a 5 due to the fact that it minimized the direct and indirect impacts to the wetlands by following the wet/dry interface.	4 Received a 4 due to the fact that it would parallel the Hope Canal Diversion and would not interfere with the proposed lateral discharges.	1 Received a 1 because the plan would disrupt the local drainage patterns northward. A pump station would have to be placed on each drainage ditch to remove rainwaters during a storm surge event.	5 Received a 5 due to the fact that it avoided all indirect and direct impacts to the WMA.	1 Received a 1 because it did not avoid a large # of pipelines. There are over 70 pipeline crossings. Many of these pipelines are small feeder pipelines that join up with a mainline pipeline south of Plan 11.	28
Plan 10: Spillway to Hope Canal/MS River (I-10 Protection)	4 Received a 4 due to the fact that under the existing conditions there were significant flooding of structures until you reached Hope Canal. 95% of the FWOP equivalent annual damages would be addressed by this plan.	4 Received a 4 due to the fact that under the existing conditions the plan would prevent surges from flooding of areas which saw depths of flooding greater than 2.5 ft deep. It was assumed that areas that received a greater than 2.5 feet of flooding above the ground would create a hazard to life. Also the team reviewed the potential for plans to increase water depths outside of the system. Due to the tie in points of the plan there would be limited impacts to structures outside of the plan.	4 Received a 4 due to the fact that under the existing conditions the plan would prevent surges from flooding I-10 and US-61. The Plan did not receive a 5 because these highways would flood in the future west of the plan.	2 Received a 2 due to the fact that it minimized the indirect impacts to the wetlands where possible, but Plan 10 would reduce risk to the same number of structures as Plan11 and would enclose approximately 4,000 more acres of wetlands.	3 Received a 3 due to the fact that it would parallel the Hope Canal Diversion and would not interfere with the proposed lateral discharges. The plan did not receive a 4 because the plan would still have to coordinate the design of a drainage structure at Hope Canal.	3 Received a 3 due to the fact that the plan did not risk disruptions to the local drainage patterns northward.	2 Received a 2 due to the fact that it minimized the indirect impacts and direct impacts to the WMA where possible.	5 Received a 5 due to the fact that it avoided a large # of pipelines	27

Condensed Plan ID	Objectives Ranked (5=High, 4=Medium High, 3=Medium, 2=Medium-Low 1=Low)			Avoids Constraint (5=High, 4=Medium High, 3=Medium, 2=Medium-Low 1=Low)					SUM
	#1 Storm damages	#2 Reduce risk to life and health	#5 Reduce the risk of damage and loss of critical infrastructure	#1 Min. impacts to wetlands	#2 Min. impacts to diversion projects	#3 No loss of existing flood protection	#4 Avoid impacts to WMA & wetlands	#5 Min. impacts to critical infrastructure	
Plan 12: Spillway to Ascension Parish (I-10 Protection)	5 Received a 5 due to the fact it addressed all flooding under the existing conditions and future conditions. 100% of the of the FWOP equivalent annual damages would be addressed by this plan.	4 Received a 4 due to the fact that under the existing conditions the plan would prevent surges from flooding of areas which saw depths of flooding greater than 2.5 ft deep. It was assumed that areas that received a greater than 2.5 feet of flooding above the ground would create a hazard to life. Also the team reviewed the potential for plans to increase water depths outside of the system. Due to the tie in points of the plan there would be limited impacts to structures outside of the plan.	5 Received a 5 due to the fact that under the existing and future conditions the plan would prevent surges from flooding I-10 and US-61.	1 Received a 1 due to the fact that it would enclose ~79 sq miles of wetlands.	1 Received a 1 due to the fact that it would cross the Hope Canal Diversion and would enclose the Convent Blind River Diversion.	4 Received a 4 due to the fact that the plan did not risk disruptions to the local drainage patterns northward. The plan received a higher # than 3 due to the fact there is a large drainage basin to capture and hold rainfall during a storm event.	1 Received a 1 due to the fact that it directly impacted to the WMA across large areas.	4 Received a 4 due to the fact that it avoided a large # of pipelines. The plan did not receive a 5 because the plan would have to avoid additional impacts on the far western end of the plan.	25
Plan 8: Spillway to Ascension Parish/MS River	5 Received a 5 due to the fact it addressed all flooding under the existing conditions and future conditions. 100% of the of the FWOP equivalent annual damages (EAD) would be addressed by this plan.	4 Received a 4 due to the fact that under the existing conditions the plan would prevent surges from flooding of areas which saw depths of flooding greater than 2.5 ft deep. It was assumed that areas that received a greater than 2.5 feet of flooding above the ground would create a hazard to life. Also the team reviewed the potential for plans to increase water depths outside of the system. Due to the tie in points of the plan there would be limited impacts to structures outside of the plan.	5 Received a 5 due to the fact that under the existing and future conditions the plan would prevent surges from flooding I-10 and US-61.	1 Received a 1 due to the fact that it would enclose ~79 sq miles of wetlands.	1 Received a 1 due to the fact that it would cross the Hope Canal Diversion and would enclose the Convent Blind River Diversion.	4 Received a 4 due to the fact that the plan did not risk disruptions to the local drainage patterns northward. The plan received a higher # than 3 due to the fact there is a large drainage basin to capture and hold rainfall during a storm event.	1 Received a 1 due to the fact that it directly impacted to the WMA across large areas.	4 Received a 4 due to the fact that it avoided a large # of pipelines. The plan did not receive a 5 because the plan would have to avoid additional impacts on the far western end of the plan.	25

Condensed Plan ID	Objectives Ranked (5=High, 4=Medium High, 3=Medium, 2=Medium-Low 1=Low)			Avoids Constraint (5=High, 4=Medium High, 3=Medium, 2=Medium-Low 1=Low)					SUM
	#1 Storm damages	#2 Reduce risk to life and health	#5 Reduce the risk of damage and loss of critical infrastructure	#1 Min. impacts to wetlands	#2 Min. impacts to diversion projects	#3 No loss of existing flood protection	#4 Avoid impacts to WMA & wetlands	#5 Min. impacts to critical infrastructure	
Plan 3: Spillway to ESJ (wetland/non-wetland)	2 Received a 2 due to the fact that it only addressed a limited portion of the FWOP equivalent annual damages. Damages EAD. Two of the highest EAD reaches, SA-27 and SA-21 would have left be left outside of the plan.	1 Received a 1 due to the fact that the plan's tie-in point would be directly through a developed area. There would be a high risk that stages outside of the plan could be higher with the plan in place.	3 Received a 3 due to the fact that under the existing conditions the plan would prevent surges from flooding I-10 and parts of US-61. The plan did not receive a 4 because US-61 could still flood under the existing conditions west of ESJ.	5 Received a 5 due to the fact that it minimized the direct and indirect impacts to the wetlands by following the wet/dry interface.	4 Received a 4 due to the fact that it would stop before the Hope Canal Diversion and would not interfere with the proposed lateral discharges.	1 Received a 1 because the plan would disrupt the local drainage patterns northward. There would be limited storage for rainfalls events. Very efficient pump stations would have to be placed on each drainage ditch to remove rainwaters during a storm surge event.	5 Received a 5 due to the fact that it avoided all indirect and direct impacts to the WMA.	2 Received a 2 because it did not avoid a large # of pipelines.. Many of these pipelines are small feeder pipelines that join up with a mainline pipeline south of Plan 11.	23
Plan 2: Spillway to East St. John High School (ESJ)	2 Received a 2 due to the fact that it only addressed a limited portion of the FWOP equivalent annual damages. Damages EAD. Two of the highest EAD reaches, SA-27 and SA-21 would have left be left outside of the plan.	1 Received a 1 due to the fact that the plan's tie-in point would be directly through a developed area. There would be a high risk that stages outside of the plan could be higher with the plan in place.	3 Received a 3 due to the fact that under the existing conditions the plan would prevent surges from flooding I-10 and parts of US-61. The plan did not receive a 4 because US-61 could still flood under the existing conditions west of ESJ.	4 Received a 4 due to the fact that it in most areas minimized the direct and indirect impacts to the wetlands by following the wet/dry interface. It did not receive a 5 because it still enclosed wetlands between the Belle Terre Exit and ESJ.	4 Received a 4 due to the fact that it would stop before the Hope Canal Diversion and would not interfere with the proposed lateral discharges.	2 Received a 2 because the plan would disrupt the local drainage patterns northward. In most areas, a pump station would have to be placed on each drainage ditch to remove rainwaters during a storm surge event.	4 Received a 4 due to the fact that it minimized the indirect impacts to the WMA where possible.	2 Received a 2 because it did not avoid a large # of pipelines.. Many of these pipelines are small feeder pipelines that join up with a mainline pipeline south of Plan 11.	22
Plan 7: Spillway to Marathon (wetland/non-wetland)	2 Received a 2 due to the fact that it left the community of Garyville, structures in Reserve and a portion Marathon refinery outside of the plan. Both these areas would see significant flooding under the existing conditions.	2 Received a 2, because the plan did reduce flooding depths to a larger area, but the plan still could increase stages in the community of Garyville.	3 Received a 3 due to the fact that under the existing conditions the plan would prevent surges from flooding I-10 and parts of US-61. The plan did not receive a 4 because US-61 could still flood under the existing conditions west of Marathon.	4 Received a 4 due to the fact that it in most areas minimized the direct and indirect impacts to the wetlands by following the wet/dry interface. It did not receive a 5 because it still enclosed wetlands between the Belle Terre Exit and ESJ.	4 Received a 4 due to the fact that it would stop before the Hope Canal Diversion and would not interfere with the proposed lateral discharges.	1 Received a 1 because the plan would disrupt the local drainage patterns northward. There would be limited storage for rainfalls events, especially in the area of Reserve. Very efficient pump stations would have to be placed on each drainage ditch to remove rainwaters during a storm surge event.	4 Received a 4 due to the fact that it minimized the indirect impacts to the WMA where possible.	1 Received a 1 because it did not avoid a large # of pipelines. There are over 70 pipeline crossings. Many of these pipelines are small feeder pipelines that join up with a mainline pipeline south of Plan 11.	21

Condensed Plan ID	Objectives Ranked (5=High, 4=Medium High, 3=Medium, 2=Medium-Low 1=Low)			Avoids Constraint (5=High, 4=Medium High, 3=Medium, 2=Medium-Low 1=Low)					SUM
	#1 Storm damages	#2 Reduce risk to life and health	#5 Reduce the risk of damage and loss of critical infrastructure	#1 Min. impacts to wetlands	#2 Min. impacts to diversion projects	#3 No loss of existing flood protection	#4 Avoid impacts to WMA & wetlands	#5 Min. impacts to critical infrastructure	
Plan 4: Spillway to ESJ (I-10 Offset)	2 Received a 2 due to the fact that it only addressed a limited portion of the FWOP equivalent annual damages. Damages EAD . Two of the highest EAD reaches, SA-27 and SA-21 would have left be left outside of the plan.	1 Received a 1 due to the fact that the plan's tie-in point would be directly through a developed area. There would be a high risk that stages outside of the plan could be higher with the plan in place.	3 Received a 3 due to the fact that under the existing conditions the plan would prevent surges from flooding I-10 and parts of US-61. The plan did not receive a 4 because US-61 could still flood under the existing conditions west of ESJ.	2 Received a 2 due to the fact that it in most areas minimized the direct and indirect impacts to the wetlands by following the wet/dry interface. It did not receive a 3 or 4 because it still enclosed wetlands between the Belle Terre Exit and ESJ and also had direct impacts to the wetlands north of I-10.	4 Received a 4 due to the fact that it would stop before the Hope Canal Diversion and would not interfere with the proposed lateral discharges.	2 Received a 2 because the plan would disrupt the local drainage patterns northward. In most areas, a pump station would have to be placed on each drainage ditch to remove rainwaters during a storm surge event.	4 Received a 4 due to the fact that it minimized the indirect impacts to the WMA where possible.	3 Received a 3 because it did not avoided a large # of pipelines.. Many of these pipelines are small feeder pipelines that join up with a mainline pipeline south of Plan 11. The plan did get an additional point for avoiding I-10.	21
Plan 5: Spillway to Marathon	3 Received a 3 due to the fact that it left the community of Garyville and the portion Marathon refinery outside of the plan. Both these areas would see significant flooding under the existing conditions.	2 Received a 2, because the plan did reduce flooding depths to a larger area, but the plan still could increase stages in the community of Garyville.	3 Received a 3 due to the fact that under the existing conditions the plan would prevent surges from flooding I-10 and parts of US-61. The plan did not receive a 4 because US-61 could still flood under the existing conditions west of Marathon.	2 Received a 2 due to the fact that it in most areas minimized the direct and indirect impacts to the wetlands by following the wet/dry interface. It did not receive a 3 or 4 because it still enclosed wetlands between the Belle Terre Exit and Reserve Canal.	4 Received a 4 due to the fact that it would stop before the Hope Canal Diversion and would not interfere with the proposed lateral discharges.	1 Received a 1 because the plan would disrupt the local drainage patterns northward. There would be limited storage for rainfalls events, especially in the area of Reserve and Garyville. Very efficient pump stations would have to be placed on each drainage ditch to remove rainwaters during a storm surge event.	4 Received a 4 due to the fact that it minimized the indirect impacts to the WMA where possible.	1 Received a 1 because it did not avoided a large # of pipelines. There are over 70 pipeline crossings. Many of these pipelines are small feeder pipelines that join up with a mainline pipeline south of Plan 11.	20
Plan 1: Spillway to Reserve Canal	2 Received a 2 due to the fact that it only addressed a limited portion of the FWOP equivalent annual damages. Damages EAD . Two of the highest EAD reaches, SA-27 and SA-21 would have left be left outside of the plan.	1 Received a 1 due to the fact that the plan's tie-in point would be directly through a developed area. There would be a high risk that stages outside of the plan could be higher with the plan in place.	3 Received a 3 due to the fact that under the existing conditions the plan would prevent surges from flooding I-10 and parts of US-61. The plan did not receive a 4 because US-61 could still flood under the existing conditions west of Reserve Canal.	2 Received a 2 due to the fact that it in most areas minimized the direct and indirect impacts to the wetlands by following the wet/dry interface. It did not receive a 3 or 4 because it still enclosed wetlands between the Belle Terre Exit and Reserve Canal.	4 Received a 4 due to the fact that it would stop before the Hope Canal Diversion and would not interfere with the proposed lateral discharges.	2 Received a 2 because the plan would disrupt the local drainage patterns northward. In most areas, a pump station would have to be placed on each drainage ditch to remove rainwaters during a storm surge event.	4 Received a 4 due to the fact that it minimized the indirect impacts to the WMA where possible.	2 Received a 2 because it did not avoided a large # of pipelines.. Many of these pipelines are small feeder pipelines that join up with a mainline pipeline south of Plan 11.	20

Condensed Plan ID	Objectives Ranked (5=High, 4=Medium High, 3=Medium, 2=Medium-Low 1=Low)			Avoids Constraint (5=High, 4=Medium High, 3=Medium, 2=Medium-Low 1=Low)					SUM
	#1 Storm damages	#2 Reduce risk to life and health	#5 Reduce the risk of damage and loss of critical infrastructure	#1 Min. impacts to wetlands	#2 Min. impacts to diversion projects	#3 No loss of existing flood protection	#4 Avoid impacts to WMA & wetlands	#5 Min. impacts to critical infrastructure	
Plan 6: Spillway to Reserve (US-51 Protection)	2 Received a 2 due to the fact that it only addressed a limited portion of the FWOP equivalent annual damages. Damages EAD. Two of the highest EAD reaches, SA-27 and SA-21 would have left be left outside of the plan.	1 Received a 1 due to the fact that the plan's tie-in point would be directly through a developed area. There would be a high risk that stages outside of the plan could be higher with the plan in place.	2 Received a 2 due to the fact that under the existing conditions the plan would prevent surges from flooding I-10 and parts of US-61. The plan did not receive a 4 or 3 because US-61 could still flood under the existing conditions west of west of Marathon, and the plan also leaves out Reach SA-27. This reach includes the Reserve Airport and the Louisiana Nation Guard's High Water response vehicle facility. These two facilities are critical to SE LA storm response teams.	4 Received a 4 because west of Reserve Canal it stayed on the developed areas. It did not receive a 5 because it still enclosed wetlands between the Belle Terre Exit and Reserve Canal.	4 Received a 4 due to the fact that it would stop before the Hope Canal Diversion and would not interfere with the proposed lateral discharges.	1 Received a 1 because the plan would disrupt the local drainage patterns northward. A pump station would have to be placed on each drainage ditch to remove rainwaters during a storm surge event	4 Received a 4 due to the fact that it minimized the indirect impacts to the WMA where possible.	1 Received a 1 because it did not avoided a large # of pipelines. There are over 70 pipeline crossings. Many of these pipelines are small feeder pipelines that join up with a mainline pipeline south of Plan 11.	19

Plans 1-6 were eliminated from further consideration because they did not maximize the planning objectives. (See Table 3-2, objectives ranked column.)

Plans that could induce flooding to communities outside of the risk reduction system or divided communities were eliminated from consideration because they were considered unacceptable.

Plan 7 and Plan 9 alignments follow the wetland/non-wetland interface through St. John the Baptist Parish. However, Plan 7 would not provide risk reduction to the town of Garyville. By increasing the length of the levee by 500 feet, Plan 9 provided risk reduction to Garyville while only minimally increasing costs. Plan 7 was thus eliminated. Plan 8 and Plan 12 would provide risk reduction to the same area. The difference between the two Plans was the tie-in points at the two closest high ground areas to prevent storm surge from flanking the levee. Plan 12 would extend into Ascension Parish and tie into the Marvin Braud pump station. Plan 8 would tie into Hwy-70 in St. James Parish adding 4 miles to the alignment. Plan 12 was carried forward instead of Plan 8 because it was less costly and the direct environmental impacts were less than Plan 8.

The four remaining structural plans were carried forward: Plan 9, Plan 10, Plan 11 and Plan 12.

Descriptions of further analyses and screening are contained in Chapter 3 of the main report.

FURTHER DEVELOPMENT OF THE LOCALIZED STORM SURGE RISK REDUCTION COMPONENT

After the release of the draft report, the team received comments on both the public acceptability of the nonstructural measures proposed and the incremental benefits associated with the the components presented in the draft report. The indication from the public was that a raising or buyout program would get very little public participation if the program were voluntary. The original assumption for the cost and benefit analysis were based on 100% participation in the draft report. In addition to the participation rate, the team also had to investigate the incremental justification of the nonstructural component as a standalone feature.

In reviewing the nonstructural plan presented in the draft report, the team determined that the benefit to cost ratio (BCR) was less than 1 (below unity). In the draft report the cost of raising and/or acquiring structures located in the 2020 and 2070 100-year floodplains was evaluated by comparing the cost of elevating the structure to the cost of acquiring the structure. In subsequent discussions with the local stakeholders and experts in the field of storm surge risk reduction measures, we determined that lower cost localized storm surge risk reduction measures could have been implemented to achieve the same level of benefits. This in turn could have raised the BCR above unity.

The key to identifying which of these localized storm surge risk reduction measures would work best to reduce the risk of storm surge-related damage in this area lies in understanding the limits and characteristics of storm surge flooding and flooding in general in St. James Parish. Based on this understanding, the team determined that methods used to address tropical/hurricane storm surge in this area had to be focused in discrete locations and had to be implemented very near the base year where damages were occurring.

The team began its detailed evaluation by reviewing the existing and future tropical/hurricane storm surge flooding in the St. James Parish area. It was determined that in 2020, the 100 yr flooding in St. James Parish was between an elevation of 6.6. to 5.2 ft NAVD 88 (Figure 4).

Figure 4. 100 yr Surge Data and Reaches in St. James Parish with Structures

SA-Name	Index_Sta	FWP100yr2020	FWP100yr2070
RSA 01	102	6.6	12.1
RSA 02	104	5.8	11.8
RSA 24	148	5.5	11.6
RSA 27	154	5.7	11.7
RSA 33	166	5.2	11.8
RSA 34	168	5.2	11.8
RSA 35	170	5.2	11.8
RSA 44	188	5.5	11.6
RSA 46	192	5.8	11.8
RSA 54	208	5.7	11.7
RSA 55	210	5.5	11.6

Based on our surge modeling data, these stages would affect between 225 to 300 homes in 2020. These stages were also very similar to the stages seen from Hurricane Isaac, but less than 30 structures were impacted in St. James during that event. In discussions with local residents and stakeholder it was determined, due to the nature of the flooding and depths, the locals were able to sandbag a large number of homes over a 24 hour period and protect these homes from damage. Unlike the eastern portion of the study area, storm surges in St. James Parish typically enter the area slower and when it does flood, the depths in the developed areas are generally less than 2.5 ft deep. Most of the developed areas have a ground elevation of ~4.5 NAVD 88. As you can see from the pictures below from Hurricane Isaac, most the flooding is in the yards. Homes with a first floor less than 6.5 were typically sandbagged (Figure 18 and 19). In some cases, temporary berms made from sand bags were used to protect a group of structures (Figure 20).



Figure 18. Gramercy Area north of 3125 during Hurricane Isaac



Figure 19. Grand Point Hurricane Isaac



Figure 20. Grand Point Hurricane Isaac (Credit St. James Parish Sheriff's Office)

We also determined that flooding that occurred south of Highway 3125 had to pass under the highway. The lowest point of the highway was above a 6 ft elevation. Surge was flowing upstream through the drainage culverts under the highway and flooding structures south of the highway.

The team at that point began to investigate the feasibility of berms and flap gates on the culverts along the highway. We identified 5 major areas within St James parish that could be addressed through localized storm surge risk reduction risk reduction measures(Figure 21):

- Berm around a group of structures in the Gramercy area North of Hwy 3125.
- Berm around a group of structures in the Grand Point area North of Hwy 3125 near Longview Park. (Grand Point North).
- Berm around a group of structures in the Grand Point area north of Hwy 3125, near the Grand Point Boat Launch (Grand Point South).
- Flap Gates and Closures on drains under Hwy 3125 to reduce risk to structures south of the highway.
- Flood proof structures north of Hwy 3125 in St. James Parish outside of the berms with a first floor below the 2020 1% AEP event.



Figure 23. Graphical Representation of a Berm around the Gramercy area.

Cost for raising structures were already developed for the draft report. Cost for berms around structures were developed based on a average perimeter around a structure and a cost per linear foot of berm. The cost for the berm around the group of structures was based on the same design of the structural as the levee, but an average ground elevation was used. In most areas, the required berm heights for a 2020 100yr level of risk reduction were less than 2.5 ft above ground level. In comparing the cost between the three options, a berm around a group of structures was the more cost efficient option (Table 5). In both the Gramercy area and in the Grand Point Areas berms around a group of structures were developed (Figure 24).

Table 5. Cost comparisons for Gramercy Area

	Top of Polder Elevation/or Targeted RR level for Existing conditions (ft NAVD88)	# Structures in Polder	# Structures with first floors less than the set polder height	Total polder construction cost	Structure by Structure Evaluation of Raising or Acquisitions (noURA)	Estimated cost for individual berms per Structures impacted (# Structures X (240 lf berm*X \$800/lf) *Used ~3,500 sqft area (SQRT(3500)*4) = 240 lf
Polder 1 (Gramercy)	6.5	275	156	\$15,000,000	\$24,000,000	\$30,000,000

To reduce risk to a large area south of Hwy 3125, it was determined, that Hwy 3125 could be used as a localized storm surge risk reduction feature (Figure 24). The roadway elevation is above a 6.5 'NAVD 88 elevation and currently under a 2020 100 yr event, tropical/hurricane storm surges only flow through the culverts under the roadway (Figure 24). By closing off the culverts with one-way flap gates and a drainage canal with a floodgate during tropical/hurricane storm surge events, the plan would provide risk reduction to 19,500 acres and 4,295 structures south of Hwy 3125. Although there are a limited number of structures that are impacted by a 6.5 'NAVD 88 surge event, this closure would prevent a large portion of the parish's critical sugarcane crops from flooding during tropical/hurricane storm surge events, although no estimates of damage and benefits to agricultural resources have been made. In addition, if the parish chooses to make future improvements to Hwy 3125, any additional height added to the highway could add to the structures risk reduction level. Currently 165 structures out of 4,295 structures south of Hwy 3125 would be impacted by a 6.5 'NAVD 88 surge event without the flapgate closures.

In order to include everyone in the evaluation the team also investigated the remaining structures that were not included in the 3 polders or in the area south of Hwy 3125. We determined that 80 structures would be outside the risk reduction provided by these features. Of these structures, only 23 of them have a first floor

elevation less than the 1% AEP storm stages in 2020 (Figure 24). The plan therefore includes elevation of 14 residential structures to the stage associated with the 2070 1% (100-year) ACE event; flood-proofing of 4 non-residential structures to 3 feet above the ground elevation; and constructing smaller berms for 5 light industrial/warehouse facilities.

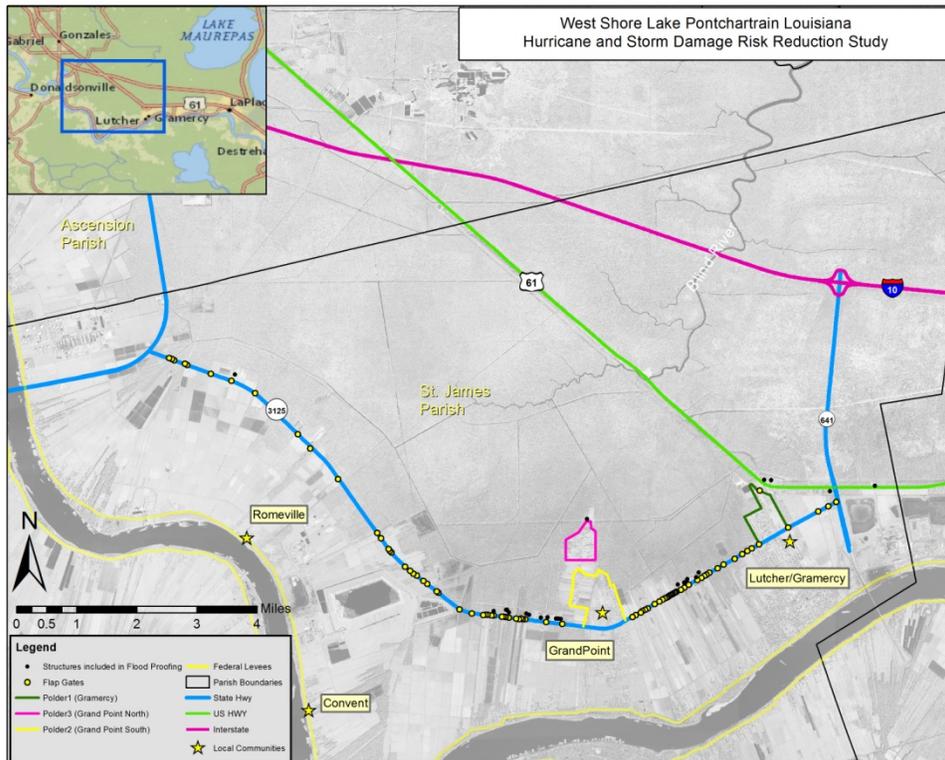


Figure 24. Final Localized Storm Surge Risk Reduction Plan for St. James

Including the optimized localized storm surge risk reduction components would reduce tropical/hurricane storm surge-related damages in St. James to the 1% AEP storm stages in 2020. The measures only provide a risk reduction above 1% AEP storm stages in 2020. In the future, the level of risk reduction provided by these measures would depend on the rate of RSLR. The level of risk reduction in year 2070 is estimated to fall between the 25 yr and 50 yr AEP storm stages. Additional efforts to investigate improvements to the berms over time were not investigated further due to the fact that the previous efforts under the draft report showed that larger localized storm surge risk reduction plans based on the 2070 1% AEP storm stages was below unity.

ENGINEERING DETAILS OF THE LOCALIZED STORM SURGE RISK REDUCTION FEATURES

Polder 1 (Gramercy Berm)

In the Gramercy area, north of Hwy 3125, a 10,100 LF berm is proposed. The berm would be constructed to a +6.5' NAVD 88 elevation. The berm would parallel both sides of Hwy 20, and parallel the railroad track

along US-61 (Airline Highway). On the south, the berm would tie into Hwy 3125 to close off the system. Hwy 3125 is key feature for all of the localized storm surge risk reduction features. The entire roadway is above a 6.5' NAVD 88 elevation and will be used as a tie in point for the berm. The design of the berm is based on with a 4' wide crown and 3:1 side slopes. Using local Light Detection and Ranging (LIDAR) data it was assumed that the existing ground elevation under the berm would be at an elevation of approximately 4.3 ft NAVD88. Using this assumption, the proposed berm would have an average height of 2.2 ft with an average width of 18 ft, and require 237,000 cy of compacted fill for construction. The berm would also include two floodgates to allow existing drainage to flow through the berm when not under surge events. A pump system to operate and remove rainwaters during tropical/hurricane storm events will be included in the features. The pump system will be approximately 217 cfs. The berm would be placed in a location so as not to interfere with existing local drainage.

Mobilization & Demolition	1	L.S.
Clearing and Grubbing (Area of berm location)	4	Ac.
100% Compacted Fill	237,021	C.Y.
Turf Establishment	4	Ac.
Flood Gate (10' to 14' Height)	50	LF
Pump Station (217 CFS)	1	Each
Flap Gate (36" circular)	1	Each

Polder2 (Grand Point South Berm)

In the Grand Point Area near Hwy 3125, a 14,488 LF a berm would be built, and would include a 4' wide crown and 3:1 side slopes. Similar to the Gramercy berm, it would tie into Hwy 3125 and be constructed to a 6.5' NAVD 88 elevation. Using LIDAR data it was assumed that the existing ground elevation under the berm would be approximately 4.5' NAVD 88. Using this assumption the proposed berm would have an average height of 2 ft with an average width of 16 ft, and require 273,900 cy of compacted fill for construction. The berm would also include one floodgate to allow existing drainage to flow through the berm when not under surge events. A pump system to operate and remove rain waters during tropical/hurricane storm events will be included in the features. The pump system will be approximately 382 cfs. The berm would be placed in a location so as not to interfere with existing local drainage. The berm would also be placed very near the edge of the property owners' parcels where feasible. This would minimize the loss of use of any property.

Mobilization & Demolition	1	L.S.
Clearing and Grubbing (Area of berm location)	5	Ac.
100% Compacted Fill	273,823	C.Y.
Turf Establishment	5	Ac.
Flood Gate (10' to 14' Height)	50	LF
Pump Station (382 CFS)	1	Each

Note: A review of each component determined that every component considered for the localized storm surge risk reduction plan, except for Polder 2 (Grand Point South), was economically justified on its own (See Table 3-8 of the main report). The USACE's ER 1105-2-100 states that separable elements have to be incrementally justified to be included in the final recommendation. Polder 2 (Grand Point South) BCR's was less than unity when evaluated separately. Polder 2 (Grand Point South) was removed from the overall system associated with the final recommendation.

Polder3 (Grand Point North Berm)

In the Grand Point Area a berm proposed around the structures in the northern portion of Grand Point, near the Grand Point Boat Launch. The berm would be 10,400 LF, and would include a 4' wide crown and 3:1 side slopes. The berm would be constructed to a 6.5 ' NAVD 88 elevation. Using local LIDAR data it was assumed that the existing ground elevation under the berm would be approximately 4' NAVD 88. Using this

assumption, the proposed berm would have an average height of 2.5 ft with an average width of 20 ft, and require 286,800 cy of compacted fill for construction. A pump system to operate and remove rain waters during tropical/hurricane storm events will be included in the features. The pump system will be approximately 140 cfs. The berm would be placed in a location so as not to interfere with existing local drainage. The berm would also be placed very near the edge of the property owners' parcels where feasible. This would minimize the loss of use of any property.

Mobilization & Demolition	1	L.S.
Clearing and Grubbing (Area of berm location)	4	Ac.
100% Compacted Fill	286,729	C.Y.
Turf Establishment	4	Ac.
Pump Station (140 CFS)	1	Each

Storm Surge **Risk Reduction Under LA Highway 3125**

In addition to the berms north of Hwy 3125, the proposal is to use 13 miles of Hwy 3125 and its existing foundation as a localized storm surge risk reduction feature. Currently the roadway elevation is above a 6.5' NAVD88 elevation. Currently, the 1% AEP storm stages in 2020 flow through the culverts under the roadway in the opposite direction from natural drainage. By closing off the culverts with one-way flap gates and a drainage canal with a floodgate during surge events, the plan would provide risk reduction to 19,500 acres and 4,295 structures south of Hwy 3125. The plan includes 145 flap gated closures, two floodgates and two small berms (Noranda and Uncle Sam). The Noranda berm ties the highway into high ground east of Gramercy. The Uncle Sam berm divides the developed area behind Hwy 3125 from an area that is primarily agricultural land. The total length of the berms is approximately 645 LF. They would be built in the same methods as the Gramercy and Grand Point berms. Due to the nature of the flooding south of Hwy 3125, it is assumed that the 19,500 acres would have ample storage capacity to hold any rainfall during the surge events. Even if some acres of crops are flooded from rainfall it would be much less than if the surge was allowed to flow under Hwy 3125.

Flap Gate (30" circular)	69	Each
Flap Gate (36" circular)	19	Each
Flap Gate (48" circular)	3	Each
Aluminum Slide Gate (48" x 72")	1	Each
Flood Gate (10' to 14' Height)	90	LF
Noranda berm		
Mobilization & Demolition	1	L.S.
Clearing and Grubbing (Levee)	1	Ac.
100% Compacted Fill (3)	8,973	C.Y.
Turf Establishment	1	Ac.
Uncle Sam berm		
Mobilization & Demolition	1	L.S.
Clearing and Grubbing (Levee)	1	Ac.
100% Compacted Fill (3)	5,120	C.Y.
Turf Establishment	1	Ac.

Remaining Structures in St. James Parish

The plan includes 14 residential structures that would be raised to the stage associated with the 2070 1% (100-year) AEP event; 4 non-residential structures would be flood proofed to 3 feet above the ground elevation; and smaller berms would be constructed for 5 light industrial/warehouse facilities. The final design will be refined in PED once additional information each structures is collected. The table below provides the information used for cost estimating purposes. The 14 residential structures are being raised to the 2070 height because it is more cost effective to raise a home once. The final method for raising and flood proofing will be refined during PED and could differ between residential structures and non-residential structures. The pictures below provide examples of the different methods.

14 residential structures:

ID	Structure Type	Existing 1st Floor Elevation (NAVD88)	Final Raised Elevation (NAVD88)
1392	1STY-PIER	3.76	8
367	1STY-PIER	4.91	7
611	1STY-SLAB	5.37	6
612	1STY-SLAB	4.67	7
624	1STY-SLAB	3.24	8
622	1STY-SLAB	3.72	8
621	1STY-SLAB	3.7	8
1396	1STY-SLAB	3.53	8
1395	1STY-SLAB	3.34	8
1394	1STY-SLAB	4.41	7
237	1STY-SLAB	4.51	7
236	1STY-SLAB	4.5	7
232	1STY-SLAB	5.32	6
1393	1STY-SLAB	3.8	8

4 non-residential structures would be flood proofed to 3 feet above the ground elevation:

ID	Type of Structure	First Floor Elevation (NAD88)	~ Square Feet of Structure
617FP	EAT	3.71	3,251
1FP	PROF	3.76	22,800
618FP	PROF	4.95	22,800
3FP	PUBL	4.51	7,815

5 light industrial/warehouse facilities with berms:

ID	Type	First Floor Elevation (NAD88)	Estimated Square Feet	Perimeter	Perimeter With Buffer
615B	COM	5.02	10431.7	408.54	568.54
614B	COM	4.39	10431.7	408.54	568.54
638B	COM	4.73	10431.7	408.54	568.54
114B	IND	4.99	10431.7	408.54	568.54
111B	IND	5.65	10431.7	408.54	568.54

Structures Foundation walls extended:



Structures elevated on piers, post, piles, or columns:



Low Flood Wall:



Berm around non-residential structure:

