INTEGRATED DRAFT FEASIBILITY REPORT

APPENDIX D
ECONOMICS

U.S. Army Corps of Engineers
Mississippi Valley Division
New Orleans District
7400 Leake Avenue
New Orleans, Louisiana 70118

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REVISED DRAFT FEASIBILITY REPORT
DRAFT Economics Appendix

TABLE OF CONTENTS

TABLES

FIGURES

1.0 BACKGROUND INFORMATION

1.1 INTRODUCTION

General. This appendix presents an economic evaluation of the coastal storm surge and riverine flood risk reduction measures for the South Central Coastal Louisiana Feasibility Study. The evaluation area includes portions of three south central parishes that include Iberia, St. Mary, and St. Martin. The report was prepared in accordance with Engineering Regulation (ER) 1105-2-100, Planning Guidance Notebook, and ER 1105-2-101, Planning Guidance, Risk Analysis for Flood Damage Reduction Studies. The National Economic Development Procedures Manual for Flood Risk Management and Coastal Storm Risk Management, prepared by the Water Resources Support Center, Institute for Water Resources, was also used as a reference, along with the User's Manual for the Hydrologic Engineering Center Flood Damage Analysis Model (HEC-FDA).

The economic appendix consists of a description of the methodology used to determine National Economic Development (NED) damages and benefits under existing conditions and the projects costs. The damages and costs were calculated using FY 2019 price levels. Costs were annualized using the FY 2020 Federal discount rate of 2.75 percent and a period of analysis of 50 years with the year 2025 as the base year. The expected annual damage and benefit estimates were compared to the annual construction costs and the associated OMRR&R costs for each of the project measures.

NED Benefit Categories Considered. The NED procedure manuals for coastal and urban areas recognize four primary categories of benefits for flood risk management measures: inundation reduction, intensification, location, and employment benefits. The majority of the benefits attributable to a project measure generally result from the reduction of actual or potential damages caused by inundation. Inundation reduction includes the reduction of physical damages to structures, contents, and vehicles and indirect losses to the national economy.

Physical Flood Damage Reduction. Physical flood damage reduction benefits include the decrease in potential damages to residential and commercial structures, their contents, and the privately owned vehicles associated with these structures.

Emergency Cost Reduction Benefits. Emergency costs are those costs incurred by a community during and immediately following a major storm. The cost of debris removal from inundated residential and non-residential structures was the only emergency cost reduction benefit considered for this analysis.

NED Benefit Categories NOT Considered. The following NED benefit categories were not addressed in this economic appendix prior to selection of a Tentatively Selected Plan (TSP) include the following:

- Costs associated with evacuation and reoccupation activities before, during and following a flood event incurred by property owners and governments;
- Indirect losses to the national economist as a result of disruptions in the production of goods and services by industries affected by the storm or riverine flooding
- Increased cost of operations for industrial facilities following a flood event relative to normal business operations
- Physical loss of agricultural crops grown to be sold for commercial profit

Regional Economic Development. When the economic activity lost in a flooded region can be transferred to another area or region in the national economy, these losses cannot be included in the NED account. However, the impacts on the employment, income, and output of the regional economy are considered part of the RED account. The input-output macroeconomic model RECONS can be used to address the impacts of the construction spending associated with the project alternatives. The RED account has not been addressed in the economic appendix prior to selection of the TSP.

Other Social Effects. The other social effects (OSE) account includes impacts to life safety, vulnerable populations, local economic vitality, and community optimism. Impacts on these topics are a natural outcome of civil works projects and are most commonly qualitatively discussed in the OSE account. Life loss modeling software such as HEC-FIA and HEC-LifeSim have the ability to quantify loss of life for a given alternative to determine if life safety risk decreases or is induced as a result of federal investment. The OSE account has not been addressed in the economic appendix prior to the selection of the TSP.

1.2 DESCRIPTION OF THE STUDY AREA

Geographic Location. The South Central Coastal Louisiana (SCCL) study area includes three parishes (Iberia, St. Martin, St. Mary) and extends from the City of Lafayette south to the coastal portions of the study area bordering the Gulf of Mexico. The region includes both coastal storm surge and riverine flooding. The SCCL measures for the study area will be analyzed in this part of the Economics Appendix. An inventory of residential and non-residential structures was developed using the National Structure Inventory (NSI) version 2.0 for the portions of the three parishes impacted by storm surge and riverine flooding associated with the future without project condition. Figure 1 shows the structure inventory and the boundaries of the parishes. Individual study reaches have not yet been defined for the study area.

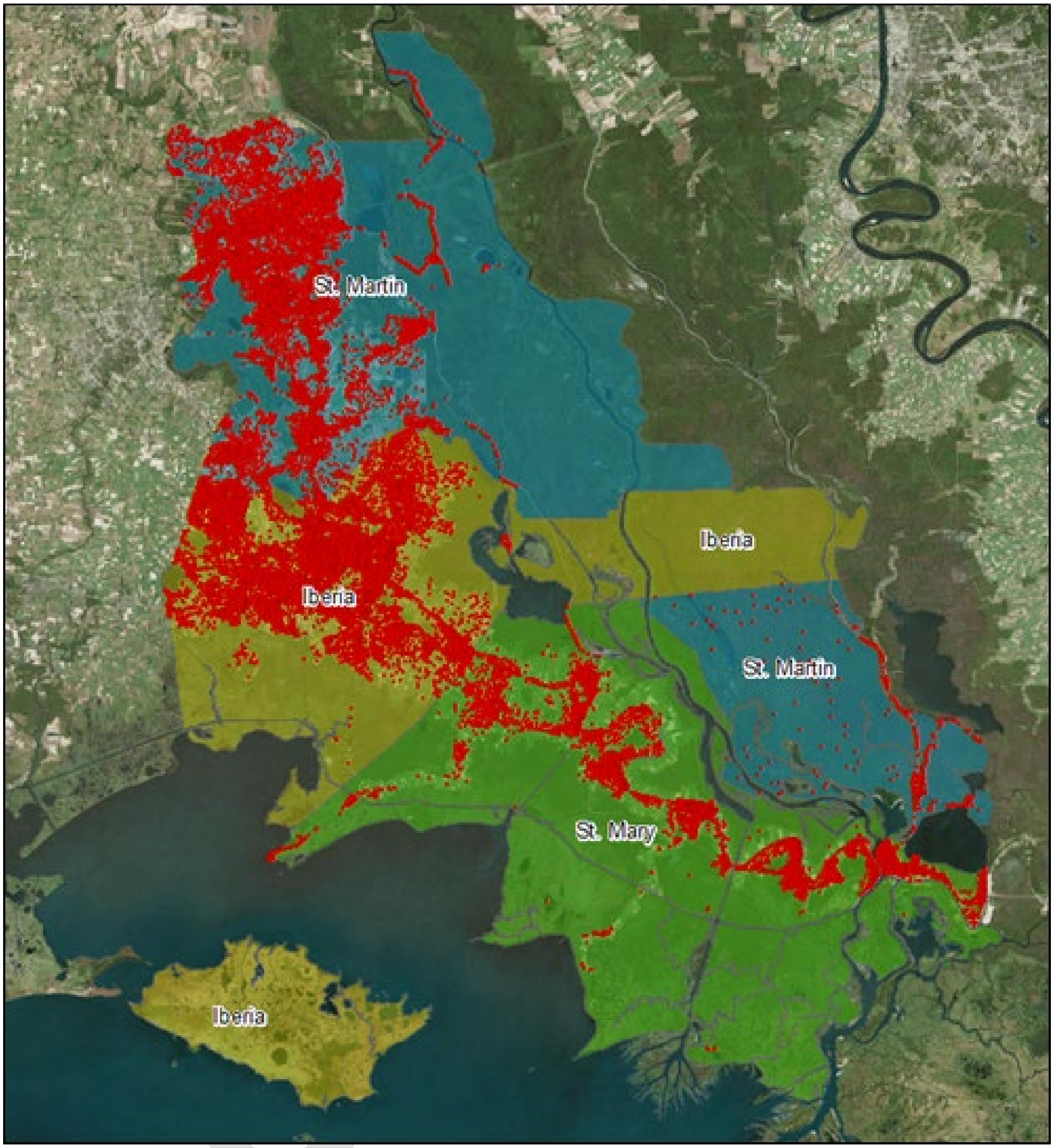

Figure 1. Parish Boundaries and Structure Inventory

The study area was further divided into 158 study area subunits that were designed by the hydraulic engineer to contain areas that experienced similar hydraulic conditions. Some groups of subunits are small, designating rapidly changing hydraulic conditions across the study area. Other clusters of subunits are larger, designating more consistent water surface profiles. Structures located within each subunit were assigned that area, which is classified as a reach in HEC-FDA. Figure 2 shows the study area subunit/reach boundaries for Region 1. Table 1 shows a structure count by reach, split by the structure being either residential or non-residential, which includes commercial, industrial, and public structures. The study area has a total of 63,537 structures located across the 158 study area subunits.

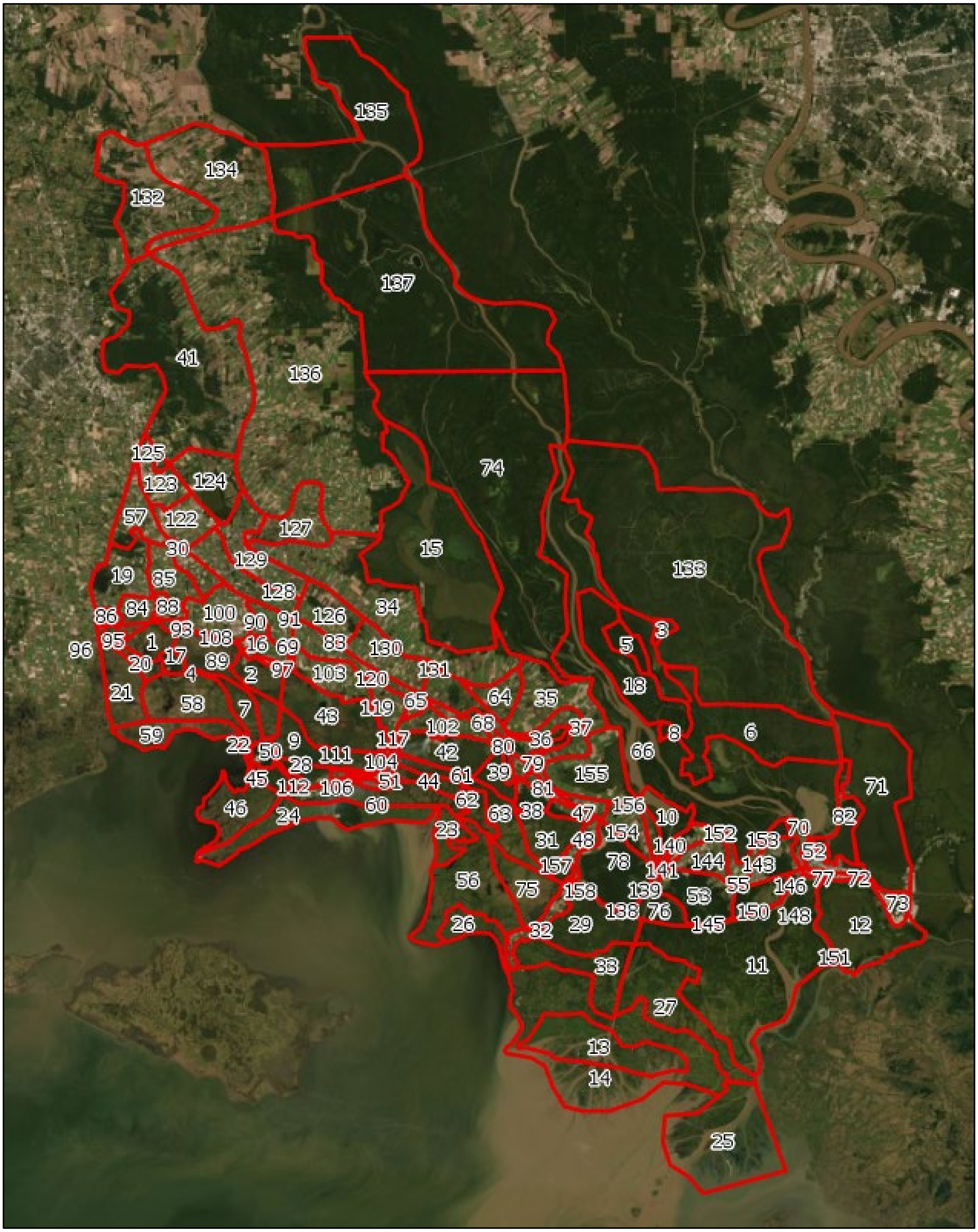

Figure 2. Study Subunits (Reaches)

Table 1. Structure Count by Reach

Reach	Residential	Non-Residential	Total Structures
1	1	0	1
2	1	0	1
3	0	0	0
4	2	0	2
5	10	0	10
6	0	0	0
7	0	0	0
8	3	0	3
9	4	1	5
10	0	6	6
11	0	5	5
12	4	0	4
13	2	3	5
14	40	5	45
15	162	9	171
16	68	8	76
17	2	0	2
18	371	42	413
19	2	1	3
20	0	0	0
21	0	0	0
22	1	0	1
23	218	5	223
24	0	0	0
25	0	0	0
26	0	0	0
27	0	1	1
28	0	0	0
29	293	52	345
30	0	0	0
31	37	5	42
32	0	0	0
33	4,020	404	4,424
34	122	23	145
35	70	35	105
36	2,019	311	2,330
37	8	7	15
38	3	2	5

39	14	5	19
40	4,378	785	5,163
41	0	0	0
42	0	0	0
43	0	0	0
44	0	0	0
45	136	4	140
46	0	0	0
47	17	8	25
48	2	1	3
49	0	2	2
50	1	1	2
51	4,467	1,066	5,533
52	814	105	919
53	8	0	8
54	35	1	36
55	1	0	1
56	923	206	1,129
57	6	0	6
58	0	0	0
59	24	9	33
60	0	0	0
61	0	0	0
62	1	0	1
63	843	96	939
64	177	16	193
65	28	1	29
66	0	0	0
67	72	5	77
68	107	5	112
69	9	21	30
70	615	42	657
71	12	37	49
72	249	184	433
73	6	2	8
74	0	0	0
75	1	0	1
76	157	45	202
77	64	7	71
78	419	53	472
79	602	77	679

80	465	32	497
81	288	36	324
82	308	50	358
83	88	5	93
84	763	61	824
85	47	9	56
86	70	29	99
87	197	17	214
88	1	2	3
89	25	1	26
90	577	62	639
91	0	0	0
92	25	5	30
93	5	0	5
94	1	0	1
95	0	0	0
96	0	0	0
97	0	0	0
98	0	2	2
99	502	209	711
100	0	0	0
101	189	7	196
102	44	7	51
103	1	0	1
104	0	0	0
105	4	0	4
106	0	2	2
107	1	0	1
108	0	0	0
109	0	0	0
110	0	0	0
111	0	1	1
112	1	0	1
113	0	0	0
114	0	0	0
115	0	0	0
116	2	2	4
117	0	0	0
118	41	4	45
119	19	6	25
120	51	1	52

121	302	119	421
122	301	113	414
123	338	49	387
124	142	30	172
125	368	52	420
126	1,311	81	1,392
127	1,430	463	1,893
128	5,756	1522	7,278
129	1,913	254	2,167
130	430	75	505
131	1,470	72	1,542
132	186	23	209
133	2,584	158	2,742
134	14	2	16
135	6,895	789	7,684
136	378	22	400
137	0	0	0
138	0	0	0
139	0	0	0
140	4	2	6
141	0	0	0
142	2,368	328	2,696
143	1,906	224	2,130
144	0	0	0
145	436	60	496
146	0	0	0
147	0	0	0
148	10	6	16
149	2	13	15
150	0	0	0
151	13	1	14
152	13	1	14
153	34	2	36
154	202	10	212
155	600	33	633
156	0	0	0
157	0	0	0
158	0	0	0

Land Use. The total number of acres of developed, agricultural, and undeveloped land in Iberia, St. Martin, and St. Mary parishes are shown in Table 2. As shown in the table, 7 percent of the total acres in the study area are currently developed land. There are slightly over 1.2 million acres of agricultural land and 3.9 million acres of undeveloped land.

Table 2. Land Use in the Study Area

Land Class Name	Acres	Percentage of Total
Developed Land	364,094	7%
Agricultural Land	1,278,535	23%
Undeveloped Land	3,913,174	70%
Total	5,555,803	100%

Source: USGS National Land Cover Database
Note: Sugarcane accounts for the majority of the agricultural land and pasture/hay the remainder.

1.3 SOCIOECONOMIC SETTING

Population, Number of Households, and Employment. Tables 3, 4, and 5 display the population, number of households, and the employment (number of jobs) for each of the three parishes for the years 2000 and 2010, as well as projections for the years 2017, 2025, and 2045. The 2000 and 2010 estimates for population, number of households and employment are from the U.S. Census and the projections were developed by Moody's Analytics (ECCA) Forecast, which has projections to the year 2045.

Table 3. Historical and Projected Population by Parish

Parish	2000	2010	2017	2025	2045
Iberia	73,266	73,240	72,176	71,052	63,087
St. Martin	48,583	52,160	54,171	53,771	51,598
St. Mary	53,500	54,650	50,973	52,136	50,551
Total	175,349	180,050	177,320	176,959	165,237

Sources: 2000, 2010, 2017 from U.S. Census Bureau; 2025, 2045 from Moody's Analytics (ECCA) Forecast

Table 4. Existing Condition and Projected Households by Parish

Parish	2000	2010	2017	2025	2045
Iberia	25,381	26,770	28,028	27,800	26,530
St. Martin	17,164	19,216	20,674	21,188	21,841
St. Mary	19,317	20,457	20,390	20,883	21,784
Total	61,862	66,443	69,092	69,871	70,155

Sources: 2000, 2010, 2017 from U.S. Census Bureau; 2025, 2045 from Moody's Analytics (ECCA) Forecast

Table 5. Existing Condition and Projected Employment by Parish

Parish	2000	2010	2017	2025	2045
Iberia	28,760	29,464	27,627	26,613	25,531
St. Martin	20,192	22,137	21,104	21,010	21,761
St. Mary	20,866	22,815	20,763	21,233	21,602
Total	69,818	74,416	69,494	68,857	68,895

Sources: 2000, 2010, 2017 from U.S. Census Bureau; 2025, 2045 from Moody's Analytics (ECCA) Forecast

Income. Table 6 shows the actual and projected per capita personal income levels for the three parishes from 2000 to 2025.

Table 6. Per Capita Income ($)

Parish	2000	2010	2017	2025
Iberia	20,423	34,986	39,421	50,937
St. Martin	17,912	32,060	39,979	56,565
St. Mary	21,602	35,400	39,784	51,010

Sources: 2000, 2010 from U.S. Census Bureau; 2017, 2025, 2045 from Moody's Analytics (ECCA) Forecast

Compliance with Policy Guidance Letter (PGL) 25 and Executive Order 11988. Given continued growth in employment and income, it is expected that development will continue to occur in the study area with or without the storm surge risk reduction system, and will not conflict with PGL 25 and EO 11988, which state that the primary objective of a flood risk reduction project is to protect existing development, rather than to make undeveloped land available for more valuable uses. However, the overall growth rate is anticipated to be the same with or without the project in place. Thus, the project will not induce development, but would rather reduce the risk of the population being displaced after a major storm event.

1.4 RECENT FLOOD HISTORY

Tropical Flood Events. Coastal Louisiana experiences localized flooding from both excessive rainfall events, leading to riverine flooding, and also storm surge events from tropical storms and hurricanes. Since 1851, the paths of 30 tropical events have crossed the study area. The paths and intensities of these storms are shown in Figure 3.

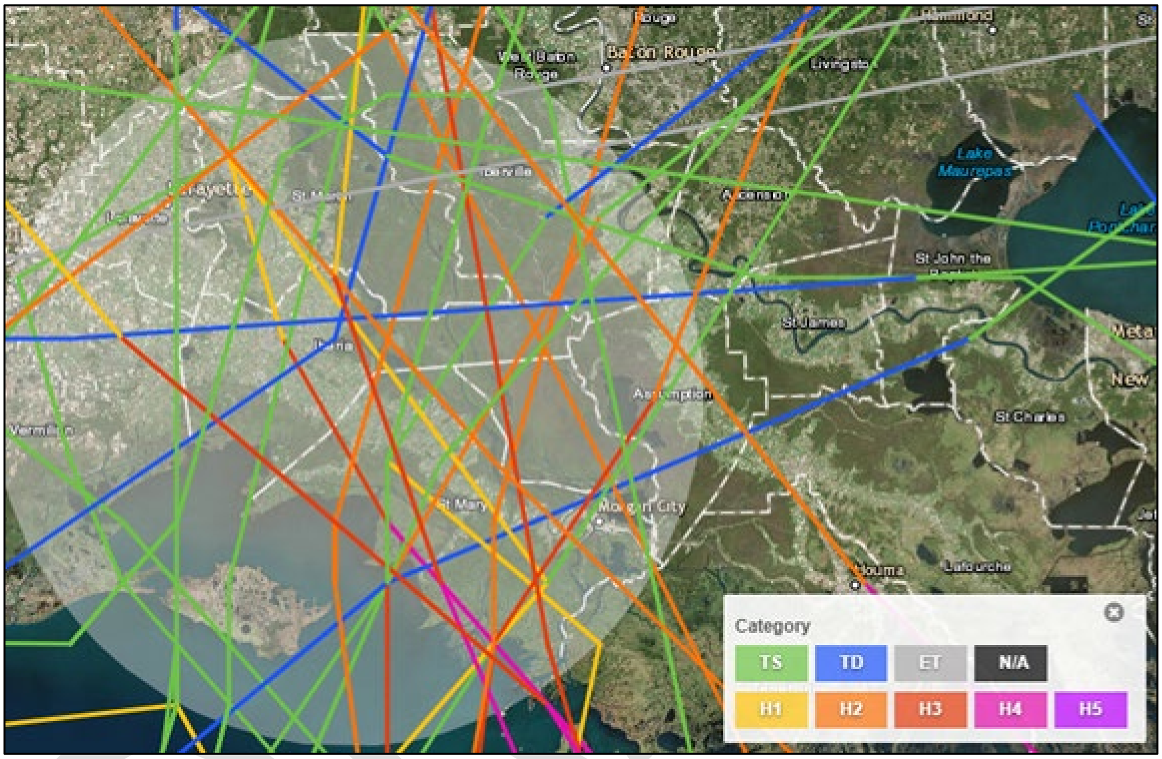

Figure 3. Hurricane and Tropical Storm Paths Since 1851

FEMA Flood Claims The most recent named storms to affect the SCCL study area include Tropical Storm Lee in 2011, Hurricane Ike in 2008, Hurricane Gustav in 2008, and Hurricane Rita in 2005. With that said, the 2016 flooding across Louisiana, including the SCCL study area, was the single worst event by amount paid per flood insurance claim. The FEMA flood claims for these events, including the 2016 storms, are shown Table 7. The flood events listed in Table 6 includes damages to structures both inside and out of the study area, and the exact impact to the SCCL study area is not known. Table 8 shows the flood claims paid between 1978 and January 2018 for the three parishes within study area. The table includes the number of paid losses, the total amount paid, and the average amount paid on each loss in the dollar value at the time of the storm. The table excludes losses that were not covered by flood insurance. While there have been events that have damaged portions of the study area, there has never been a major named hurricane that has directly impacted the study area over the last 20 years.

Table 7. Top Tropical Storms by Amount Paid by FEMA

Event	Month & Year	Number of Paid Claims	Total Amount Paid (millions)
2016 Louisiana Floods	Aug-16	26,909	$2,610
Tropical Storm Lee	Sep-11	9,900	$550
Hurricane Ike	Sep-08	46,684	$3,580
Hurricane Gustav	Sep-08	4,545	$150
Hurricane Rita	Sep-05	9,354	$740
Hurricane Andrew	Aug-92	5,587	$380

Source: Federal Emergency Management Agency (FEMA)
Note 1: Total amount paid has been indexed to 2019 price level using RS Means Cost Index
Note 2: Claims and amount paid are for entire event, which may include areas outside of the study area.

Table 8. FEMA Flood Claims by Parish (Jan 1978 – Sept 2018)

Parish	Total Number of Claims	Number of Paid Claims	Total Payments (millions)
Iberia	3,085	2,683	$94.70
St. Martin	1,323	1,093	$19.10
St. Mary	2,346	1,794	$31.50
Total	6,754	5,570	$145.20

Source: Federal Emergency Management Agency (FEMA)

1.5 SCOPE OF THE STUDY

Problem Description. The study area is characterized by low, flat terrain, which makes the area highly susceptible to flooding from the tidal surges of hurricanes and tropical storms, as well as riverine flooding from excess precipitation. Exacerbating the flooding is the phenomenon of relative sea level rise (RSLR), which is the combination of water level rise and land subsidence. The highest rates of RSLR of all North America coastal communities are found in the SCCL study area.

The exposure of the study area to coastal storm surge was made apparent by Hurricane Gustav in 2008, which made landfall around Cocodrie, which is near Houma and the study area extents in Morgan City (see Figure 4). Hurricane Gustav shut down the primary highway leading from southern Louisiana to New Orleans and required thousands of residents to either evacuate or shelter in place.

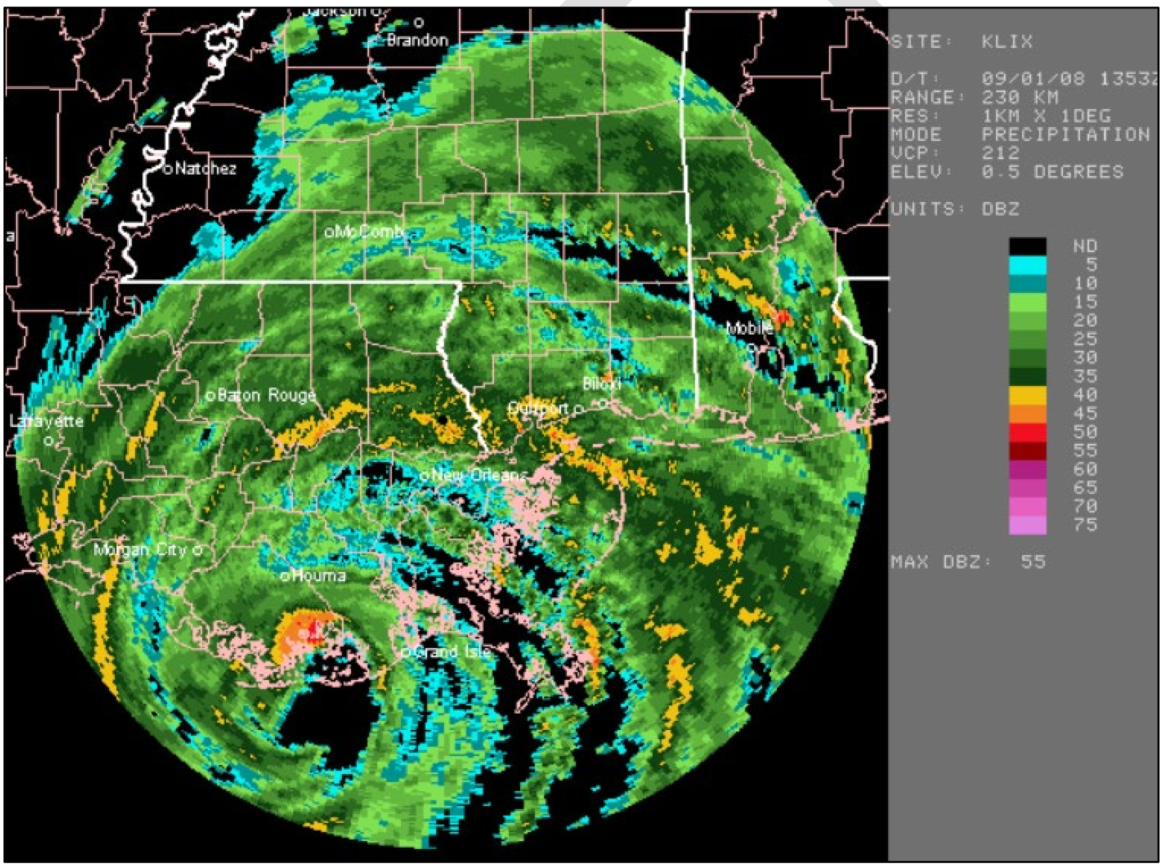

Figure 4. Satellite View of Hurricane Ike

Project Measures. The suite of measures carried through to the final array included:

- Raising Levees West of Berwick (Ex -1)
- Construction of new Ring Levees 1+2, or 2,
- Raising levees surrounding Morgan City
- Nonstructural elevations and flood proofing at the 25, 50 and 100 year floodplain
- Nonstructural acquisitions and relocation at the 25 year floodplain

The economic appendix only includes basic descriptions of measures carried through to the final array (4th planning iteration). A full description of measures included in the focused array (3rd planning iteration) and final array can be found in Chapter 3.

Raising Levees West of Berwick.

Economic assessments of all levee segments within Levees West of Berwick, were not justified during the third planning iteration. However, coordination with the non-federal sponsor highlighted the importance of these reaches due to presence of critical infrastructure and economic hot spot identification. The hot spot analysis showed geographic areas where existing damages to infrastructure were expected to be experienced during future coastal storm hazard events. The PDT refined the Levee West of Berwick measure to include only the levee subsegment (Ex-1) near Franklin, Louisiana that had the highest probability of meeting economic justification.

Construction of new Ring Levees.

Analysis during the third iteration resulted in the screening of Ring levees 1 and 3 individually. Due to the Port of Iberia being an economic hot spot, the PDT determined evaluation of Ring levee 1 combined with Ring Levee 2 may result in a justified project. Ring Levee 1 in conjunction with Ring Levee 2 was carried forward.

Raising Levees Surrounding Morgan City.

There are two portions of the Morgan City Back Levees not currently completed to represent 0.01 AEP storm surge risk reduction elevation, known as Lakeside Gap (Ex-21) and Youngs Rd (Ex-19). Youngs Road Levee Gap levee elevation would be raised over a 3,054 linear foot length. Lakeside Gap I-wall with barge gate at Lakeside Subdivision, is 2,143 feet long. An I-wall is a line of steel sheet piling similar to adjacent levee segments. This feature also included replacing an existing barge gate on the eastern edge.

Nonstructural.

Two nonstructural measures have been carried forward to the final array and include elevating residential structures up to 13 feet and floodproofing non-residential structures up to 3 feet. The acquisition measure includes acquiring and relocating structures. For both nonstructural measures, a floodplain aggregation methodology was utilized that grouped structures together based on their flood depth relative to first floor elevation during various coastal storm surge events (25, 50, and 100YR). For example, all structures with flood depths greater than the first floor elevation during the 25YR event would be grouped together into a "25-Year Aggregation" nonstructural plan. Evaluating a group of structures together instead of individually helps remove bias related to structure values, building type, social status, or any other contributing factor besides the combination of flood frequency and magnitude. The 25-

year aggregation was determined to be the most efficient plan and therefore the acquisition measure was limited to that aggregation.

2.0 ECONOMIC AND ENGINEERING INPUTS TO THE HEC-FDA MODEL

2.1 HEC-FDA MODEL

Model Overview. The Hydrologic Engineering Center Flood Damage Analysis (HEC-FDA) Version 1.4.2 Corps-certified model was used to calculate the damages and benefits for the South Central Coastal Louisiana evaluation. The economic and engineering inputs necessary for the model to calculate damages for the project base year (2025) include the existing condition structure inventory, contents-to-structure value ratios, vehicles, first floor and ground elevations, and depth-damage relationships, and without-project and with-project stage-probability relationships.

The uncertainty surrounding each of the economic and engineering variables was also entered into the model. Either a normal probability distribution, with a mean value and a standard deviation, or a triangular probability distribution, with a most likely, a maximum and a minimum value, was entered into the model to quantify the uncertainty associated with the key economic variables. A normal probability distribution was entered into the model to quantify the uncertainty surrounding the ground elevations. The number of years that stages were recorded at a given gage was entered for each study area reach to quantify the hydrologic uncertainty or error surrounding the stage-probability relationships.

2.2 ECONOMIC INPUTS TO THE HEC-FDA MODEL

Structure Inventory. A structure inventory of residential and non-residential structures for the SCCL study area was obtained using the National Structure Inventory (NSI), version 2.0. NSI was originally created by USACE to simplify the GIS pre-processing workflow for the Modeling Mapping and Consequence center (MMC) and was recently upgraded to version 2 using upgraded data sources and algorithms. The NSI 2.0 database was significantly improved through various techniques further described in subsequent sections.

National Structure Inventory 2.0. NSI 2.0 sources its structural attribute data from tax assessed parcel data (available through CoreLogic), business location data available through Esri/Infogroup, and HAZUS (where other datasets were unavailable). NSI 2.0 data is not an exact representation of reality, but rather contains many county-level, state-level, or regional assumptions applied to individual structures, often by random assignment. As such, while county or other large aggregations of structures will be accurate on average, individual structure characteristics may not be accurate. Although these and other accuracy issues exist, the NSI 2.0 dataset functions as an available common and consistent standard for the United States. The chief advantage of NSI 2.0 over other national datasets is its spatial accuracy, which is a significant improvement over the census block level accuracy that NSI 1.0 relied on.

Structure Values. As previously identified by the description of the NSI 2.0, the national database has limitations and oversimplifications that lead to unacceptable levels of uncertainty for a feasibility level study. To overcome the limitations and reduce uncertainty, RS Means was used to reevaluate the depreciated replacement values and a statistically significant sample was performed to ensure an accurate representation of structural attributes. This process is further described in the "*Sample Structural Attributes*" section.

The 2019 RS Means Square Foot Costs Data catalog was used to assign a depreciated replacement cost to the residential and non-residential structures in the study area reaches. Residential replacement costs per square foot were provided for four exterior walls types (wood frame, brick veneer, stucco, or masonry) and three construction classes (economy, average, and luxury) reflecting the quality of the materials used in the construction of the buildings. An average replacement cost per square foot for the four exterior wall types was calculated for each construction class. Based on windshield surveys, it was determined that the characteristics of the structures in the area were consistent with those of the average construction class, and as such were depreciated 15 percent. An additional regional adjustment factor (0.86 for residential) based on construction costs around Lafayette, Louisiana was applied to the depreciated cost per square foot. The mean final cost per square foot by occupancy type was then applied to every structure in the inventory to determine depreciated replacement values. The square footage for each of the individual residential structures was multiplied by the size-specific depreciated cost per square for the average construction class to obtain a total depreciated cost. Finally, the Marshall and Swift Valuation Service was used to calculate a depreciated replacement cost per square foot for the manufactured or mobile homes in the Southern Louisiana area.

Non-residential replacement costs per square foot were provided in the RS Means catalog for six exterior wall types: decorative concrete with steel frame and with bearing walls frame, face brick with concrete block back-up with steel frame and with bearing walls frame, metal sandwich panel with steel frame, and precast concrete panel with bearing walls frame. An average replacement cost per square foot was calculated for each of the six exterior wall types and for each non-residential occupancy. The RS Means depreciation schedule for non-residential structures provides depreciation percentages for three structure frames: wood frame exterior, masonry on wood frame, and masonry on steel frame. Based on windshield surveys, it was determined that the majority of the non-residential structures in the area reflected the masonry on wood exterior wall construction with an approximate observed age of 20 years. The masonry on wood depreciation percentage (25 percent) was applied to all of the non-residential structures in the structure inventory. An additional regional adjustment factor (0.84 for non-residential) based on construction costs around Lafayette, Louisiana was applied to the depreciated cost per square foot. The square footage for each of the individual structures was multiplied by the size-specific depreciated cost per square for each non-residential occupancy to obtain a total depreciated cost.

Table 9 shows the structure count, average square footage, and distribution of costs per square foot for each of the RS Means occupancy types.

Table 9. RS Means Structure Inventory Statistics

			RS Means Cost per Sq Ft		
RS Means Occupancy Type	Count	Avg. Square Ft	Minimum	Most Likely	Maximum
Post Frame Barn	167	3,300	29	36	45
Store, Retail	1,235	7,200	84	105	128
Garage, Parking	12	9,700	44	56	68
Warehouse	792	11,200	79	99	122
Garage, Service Station	1,026	4,000	116	145	178
Office, 1 Story	2,275	4,710	122	152	187
Bank	140	5,400	134	167	205
Hospital, 2-3 Story	20	43,900	188	236	289
Medical Office, 1 Story	325	3,800	104	129	159
Restaurant	715	9,300	113	141	174
Movie Theatre	11	9,700	108	135	165
School, Elementary	140	8,000	87	108	133
College, 2-3 Story	8	15,200	108	135	165
Police Station	101	10,500	140	175	215
Factory, 1 Story	657	9,702	76	95	117
Church	418	4,200	164	205	251
1 Story Res	39,176	2,512	53	78	90
2 Story Res	9,212	2,575	57	83	97
Mobile Home	5,597	900	24	50	73
Apartment, 1-3 Story	821	13,116	101	126	155
Motel, 1 Story	91	13,000	78	97	120
Jail	19	28,100	189	236	290
Nursing Home	25	46,500	110	138	169

Structure Value Uncertainty. The uncertainty surrounding the residential structure values includes the depreciation percentage applied based on the effective age and condition of the structures as well as the four exterior wall types. A triangular probability distribution was developed for residential structures using the following RS Means information:

- Minimum Depreciation – Effective Age: 10 Years & Good Condition
- Most Likely Depreciation – Effective Age: 20 Years & Average Condition
- Maximum Depreciation – Effective Age: 30 Years & Poor Condition

Effective age for this uncertainty analysis was defined as the average observed age of a structure as recorded during the windshield survey. These values were then converted to a percentage of the most-likely value with the most-likely value equal to 100 percent of the average value for each exterior wall type and occupancy category. The triangular probability distributions were entered into the HEC-FDA model to represent the uncertainty surrounding the structure values in each residential occupancy category.

The uncertainty surrounding the non-residential structure values was based on the depreciation percentage applied to the average replacement cost per square calculated from the six exterior wall types. A triangular probability distribution was developed for non-residential structures using the following RS Means information:

- Minimum Depreciation – Effective Age: 10 Years & Masonry on Masonry/Steel
- Most Likely Depreciation – Effective Age: 20 Years & Masonry on Wood
- Maximum Depreciation – Effective Age: 30 Years & Frame

These values were then converted to a percentage of the most-likely value with the most-likely value being equal to 100 percent and the minimum and maximum values equal to percentages of the most-likely value. The triangular probability distributions were entered into the HEC-FDA model to represent the uncertainty surrounding the structure values for each non-residential occupancy category. Table 10 shows the minimum and maximum percentages of the most-likely structure values assigned to the various structure categories.

Table 10. RS Means Structure Value Uncertainty Factors

	RS Means Cost per Sq Ft Factor		
RS Means Occupancy Type	Minimum	Most Likely	Maximum
Non-Residential	0.80	1.00	1.23
1 Story Res	0.69	1.00	1.16
2 Story Res	0.69	1.00	1.16
Mobile Home	0.48	1.00	1.47

Residential and Non-Residential Content-to-Structure Value Ratios. Based on Economic Guidance Memorandum (EGM), 01-03, dated 4 December 2000, a content-to-structure value ratio (CSVR) of 100 percent was applied to all of the residential structures in the structure inventory. The EGM states that the 100 percent CSVR is to be used with the generic depth-damage relationships developed for residential structures, which were also used for this study.

The content-to-structure value ratios (CSVRs) applied to the non-residential structure occupancies were taken from an extensive survey of business owners in coastal Louisiana for three large coastal storm risk management evaluations. These interviews included a sampling from the eight non-residential content categories from each of the three evaluation areas. A total of 210 non-residential structures were used to develop CSVRs for each of the non-residential categories.

Since only a limited number of property owners participated in the field surveys and the participants were not randomly selected, statistical bootstrapping was performed to address the potential sampling error in estimating the mean and standard deviation of the CSVR values. Statistical bootstrapping uses re-sampling with replacement to improve the estimate of a population statistic when the sample size is insufficient for straightforward statistical inference. The bootstrapping method has the effect of increasing the sample size and accounts for distortions caused by a specific sample that may not be fully representative of the population.

Content-to-Structure Value Ratio Uncertainty. For each of the occupancy types, a mean CSVR and a standard deviation was calculated and entered into the HEC-FDA model using the information gathered from the survey performed for the three large coastal storm risk management evaluations. A normal probability density function was used to describe the uncertainty surrounding the CSVR for each content category. The expected CSVR percentage values and standard deviations for each of the occupancy types are shown in Table 11.

Table 11. Content-to-Structure Value Ratios and Uncertainty

	Average	Standard Deviation
1-Story Res	69%	37%
2-Story Res	67%	35%
Mobile Home	114%	79%
EAT	168%	327%
GROC	134%	80%
MULT	28%	17%
PROF	54%	59%
PUBL	57%	90%
REPA	239%	320%
RETA	124%	111%
WARE	207%	366%

Vehicle Inventory and Values. Based on 2017 Census information for the Louisiana area, there are an average of 1.76 vehicles associated with each household (owner occupied housing or rental unit). According to the Southeast Louisiana Evacuation Behavioral Report published in 2006 following Hurricanes Katrina and Rita, approximately 70 percent of privately owned vehicles are used for evacuation during storm events. The remaining 30 percent of the privately owned vehicles remain parked at the residences and are subject to flood damages. According to Edmund, the average value of a used car was $19,700 as of June 2018. Since only those vehicles not used for evacuation can be included in the damage calculations, an adjusted average vehicle value of $10,400 ($19,657 x 1.76 x 0.30) was assigned to each individual residential automobile structure record in the HEC-FDA model.

If an individual structure contained more than one housing unit, then the adjusted vehicle value was assigned to each housing unit in a residential or multi-family structure category. Only vehicles associated with residential structures were included in the analysis. Vehicles associated with non-residential properties were not included in the evaluation. As of the TSP milestone, vehicle values were calculated as discussed but not included in the final HEC-FDA model runs associated with the costs and benefits. It is not expected that the forgone benefits of not including vehicles has an impact on the overall plan selection.

Vehicle Value Uncertainty. The uncertainty surrounding the values assigned to the vehicles in the inventory was determined using a triangular probability distribution function. The average value of a used car, $19,700, was used as the most-likely value. The average value of a new vehicle, $33,560, before taxes, license, and shipping charges was used as the maximum value, while the average 10-year depreciation value of a vehicle, $3,000 was used as the minimum value. The percentages were developed for the most-likely, minimum, and the maximum values with the most-likely equal to 100 percent, and the minimum and the maximum values as percentages of the most-likely value (minimum=16%, most-likely=100%, maximum=180%). These percentages were entered into the HEC-FDA model as a triangular probability distribution to represent the uncertainty surrounding the vehicle value for both residential and non-residential vehicles.

Elevation Data. Elevation data associated with the ground surface, foundation heights, and first floors of structures are critical to the economic analysis and feasibility of studies. Given the low-resolution of elevation data provided with the NSI 2.0 database, a statistically significant sample was calculated to inform a windshield survey to improve the estimates associated with foundation and first floor elevations.

A geo-stratified sample was applied to the SCCL study area to split the structure inventory into separable elements that do not naturally share similar attributes, such as foundation height. For the SCCL study, the sample was geospatially stratified between the coastal and inland areas using coastal storm surge data provided by the H&H Branch. Figure 5 shows how the SCCL study area was stratified between coastal and inland using storm surge flood depth break lines at approximately the 9.8 feet level.

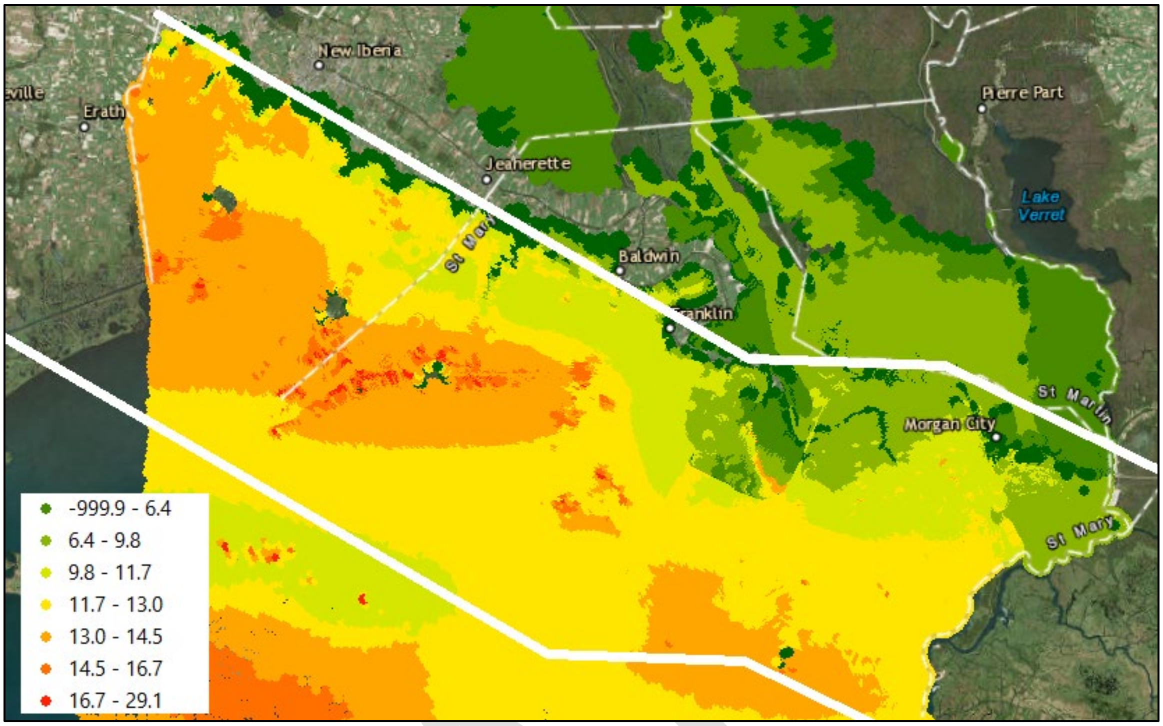

Figure 5. Geo-stratified Break Lines using Coastal Storm Surge Depths of Inundation

A GIS-based sampling design tool developed by the National Oceanic and Atmospheric Administration (NOAA) was used to generate a geographically random sample of structures split between inland and coastal structures. Within either the coastal or inland stratification, structures were sampled using construction categories (either residential or commercial). The amount of structures to sample was computed using the statistically significant sample size formula in Figure 6. The allowable error within the formula deviated from 0.20 feet but was limited to 20% to 30% of the standard deviation of the foundation height to reduce the amount of uncertainty in the structural attributes being sampled.

$$n = \left(\frac{Z*S}{E}\right)^2, \text{ where}$$

n = Sample size

Z = Z-Value (1.96)

$$S = \frac{Foundation\ Height_{High} - Foundation\ Height_{Low}}{6}$$

E = Allowable error (0.20 feet)

Figure 6. Statistically Significant Sample Size Formula

Two Google Street View windshield surveys were conducted:

1) The first was a preliminarily survey completed prior to calculating the formula in Figure 9 to determine the standard deviation of the average residential and commercial structures foundation height (S).
2) Once the standard deviation was estimated, it was entered into the formula in Figure 9 to determine how many structures to sample based on the designated stratification. The second windshield survey was the final survey performed.

For the SCCL study area, the formula resulted in sampling 84 residential coastal, 21 commercial coastal, 43 residential inland, and 35 commercial inland structures. This amount was exceeded in all categories by at least 30%. The standard deviation of the final survey was compared to the preliminary survey and verified that the amount of structures sampled exceeded the minimum calculated in the formula. The variables sampled included:

- Foundation height – measured from the bottom of the front door to adjacent ground, each step was assumed to be 8 inches
- Foundation type – designated as either slab on grade, pier/pile, or crawlspace
- Story count – measured as either one or two or more story height
- Existing condition – qualitative judgment of the condition of the exterior of the structure condition
- Verification of occupancy type – confirmation of the occupancy being one of the 10 occupancy types

The results of the SCCL sample were compared with the results from the significantly larger 2012 Morganza to the Gulf sample. The comparison is shown in Table 12.

Table 12. Comparison of Sampling Results between SCCL and Morganza to the Gulf

South Central Coastal Sample				Morganza To the Gulf Sample		
OccType	Number of Structures	Average. Foundation (ft.)	Standard Deviation (ft.)	Number of Structures	Average. Foundation (ft.)	Standard Deviation (ft.)
1STY-PIER	90 (23%)	3.4	1.39	12,510 (24%)	2.9	3.15
1STY-SLAB	168 (43%)	0.92	0.42	21,505 (41%)	0.64	0.33
2STY-PIER	2 (1%)	3	N/A	566 (3%)	2.01	1.96
2STY-SLAB	6 (2%)	0.88	N/A	1338 (11%)	0.64	0.33
COM	122 (31%)	0.68	0.54	16,098 (31%)	0.94	0.56

The two studies share similar geographic characteristics, and Table 11 helps show that the structural attributes sampled for both inventories were very similar despite the difference in sample sizes and budget. As a result of this comparison, the foundation height value and standard deviation by occupancy type was applied to the SCCL studies structure inventory.

Ground Surface Elevations. Topographical data based on Light Detection and Ranging (LiDAR) data using NAVD 88 vertical datum was processed by the United States Geological Survey (USGS) and provided in a 3-meter resolution raster format. The 3-meter LiDAR data were used to assign ground elevations to structures and vehicles in the study area.

First Floor Elevations. The ground elevation was added to the height of the foundation of the structure above the ground in order to obtain the first floor elevation of each structure in the study area. Vehicles were assigned to the ground elevation of the adjacent residential structures and did not include adjustments for foundation heights.

Elevation Uncertainty. There are two sources of uncertainty surrounding the first floor elevations: the use of the LiDAR data for the ground elevations, and the methodology used to determine the structure foundation heights above ground elevation. The error surrounding the LiDAR data was determined to be plus or minus 0.5895 feet at the 95 percent level of confidence. This uncertainty was normally distributed with a mean of zero and a standard deviation of 0.3 feet.

The uncertainty surrounding the foundation heights for the residential and commercial structures was estimated by calculating the standard deviations surrounding the sampled mean values. An overall weighted average standard deviation for the four structure groups was computed for each structure category. Table 11 on the previous page shows the distribution of the foundation height uncertainty for each occupancy type.

The standard deviations for the ground elevations and foundation heights were combined, which resulted in a 3.16 feet standard deviation for residential pier foundation structures and 0.45 for slab foundation structures. For commercial structures, the combined standard deviation was calculated to be 0.64 feet for pier foundation structures. For industrial structures, the commercial value was utilized. Table 13 displays the calculations used to combine the uncertainty surrounding the ground elevations with uncertainty surrounding the foundation height to derive the uncertainty surrounding the first floor elevations of residential, commercial and industrial structures.

Table 13. First Floor Stage Uncertainty Standard Deviation (SD) Calculation

Ground - LiDAR		
(conversion cm to inches to feet)		
+/- 18 cm @ 95% confidence		18cm
	x	0.393
z = (x - u)/ std. dev.		7.074in
	÷	12
1.96 = (0.5895 - 0)/ std.dev.		0.5895ft

Foundation Height (shown in feet)			
Residential		Commercial	Industrial
Pier	Slab	All	All
3.15	0.33	0.56	0.56

0.3007 = std.dev.

Combined First Floor

(shown in feet)

Residential		Commercial	Industrial	
Pier	Slab	All	All	
0.30	0.30	0.30	0.30	ground std. dev.
0.09	0.09	0.09	0.09	ground std. dev. Squared
3.15	0.33	0.56	0.56	1st floor std. dev.
9.92	0.11	0.31	0.31	1st floor std. dev. squared
10.01	0.20	0.40	0.40	Sum of Squared
3.16	**0.45**	**0.64**	**0.64**	**Square Root of Sum of Squared = Combined Std. Dev.**

Note 1: Mobile Homes are assigned the same uncertainty as Residential Pier.

Note 2: Autos do not have foundations, so only ground uncertainty is used.

Debris Removal Costs. Debris removal costs are typically discussed in the Other Benefit Categories section of the Economic Appendix. However, since debris removal costs were included as part of the HEC-FDA structure records for the individual residential and non-residential structures in the SCCL study area, these costs are being treated as an economic input. The HEC-FDA model does not report debris removal costs separately from the total expected annual without-project and with-project damages.

Following Hurricanes Katrina and Rita, interviews were conducted with experts in the fields of debris collection, processing and disposal to estimate the cost of debris removal following a storm event. Information obtained from these interviews was used to assign debris removal costs for each residential and non-residential structure in the SCCL structure inventory. The experts provided a minimum, most likely, and maximum estimate for the cleanup costs associated with the 2 feet, 5 feet, and 12 feet depths of flooding. A prototypical structure size in square feet was used for the residential occupancy categories and for the non-residential occupancy categories. The experts were asked to estimate the percentage of the total cleanup caused by floodwater and to exclude any cleanup that was required by high winds.

In order to account for the cost/damage surrounding debris cleanup, values for debris removal were incorporated into the structure inventory for each record according to its occupancy type. These values were then assigned a corresponding depth-damage function with uncertainty in the HEC-FDA model. For all structure occupancy types, 100% damage was reached at 12 feet of flooding. All values and depth-damage functions were selected according to the long-duration flooding data specified in a report titled “Development of

Depth-Emergency Cost and Infrastructure Damage Relationships for Selected South Louisiana Parishes." The debris clean-up values provided in the report were expressed in 2010 price levels for the New Orleans area. These values were converted to 2019 price levels for the SCCL study area using the indexes provided by Gordian's 2019 edition of "Square Foot Costs with RS Means Data." The debris removal costs were included as the "other" category on the HEC-FDA structure records for the individual residential and non-residential structures and used to calculate the expected annual without-project and with-project debris removal and cleanup costs.

Debris Removal Costs Uncertainty. The uncertainty surrounding debris percentage values at 2 foot, 5 foot and 12 foot depths of flooding were based on range of values provided by the four experts in the fields of debris collection, processing, and disposal. The questionnaires used in the interview process were designed to elicit information from the experts regarding the cost of each stage of the debris cleanup process by structure occupancy type. The range of responses from the experts were used to calculate a mean value and standard deviation value for the cleanup costs percentages provided at 2 feet, 5 feet, and 12 feet depths of flooding. The mean values and the standard deviation values were entered into the HEC-FDA model as a normal probability distribution to represent the uncertainty surrounding the costs of debris removal for residential and non-residential structures. The depth-damage relationships containing the damage percentages at the various depths of flooding and the corresponding standard deviations representing the uncertainty are shown with in the depth–damage tables.

Depth-Damage Relationships. The USACE generic depth-damage relationships for one-story and two-story residential structures with no basement from EGM, 01-03, dated 4 December 2000, were used in the analysis. The mobile home depth-damage relationships were based on the relationships developed by a panel of insurance experts as part of the Morganza to the Gulf feasibility study, previously referenced above Table 11. The vehicle depth-damage functions were based on the generic depth-damage curves from EGM, 09-04, generic depth-damage relationships for vehicles, dated 22 June 2009. The generic vehicle curves for sedans were used for vehicles associated with residential structures.

Since site-specific non-residential depth-damage relationships were not available for the SCCL study area, the saltwater, long duration (greater than 1 day of inundation) depth-damage relationships, developed by a panel of building and construction experts for the Lower Atchafalaya and Morganza to the Gulf, Louisiana feasibility study, were used in the economic analysis. These relationships were deemed appropriate because the adjacent study area has similar coastal topography and hydrology and similar structure categories and occupancies. Both study areas are characterized by low, flat terrain and are highly susceptible to flooding from the tidal surges associated with hurricanes and tropical storms due to their proximity to the Gulf of Mexico. The majority of the residential structures in the inventory are either wood frame construction with pier foundation or masonry construction with slab foundation. The areas have similar types of retail, eating and recreation non-residential structures and warehouse facilities.

Since the major source of flooding in both study areas is related to tropical storm surges from the Gulf of Mexico, saltwater depth-damage relationships were used in the analysis. Water is pushed into the area during a tropical event must flow over land features such as beaches, agricultural land, roads and highways, ridges along waterways and localized flood risk management systems. After the storm system moves through the area, there are no mechanisms to push the water back over these land features, and the saltwater could remain inside of inundated structures for several days. Evacuated residents may not be able to return to their homes until the roads are safely passable and electrical power has been restored. According to a panel of experts, when water remains inside of structures located in a warm, humid climate for several days, mold will quickly develop, and additional damages will occur.

Depth-damage relationships indicate the percentage of the total structure value that would be damaged at various depths of flooding. For residential structures, damage percentages were provided at each one-foot increment from two feet below the first floor elevation to 16 feet above the first floor elevation for the structural components and the content components. For non-residential structures, damage percentages were determined for each one-half foot increment from one-half foot below first floor elevation to two feet above first floor, and for each one-foot increment from 2 feet to 15 feet above first floor elevation. Vehicle damage relationships were provided from one-half foot above the ground to 10 feet above the ground.

Uncertainty Surrounding Depth-Damage Relationships. A normal distribution with a standard deviation for each damage percentage provided at the various increments of flooding was used to determine the uncertainty surrounding the generic depth-damage relationships used for residential structures and vehicles. For non-residential structures and mobile homes, a triangular probability density function was used to determine the uncertainty surrounding the damage percentage associated with each depth of flooding. A minimum, maximum and most-likely damage estimate was provided by a panel of experts for each depth of flooding. The specific range of values regarding probability distributions for the depth-damage curves can be found in the final report dated May 1997 entitled Depth-Damage Relationships for Structures, Contents, and Vehicles and Content-to-Structure Value Ratios (CSVRs) in Support of the Lower Atchafalaya Reevaluation and Morganza to the Gulf, Louisiana Feasibility Studies. The specific range of values regarding probability distributions for the debris depth-damage curves can be found in the final report dated March 2012 entitled Development of Depth-Emergency Cost and Infrastructure Damage Relationships for Selected South Louisiana Parishes. This report was also used as the basis for the depth-damage relationships developed for transportation infrastructure, which will be discussed more fully in the Other Benefits section of the economic appendix.

Part 6 of this appendix (supplemental tables) shows the damage relationships for structures, contents, vehicles, and debris removal. The tables contains the damage percentages at each depth of flooding along with the uncertainty surrounding the damage percentages.

2.3 ENGINEERING INPUTS TO THE HEC-FDA MODEL

Stage-Probability Relationships. Stage-probability relationships were provided for the existing without-project condition (2025) and future without-project condition (2075). With-project and future with-project and for future with-project conditions were not provided for the TSP milestone given the complexity of modifying the ADCIRC (storm surge) model. For more information on how benefits were computed without with project hydraulic conditions, see Section 5.1.The ADCIRC model was originally developed for the 2010

LACPR coastal study, and the SCCL study used unmodified versions of the ADCIRC outputs for the existing and future conditions.

The ADCIRC model provided water surface profiles for six annual exceedance probability (AEP) events ranging from the 0.02 (50-year) to the 0.001 (1000-year) events. The H&H and GIS branches interpolated the results to provide water surface profiles for eight AEP events: 0.50 (2-year), 0.20 (5-year), 0.10 (10-year), 0.04 (25-year), 0.02 (50-year), 0.01 (100-year), 0.004 (250-year), and 0.002 (500-year). The without-project water surface profiles were based on storm surge and incorporated heavy rainfall events. The future without-project condition (2075) is based on an intermediate sea level rise (SLR) forecast that assumes an approximate raise in seal level of 1.8 feet and was only used to scale the height at which structures will be elevated in the nonstructural condition. The ADCIRC model results were summarized in a geospatial format though the designation of hydraulic subunits, as previously shown in Figure 2.

Uncertainty Surrounding the Stage-Probability Relationships. A 50-year equivalent record length was used to quantify the uncertainty surrounding the stage-probability relationships for each study area reach. Based on this equivalent record length, the HEC-FDA model calculated the confidence limits surrounding the stage-probability functions.

3.0 NATIONAL ECONOMIC DEVELOPMENT (NED) FLOOD DAMAGE AND BENEFIT CALCULATIONS

3.1 HEC-FDA MODEL CALCULATIONS

The HEC-FDA model was utilized to evaluate flood damages using risk-based analysis. Damages were reported at the index location for each of the 158 study area reaches for which a structure inventory had been created. A range of possible values, with a maximum and a minimum value for each economic variable (first floor elevation, structure and content values, and depth-damage relationships), was entered into the HEC-FDA model to calculate the uncertainty or error surrounding the elevation-damage, or stage-damage, relationships. The model also used the number of years that stages were recorded at a given gage to determine the hydrologic uncertainty surrounding the stage-probability relationships.

The possible occurrences of each variable were derived through the use of Monte Carlo simulation, which used randomly selected numbers to simulate the values of the selected variables from within the established ranges and distributions. For each variable, a sampling technique was used to select from within the range of possible values. With each sample, or iteration, a different value was selected. The number of iterations performed affects the simulation execution time and the quality and accuracy of the results. This process was conducted simultaneously for each economic and hydrologic variable. The resulting mean value and probability distributions formed a comprehensive picture of all possible outcomes.

3.2 STAGE-DAMAGE RELATIONSHIPS WITH UNCERTAINTY

The HEC-FDA model used the economic and engineering inputs to generate a stage-damage relationship for each structure category in each study area reach under existing (2025). The possible occurrences of each economic variable were derived through the use of Monte Carlo simulation. A total of 1,000 iterations were executed in the model for the stage-damage relationships. The sum of all sampled values was divided by the number of samples to yield the expected value for a specific simulation. A mean and standard deviation was automatically calculated for the damages at each stage.

3.3 STAGE-PROBABILITY RELATIONSHIPS WITH UNCERTAINTY

The HEC-FDA model used an equivalent record length (50 years) for each study area reach to generate a stage-probability relationship with uncertainty for the without-project condition under base year (2025) conditions through the use of graphical analysis. The model used the eight stage-probability events together with the equivalent record length to define the full range of the stage-probability functions by interpolating between the data points. Confidence bands surrounding the stages for each of the probability events were also provided.

3.4 WITHOUT-PROJECT EXPECTED ANNUAL DAMAGES.

The model used Monte Carlo simulation to sample from the stage-probability curve with uncertainty. For each of the iterations within the simulation, stages were simultaneously selected for the entire range of probability events. The sum of all damage values divided by the number of iterations run by the model yielded the expected value, or mean damage value, with confidence bands for each probability event. The probability-damage relationships are integrated by weighting the damages corresponding to each magnitude of flooding (stage) by the percentage chance of exceedance (probability). From these weighted damages, the model determined the expected annual damages (EAD) with confidence bands (uncertainty). For the without-project alternative, the expected annual damages (EAD) were totaled for each study area reach to obtain the total without-project EAD under base year (2025) conditions.

Table shows the number and type of structures that are damaged by each of annual exceedance probability events for the year 2025 under without-project conditions.

Table 14. Total Economic Damage by Probability Events in 2025 ($1,000s)

Annual Exceedance Probability (AEP)	**Residential**	**Non-Residential**	**Total**
Existing Condition (2025)			
0.50 (2 yr)	-	-	-
0.20 (5 yr)	-	-	-
0.10 (10 yr)	63,000	214,000	277,000
0.04 (25 yr)	266,000	521,000	787,000
0.02 (50 yr)	613,000	1,081,000	1,694,000
0.01 (100 yr)	1,160,000	1,712,000	2,872,000
0.005 (200 yr)	1,436,000	2,043,000	3,479,000
0.002 (500 yr)	2,324,000	3,081,000	5,405,000

Source: Structure Detail Output from the HEC-FDA model

3.5 STRUCTURE INVENTORY ADJUSTMENTS FOR HIGH FREQUENCY INUNDATION

Adjustments were made to the structure inventory to more accurately reflect the most-likely future without-project and with-project conditions. Under without-project and with-project conditions, residential and non-residential structures that were identified as being inundated above the first floor elevation from the 0.50 (2-year) and 0.20 (5-year) AEP events were modified to have the 2-year and 5-year stages below the ground surface elevation by at least seven feet to ensure high frequency damages were mitigated in the existing and future without-project conditions. This adjustment is consistent with the FEMA floodplain regulations that require residents to rebuild above the base flood elevation after a structure receives greater than 50 percent damage to the structural components as a result of a flood.

Table 14 shows the without project condition expected annual damages for the final array of measures. Table 15 shows the expected annual damage reduced for the final array of measures. The probability of damages being reduced exceeds the 75%, 50% and 25% thresholds typically reported was not available since the with project nonstructural alternative information was provided by the structuredetail.out table, which does not include uncertainty. Figure 7 shows the geographic distribution of existing condition expected annual damages and Figure 8 shows the geographic distribution of expected annual damages reduced as a result of implementing the TSP recommendation of the 25YR nonstructural plan. The figures show that the recommended plan is effective at reducing expected annual damages in the reaches that have damages occurring in the existing condition.

Table 15. Expected Annual Damages by Damage Category ($1,000's)

Plan	Vehicle	Commercial	Industrial	Public	Residential	Total
Without Project	4,398	100,074	47,626	7,046	61,102	220,246
25-year Elev/Floodproof	4,398	64,076	30,494	4,511	41,938	145,417
50-year Elev/Floodproof	4,398	59,958	28,534	4,221	39,243	136,354
100-year Elev/Floodproof	4,398	55,353	26,343	3,897	36,229	126,220
25-year Acquisitions	2,336	53,164	25,301	3,743	32,460	117,005
Berwick Levee Raises	4,333	98,599	46,924	6,942	60,201	216,999
Ring Levees 1+2	4,049	91,105	78,957	2,025	26,319	202,455
Ring Levee 2	4,170	93,822	81,312	2,085	27,104	208,493
Morgan City Levee Raises	4,345	97,760	84,725	2,172	28,242	217,244

Table 16. Expected Annual Damages Reduced by Measure ($1,000's)

Plan	Total Without Project	Total With Project	Damages Reduced
Without Project	220,246	220,246	0
25-year Elev/Floodproof	220,246	145,417	74,829
50-year Elev/Floodproof	220,246	136,354	83,892
100-year Elev/Floodproof	220,246	126,220	94,026
25-year Acquisitions	220,246	117,005	103,241
Berwick Levee Raises	220,246	216,999	3,247
Ring Levees 1+2	220,246	202,455	17,791
Ring Levee 2	220,246	208,493	11,753
Morgan City Levee Raises	220,246	217,244	3,002

Figure 7. Expected Annual Damages Reduced by Subunit (Reach) for the Existing Condition

Figure 8. Expected Annual Damages Reduced by Subunit (Reach) for the 25YR Nonstrucural Plan

4.0 PROJECT COSTS

Construction Schedule. Construction of the project alternatives is expected to begin in the year 2025 and will continue for a period of three months.

Structural Costs. Structural cost estimates for the final array were developed by the New Orleans District Cost Engineering Branch and were commensurate with a level 4 cost estimate. An abbreviated cost risk analysis was completed to determine the contingencies used for all structural measures.

Nonstructural Costs – Elevation & Floodproofing. Nonstructural cost estimates for the final array were developed through a joint effort between the New Orleans District Economics and Cost Engineering Branches. A 34.5% contingency was applied to all nonstructural cost estimates to represent the uncertainty regarding the cost and schedule risk of these measures. The contingency amount was computed during a detailed cost risk analysis performed for the Southwest Coastal Feasibility Study and was applied to this study after reviewing the associated risks and concluding they were similar for both studies.

Residential Structures. The estimate of the cost to elevate all residential structures was computed once model execution was completed. Elevation costs were based on the difference in the number of feet between the original first floor elevation and the target elevation (the future condition 100-year stage, including sea level rise) for each structure in the HEC-FDA module. The number of feet that each structure was raised was rounded to the closest one-foot increment, with the exception that structures less than one foot below the target elevation were rounded-up to one foot. Elevation costs by structure were summed to yield an estimate of total structure elevation costs.

The cost per square foot for raising a structure was based on data obtained during interviews in 2008 with representatives of three major metropolitan New Orleans area firms that specialize in the structure elevation. Composite costs were derived for residential structures by type: slab and pier foundation, one story and two story configuration, and for mobile homes. These composite unit costs also vary by the number of feet that structures may be elevated. Table 16 displays the costs for each of the five residential categories analyzed and by the number of feet elevated.

The cost per square foot to raise an individual structure to the target height was multiplied by the footprint square footage of each structure to compute the costs to elevate the structure. The footprint square footage for each structure was determined by applying the average square footage estimated for each residential structure. Added to the elevation cost was the cost of performing an architectural survey, which is associated with cultural resources concerns. The total costs for all elevated structures were annualized over the 50-year period of analysis of the project using the Fiscal Year 2020 Federal discount rate of 2.75 percent. The square foot costs for elevation was price indexed to FY19 price levels using RS Means cost catalog

Non-residential Structures. The floodproofing measures were applied to all non-residential structures. Separate cost estimates were developed to floodproof non-residential structures based on their relative square footage. Table 17 shows a summary of square footage costs for floodproofing. These costs were developed for the Draft Nonstructural Alternatives Feasibility Study, Donaldsonville

LA to the Gulf evaluation (September 14, 2012) by contacting local contractors and were adopted for this study due to the similarity in the structure types between the two study areas. Added to the floodproofing cost was the cost of performing an architectural survey, which is associated with cultural resources concerns. Again, final cost estimates are expressed in FY 2019 prices.

Table 17. Nonstructural Elevation Costs for Residential Structures ($/Sqft)

Height	1STY-PIER	1STY-SLAB	2STY-PIER	2STY-SLAB	MOBILE
[ft]	[$]	[$]	[$]	[$]	[$]
N/A	0	0	0	0	0
1	105	118	116	130	58
2	105	118	116	130	58
3	109	121	120	133	58
4	109	125	120	143	71
5	109	125	120	143	71
6	112	128	122	144	71
7	112	128	122	144	71
8	114	132	125	149	71
9	114	132	125	149	71
10	114	132	125	149	71
11	114	132	125	149	71
12	114	132	125	149	71
13	116	136	128	157	71
14	116	136	128	157	71
15	116	136	128	157	71
16	116	136	128	157	71

Table 18. Nonstructural Floodproofing Costs for Non-residential Structures ($/Sqft)

Square Footage	Cost
1,000	153,006
10,000	153,006
20,000	153,006
30,000	361,536
40,000	361,536
50,000	361,536
60,000	361,536
70,000	361,536
80,000	361,536
90,000	361,536
100,000	361,536
>= *110,000*	893,720

Nonstructural Costs – Acquisition & Relocation.

Acquisition. The estimate of the cost of acquiring structures was computed once model execution was completed. Acquisition costs are based on the cost of acquiring the parcel of land, the structure(s) built on the land, an architectural survey, and miscellaneous costs associated with the acquisition process. The depreciated replacement value of the structure (excluding any contents) was used to represent the cost of the structure, which was previously described as being sourced from RS Means Square Foot Cost data. The cost of acquiring the parcel was provided by the New Orleans Real Estate Branch, and was $2 per square foot for residential structures and $3 per square foot for non-residential structures. This square foot estimate was applied to the size of the parcel of land and not the size of the structure. Added to the acquisition cost was the cost of performing an architectural survey, which is associated with cultural resources concerns. Finally, a cost of $47,000 for residential structures and $141,000 for non-residential structures was added to represent the cost of demolition, deed changes, legal fees, and regarding the surface. These miscellaneous costs associated with acquisition were sourced from the 2010 USACE Cedar Rapids, Iowa Feasibility Report. The prices derived from the 2010 report were price indexed to 2019 price levels. Acquisition costs by structure were summed to yield an estimate of total structure acquisition cost.

Relocation. Relocation costs are based on the cost of relocating the occupant, as required per Uniform Relocation Assistance and Real Property Acquisition Act of 1970 (URA), that has been removed from the acquired parcel. Relocation costs include purchasing a suitably located piece of property commensurate with the acquired parcel and the costs associated with the URA. Costs associated with URA include assisting the occupant with moving costs and incidentals for residential structures and moving costs, searching expenses, and re-establishing costs for non-residential structures. The URA costs amount to $38,000 per residential structure and $50,000 per non-residential structure. Relocation costs by structure were summed to yield an estimate of total structure relocation cost.

The total acquisition and relocation costs were added together and applied on a per structure basis to determine the full cost of acquisition and relocation.

Annual Project Costs. Life cycle cost estimates were provided for the nonstructural measures in FY19 price levels. The initial construction costs (first costs) and the schedule of expenditures were used to determine the interest during construction and gross investment cost at the end of the installation period (2025). The FY 2020 Federal interest rate of 2.75 percent was used to discount the costs to the base year and then amortize the costs over the 50-year period of analysis.

Operations, maintenance, relocations, rehabilitation, and repair (OMRR&R) costs associated with the final array of measures was not computed due to an initial screening without it that showed negative net benefits. For the projects with positive net benefits (nonstructural), there is no OMRR&R associated in the with project condition. Residential structures are recommended to be elevated to the future year (2075) stage associated with the intermediate sea level rise and therefore it is assumed that future sea level rise will not require future elevations.

Table 19. Summary of Costs for Structural Measures

	Berwick Levee Raises	Ring Levees 1+2	Ring Levee 2	Morgan City Levee Raises
Construction First Cost	131,798,000	1,311,479,000	738,204,000	251,000,000
Wetland Mitigation Cost	923,000	16,309,000	19,450,000	-
Real Estate Cost	1,560,000	33,546,000	9,416,000	841,000
Cultural Cost	100,000	114,675,000	520,000	195,000
Interest During Construction	1,846,000	18,718,000	10,547,000	6,971,000
Total Cost	136,227,000	1,494,727,000	778,137,000	259,007,000
Average Annual Cost	5,046,000	55,366,000	28,823,000	9,594,000

Table 20. Summary of Costs for Nonstructural Measures

	25-year Elev/Floodproof	50-year Elev/Floodproof	100-year Elev/Floodproof	25-year Acquisitions
Construction First Cost	1,411,000,000	1,901,000,000	3,137,000,000	2,999,758,000
Wetland Mitigation Cost	-	-	-	-
Real Estate Cost	-	-	-	*
Cultural Cost	5,307,000	8,845,000	13,142,000	5,307,000
Interest During Construction	4,793,000	6,457,000	10,656,000	4,793,000
Total Cost	1,421,100,000	1,916,302,000	3,160,798,000	3,009,858,000
Average Annual Cost	52,639,000	70,982,000	117,079,000	111,488,000

*Note: See Nonstructural Cost discussion in Section 4.0 for a discussion on Real Estate costs

5.0 RESULTS OF THE ECONOMIC ANALYSIS

5.1 NET BENEFIT ANALYSIS

Calculation of Net Benefits. The expected annual benefits attributable to the final array of measures were compared to the annual costs to develop a benefit-to-cost ratio for the measures. The net benefits for the measures were calculated by subtracting the annual costs from the expected annual benefits. The net benefits were used to determine the economic justification of the project measures.

As previously mentioned in Section 2.3, with-project hydraulic and future with-project hydraulic conditions were not available during this stage of the study. Net benefit calculations for the with-project condition were computed using the HEC-FDA structuredetail.out summary file that contains the stage frequency-damage relationships for the study. For the structural measures, two tables were made from the stage frequency-damage relationships that showed the damage by frequency for both the with and without project condition to determine the average annual damages reduced. These tables can be found in Supplemental Table 6 and 7. Once with project and future with project hydraulics are obtained, each measure can be run through HEC-FDA and the amount of damage increased over the 50-year period of analysis can be realized. Table 21 shows the net benefits for the structural measures and Table 22 shows the net benefits for the nonstructural measures.

Table 23 displays the tentatively selected plan (TSP) for the alternative that reasonably maximizes net benefits.

Table 21. Summary of Structural Economic Benefits (Damages Reduced)

Damage Category	**Berwick Levee Raises**	**Ring Levees 1+2**	**Ring Levee 2**	**Morgan City Levee Raises**
Structural	1,022,000	5,426,000	3,585,000	946,000
Contents	2,111,000	11,743,000	7,758,000	1,951,000
Vehicle	49,000	267,000	176,000	45,000
Debris Removal	65,000	356,000	235,000	60,000
Total Average Annual Benefits	3,247,000	17,792,000	11,754,000	3,002,000
Total Average Annual Cost	5,046,000	55,366,000	28,823,000	9,594,000
Net Benefits	(1,799,000)	(37,574,000)	(17,069,000)	(6,592,000)
BCR	0.64	0.32	0.41	0.31

Table 22. Summary of Nonstructural Economic Benefits (Damages Reduced)

Damage Category	**25-year Elev/Floodproof**	**50-year Elev/Floodproof**	**100-year Elev/Floodproof**	**25-year Acquisitions**
Structural	24,694,000	27,684,000	31,029,000	32,521,000
Contents	47,891,000	53,691,000	60,177,000	66,074,000
Vehicle	-	-	-	1,549,000
Debris Removal	2,245,000	2,517,000	2,821,000	3,097,000
Total Average Annual Benefits	74,830,000	83,892,000	94,027,000	103,241,000
Total Average Annual Cost	52,639,000	70,982,000	117,079,000	111,488,000
Net Benefits	22,191,000	12,910,000	(23,052,000)	(8,247,000)
BCR	1.42	1.18	0.80	0.93

Table 23. Summary of the Tentatively Selected Plan (TSP)

Item	**Expected Annual Benefits and Costs**
Structure, Contents, Vehicles, and Debris Removal	$74,830,000
Total Annual Benefits	$74,830,000
First Costs	$1,411,000,000
Interest During Construction	$4,793,000
Annual Operation & Maintenance Costs	$0
Total Annual Costs	$52,639,000
B/C Ratio	1.42
Expected Annual Net Benefits	$22,191,000

5.2 RISK ANALYSIS

The risk analysis is a section of the report that discusses the risk and uncertainty associated with the HEC-FDA model and the economic benefits. The HEC-FDA model was utilized for the existing condition and with project alternatives, but the with project alternatives were only run to the point of producing the structuredetail.out file and therefore do not include any risk and uncertainty in their results. The sections below are placeholders for after the TSP, when the with project alternatives have been successfully modeled. Qualitative statements about each risk factor were made where possible.

5.3 BENEFIT EXCEEDANCE PROBABILITY RELATIONSHIP

Based on the information and inputs available at this point in the study, there is a high likelihood that the net benefits associated with the structural alternatives presented will only decrease as more information becomes available. This statement can be rationalized given that the Berwick Levee Raise and Ring Levees are currently costed for standard design criteria and not HSRDDS design criteria. Incorporation of HSRDDS design criteria would increase the cost estimates by at least 30%, further decreasing net benefits for the structural alternatives. The nonstructural alternatives on the other hand received costs associated with square footages much higher than the average structure and furthermore were escalated with a high contingency factor.

The risks that remain for this study are the development and implementation of hydraulic data. The study is expected to receive updated existing condition hydraulics from new ADCIRC model runs and also updated future condition hydraulics. The incorporation of the new hydraulics has the potential to change net benefits, but the magnitude of the impact is currently unknown. Future damages are always higher than existing, and therefore there is a high likelihood that net benefits will increase in the future condition. The changes to the hydraulics are expected to incorporate levee raises, new pump stations, and other infrastructure improvements within the study area. The new hydraulic data is less likely to impact the nonstructural alternatives since the nonstructural aggregation method is more adaptable to changes in the floodplain (IE, reaches becoming more or less floodprone). Both structural and nonstructural methods are susceptible to an overall decrease in existing or future condition stages.

5.4 RESIDUAL RISK

The flood risk that remains in the floodplain after the proposed alternatives are implemented is known as the residual flood risk. For SCCL, the residual risk is best illustrated from Figure 10 and Figure 11, which shows that the 25-year aggregation nonstructural plan reduced expected annual damages in every reach with the exception of Reach 150 and Reach 70. With that said, the amount of expected annual damages reduced in the reaches where the recommended plan was effective is limited. As shown in Table 15, the 25-year aggregated floodplain reduces expected annual damages by close to $75,000,000, meaning there is still another $145,000,000 of residual expected annual damages in the with-project condition.

6.0 SUPPLEMENTAL TABLES

Supplemental Table 1
South Central Coastal Louisiana Feasibility Study
Depth-Damage Relationships for Structures, Contents and Vehicles including Debris Removal

Residential 1-Story on Pier (1STY-PIER)			Residential 1-Story on Slab (1STY-SLAB)			Residential 2-Story on Pier (2STY-PIER)			Residential 2-Story on Slab (2STY-SLAB)		
Depth in Structure	Structure Percent Damage	Structure Standard Deviation	Depth in Structure	Structure Percent Damage	Structure Standard Deviation	Depth in Structure	Structure Percent Damage	Structure Standard Deviation	Depth in Structure	Structure Percent Damage	Structure Standard Deviation
-2.0	0.0	0.0	-2.0	0.0	0.0	-2.0	0.0	0.0	-2.0	0.0	0.0
-1.0	2.5	2.7	-1.0	2.5	2.7	-1.0	3.0	4.1	-1.0	3.0	4.1
0.0	13.4	2.0	0.0	13.4	2.0	0.0	9.3	3.4	0.0	9.3	3.4
1.0	23.3	1.6	1.0	23.3	1.6	1.0	15.2	3.0	1.0	15.2	3.0
2.0	32.1	1.6	2.0	32.1	1.6	2.0	20.9	2.8	2.0	20.9	2.8
3.0	40.1	1.8	3.0	40.1	1.8	3.0	26.3	2.9	3.0	26.3	2.9
4.0	47.1	1.9	4.0	47.1	1.9	4.0	31.4	3.2	4.0	31.4	3.2
5.0	53.2	2.0	5.0	53.2	2.0	5.0	36.2	3.4	5.0	36.2	3.4
6.0	58.6	2.1	6.0	58.6	2.1	6.0	40.7	3.7	6.0	40.7	3.7
7.0	63.2	2.2	7.0	63.2	2.2	7.0	44.9	3.9	7.0	44.9	3.9
8.0	67.2	2.3	8.0	67.2	2.3	8.0	48.8	4.0	8.0	48.8	4.0
9.0	70.5	2.4	9.0	70.5	2.4	9.0	52.4	4.1	9.0	52.4	4.1
10.0	73.2	2.7	10.0	73.2	2.7	10.0	55.7	4.2	10.0	55.7	4.2
11.0	75.4	3.0	11.0	75.4	3.0	11.0	58.7	4.2	11.0	58.7	4.2
12.0	77.2	3.3	12.0	77.2	3.3	12.0	61.4	4.2	12.0	61.4	4.2
13.0	78.5	3.7	13.0	78.5	3.7	13.0	63.8	4.2	13.0	63.8	4.2
14.0	79.5	4.1	14.0	79.5	4.1	14.0	65.9	4.3	14.0	65.9	4.3
15.0	80.2	4.5	15.0	80.2	4.5	15.0	67.7	4.6	15.0	67.7	4.6
16.0	80.7	4.9	16.0	80.7	4.9	16.0	69.2	5.0	16.0	69.2	5.0

Depth in Structure	Contents Percent Damage	Contents Standard Deviation	Depth in Structure	Contents Percent Damage	Contents Standard Deviation	Depth in Structure	Contents Percent Damage	Contents Standard Deviation	Depth in Structure	Contents Percent Damage	Contents Standard Deviation
-2.0	0.0	0.0	-2.0	0.0	0.0	-2.0	0.0	0.0	-2.0	0.0	0.0
-1.0	2.4	2.1	-1.0	2.4	2.1	-1.0	1.0	3.5	-1.0	1.0	3.5
0.0	8.1	1.5	0.0	8.1	1.5	0.0	5.0	2.9	0.0	5.0	2.9
1.0	13.3	1.2	1.0	13.3	1.2	1.0	8.7	2.6	1.0	8.7	2.6
2.0	17.9	1.2	2.0	17.9	1.2	2.0	12.2	2.5	2.0	12.2	2.5
3.0	22.0	1.4	3.0	22.0	1.4	3.0	15.5	2.5	3.0	15.5	2.5
4.0	25.7	1.5	4.0	25.7	1.5	4.0	18.5	2.7	4.0	18.5	2.7
5.0	28.8	1.6	5.0	28.8	1.6	5.0	21.3	3.0	5.0	21.3	3.0
6.0	31.5	1.6	6.0	31.5	1.6	6.0	23.9	3.2	6.0	23.9	3.2
7.0	33.8	1.7	7.0	33.8	1.7	7.0	26.3	3.3	7.0	26.3	3.3
8.0	35.7	1.8	8.0	35.7	1.8	8.0	28.4	3.4	8.0	28.4	3.4
9.0	37.2	1.9	9.0	37.2	1.9	9.0	30.3	3.5	9.0	30.3	3.5
10.0	38.4	2.1	10.0	38.4	2.1	10.0	32.0	3.5	10.0	32.0	3.5
11.0	39.2	2.3	11.0	39.2	2.3	11.0	33.4	3.5	11.0	33.4	3.5
12.0	39.7	2.6	12.0	39.7	2.6	12.0	34.7	3.5	12.0	34.7	3.5
13.0	40.0	2.9	13.0	40.0	2.9	13.0	35.6	3.5	13.0	35.6	3.5
14.0	40.0	3.2	14.0	40.0	3.2	14.0	36.4	3.6	14.0	36.4	3.6
15.0	40.0	3.5	15.0	40.0	3.5	15.0	36.9	3.8	15.0	36.9	3.8
16.0	40.0	3.8	16.0	40.0	3.8	16.0	37.2	4.2	16.0	37.2	4.2

Debris Depth	Debris Percent Damage	Debris Standard Deviation	Debris Depth	Debris Percent Damage	Debris Standard Deviation	Debris Depth	Debris Percent Damage	Debris Standard Deviation	Debris Depth	Debris Percent Damage	Debris Standard Deviation
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.0	85.0	15.0	2.0	87.0	14.0	2.0	85.0	14.0	2.0	82.0	11.0
5.0	92.0	14.0	5.0	94.0	15.0	5.0	92.0	14.0	5.0	90.0	12.0
12.0	100.0	15.0	12.0	100.0	15.0	12.0	100.0	15.0	12.0	100.0	12.0

Supplemental Table 2
South Central Coastal Louisiana Feasibility Study
Depth-Damage Relationships for Structures, Contents and Vehicles including Debris Removal

Mobile Home — Mobile Home (MOBHOME)

Depth in Structure	Structure Lower Percent	Structure Percent Damage	Structure Higher Percent
-1.1	0.0	0.0	0.0
-1.0	6.1	6.4	7.7
-0.5	6.9	7.3	8.8
0.0	9.4	9.9	11.9
0.5	41.2	43.4	52.1
1.0	42.5	44.7	53.6
2.0	43.6	45.9	55.1
3.0	44.3	46.6	55.9
4.0	44.5	46.8	56.2
5.0	48.5	51.0	61.2
6.0	63.5	66.9	80.2
7.0	63.5	66.9	80.2
8.0	64.0	67.3	80.8
9.0	64.0	67.3	80.8
10.0	64.0	67.3	80.8
11.0	64.0	67.3	80.8
12.0	64.0	67.3	80.8
13.0	64.0	67.3	80.8
14.0	64.0	67.3	80.8

Depth in Structure	Contents Lower Percent	Contents Percent Damage	Contents Higher Percent
-1.0	0.0	0.0	0.0
-0.5	0.0	0.0	0.0
0.0	0.0	0.0	0.0
0.5	90.0	95.0	100.0
1.0	92.0	96.0	100.0
1.5	94.0	97.0	100.0
2.0	96.0	98.0	100.0
3.0	98.0	99.0	100.0
4.0	100.0	100.0	100.0
5.0	100.0	100.0	100.0
6.0	100.0	100.0	100.0
7.0	100.0	100.0	100.0
8.0	100.0	100.0	100.0
9.0	100.0	100.0	100.0
10.0	100.0	100.0	100.0
11.0	100.0	100.0	100.0
12.0	100.0	100.0	100.0
13.0	100.0	100.0	100.0
14.0	100.0	100.0	100.0
15.0	100.0	100.0	100.0

Debris Depth	Debris Percent Damage	Debris Standard Deviation
0.0	0.0	0.0
2.0	82.0	14.0
5.0	90.0	14.0
12.0	100.0	15.0

Industrial — Industrial (IND)

Depth in Structure	Structure Lower Percent	Structure Percent Damage	Structure Higher Percent
-1.0	0.0	0.0	0.0
-0.5	0.0	0.0	0.0
0.0	1.0	1.1	1.3
0.5	18.7	20.2	24.1
1.0	18.7	20.2	24.1
1.5	23.2	25.8	31.0
2.0	26.9	29.9	36.7
3.0	29.9	34.0	40.8
4.0	34.6	40.7	50.9
5.0	41.7	49.0	61.3
6.0	41.7	49.0	61.3
7.0	43.2	50.8	63.6
8.0	44.5	52.4	65.5
9.0	48.7	57.3	71.6
10.0	48.7	57.3	71.6
11.0	48.7	57.3	71.6
12.0	51.3	60.4	75.4
13.0	51.3	60.4	75.4
14.0	51.3	60.4	75.4

Depth in Structure	Contents Lower Percent	Contents Percent Damage	Contents Higher Percent
-1.0	0.0	0.0	0.0
-0.5	0.0	0.0	0.0
0.0	0.0	0.0	0.0
0.5	7.6	8.5	10.2
1.0	11.4	12.6	15.2
1.5	15.2	16.8	20.2
2.0	19.0	21.1	25.4
3.0	25.1	27.9	33.5
4.0	29.2	32.5	39.0
5.0	36.8	40.9	49.1
6.0	43.6	48.5	58.2
7.0	50.5	56.1	67.3
8.0	57.3	63.7	76.4
9.0	64.1	71.3	85.5
10.0	68.5	76.1	91.3
11.0	68.5	76.1	91.3
12.0	68.5	76.1	91.3
13.0	68.5	76.1	91.3
14.0	68.5	76.1	91.3
15.0	68.5	76.1	91.3

Debris Depth	Debris Percent Damage	Debris Standard Deviation
0.0	0.0	0.0
2.0	76.0	13.0
5.0	87.0	14.0
12.0	100.0	14.0

Commercial — Warehouses & Contractors (WARE)

Depth in Structure	Structure Lower Percent	Structure Percent Damage	Structure Higher Percent
-1.0	0.0	0.0	0.0
-0.5	0.0	0.0	0.0
0.0	1.0	1.1	1.3
0.5	18.7	20.2	24.1
1.0	18.7	20.2	24.1
1.5	23.2	25.8	31.0
2.0	26.9	29.9	36.7
3.0	29.9	34.0	40.8
4.0	34.6	40.7	50.9
5.0	41.7	49.0	61.3
6.0	41.7	49.0	61.3
7.0	43.2	50.8	63.6
8.0	44.5	52.4	65.5
9.0	48.7	57.3	71.6
10.0	48.7	57.3	71.6
11.0	48.7	57.3	71.6
12.0	51.3	60.4	75.4
13.0	51.3	60.4	75.4
14.0	51.3	60.4	75.4

Depth in Structure	Contents Lower Percent	Contents Percent Damage	Contents Higher Percent
-1.0	0.0	0.0	0.0
-0.5	0.0	0.0	0.0
0.0	0.0	0.0	0.0
0.5	7.6	8.5	10.2
1.0	11.4	12.6	15.2
1.5	15.2	16.8	20.2
2.0	19.0	21.1	25.4
3.0	25.1	27.9	33.5
4.0	29.2	32.5	39.0
5.0	36.8	40.9	49.1
6.0	43.6	48.5	58.2
7.0	50.5	56.1	67.3
8.0	57.3	63.7	76.4
9.0	64.1	71.3	85.5
10.0	68.5	76.1	91.3
11.0	68.5	76.1	91.3
12.0	68.5	76.1	91.3
13.0	68.5	76.1	91.3
14.0	68.5	76.1	91.3
15.0	68.5	76.1	91.3

Debris Depth	Debris Percent Damage	Debris Standard Deviation
0.0	0.0	0.0
2.0	76.0	13.0
5.0	87.0	14.0
12.0	100.0	14.0

Supplemental Table 3
South Central Coastal Louisiana Feasibility Study
Depth-Damage Relationships for Structures, Contents and Vehicles including Debris Removal

Commercial Groceries & Gas Station (GROC)				**Commercial Repairs & Home Use (REPA)**				**Commercial Retail and Personal Services (RETA)**			
Depth in Structure	Structure Lower Percent	Structure Percent Damage	Structure Higher Percent	Depth in Structure	Structure Lower Percent	Structure Percent Damage	Structure Higher Percent	Depth in Structure	Structure Lower Percent	Structure Percent Damage	Structure Higher Percent
-1.0	0.0	0.0	0.0	-1.0	0.0	0.0	0.0	-1.0	0.0	0.0	0.0
-0.5	0.0	0.0	0.0	-0.5	0.0	0.0	0.0	-0.5	0.0	0.0	0.0
0.0	1.0	1.1	1.3	0.0	1.0	1.1	1.3	0.0	1.5	1.6	1.9
0.5	18.7	20.2	24.1	0.5	18.7	20.2	24.1	0.5	11.2	12.0	14.4
1.0	18.7	20.2	24.1	1.0	18.7	20.2	24.1	1.0	11.2	12.0	14.4
1.5	23.2	25.8	31.0	1.5	23.2	25.8	31.0	1.5	11.2	12.0	20.6
2.0	26.9	29.9	36.7	2.0	26.9	29.9	36.7	2.0	15.5	17.2	21.4
3.0	29.9	34.0	40.8	3.0	29.9	34.0	40.8	3.0	15.6	17.4	26.9
4.0	34.6	40.7	50.9	4.0	34.6	40.7	50.9	4.0	19.7	22.4	32.9
5.0	41.7	49.0	61.3	5.0	41.7	49.0	61.3	5.0	22.4	26.3	36.9
6.0	41.7	49.0	61.3	6.0	41.7	49.0	61.3	6.0	25.1	29.5	36.9
7.0	43.2	50.8	63.6	7.0	43.2	50.8	63.6	7.0	25.1	29.5	36.9
8.0	44.5	52.4	65.5	8.0	44.5	52.4	65.5	8.0	25.1	29.5	39.9
9.0	48.7	57.3	71.6	9.0	48.7	57.3	71.6	9.0	27.1	31.9	52.8
10.0	48.7	57.3	71.6	10.0	48.7	57.3	71.6	10.0	35.9	42.3	60.6
11.0	48.7	57.3	71.6	11.0	48.7	57.3	71.6	11.0	41.2	48.4	60.6
12.0	51.3	60.4	75.4	12.0	51.3	60.4	75.4	12.0	41.2	48.4	65.5
13.0	51.3	60.4	75.4	13.0	51.3	60.4	75.4	13.0	44.6	52.4	65.5
14.0	51.3	60.4	75.4	14.0	51.3	60.4	75.4	14.0	44.6	52.4	65.5

Depth in Structure	Contents Lower Percent	Contents Percent Damage	Contents Higher Percent	Depth in Structure	Contents Lower Percent	Contents Percent Damage	Contents Higher Percent	Depth in Structure	Contents Lower Percent	Contents Percent Damage	Contents Higher Percent
-1.0	0.0	0.0	0.0	-1.0	0.0	0.0	0.0	-1.0	0.0	0.0	0.0
-0.5	0.0	0.0	0.0	-0.5	0.0	0.0	0.0	-0.5	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.5	8.9	9.9	11.9	0.5	13.1	14.6	17.5	0.5	10.8	12.0	14.4
1.0	26.6	29.6	35.5	1.0	18.5	20.6	24.7	1.0	22.7	25.3	30.3
1.5	67.9	75.4	90.5	1.5	28.6	31.8	38.2	1.5	32.9	36.6	43.9
2.0	78.5	87.2	100.0	2.0	29.5	32.8	39.3	2.0	54.5	60.5	72.6
3.0	85.7	95.2	100.0	3.0	59.4	66.0	79.2	3.0	67.8	75.4	90.5
4.0	88.9	98.8	100.0	4.0	60.7	67.4	80.9	4.0	76.6	85.1	100.0
5.0	90.0	100.0	100.0	5.0	62.0	68.8	82.6	5.0	85.0	94.5	100.0
6.0	90.0	100.0	100.0	6.0	69.3	76.9	92.3	6.0	90.0	100.0	100.0
7.0	90.0	100.0	100.0	7.0	71.9	79.9	95.9	7.0	90.0	100.0	100.0
8.0	90.0	100.0	100.0	8.0	71.9	79.9	95.9	8.0	90.0	100.0	100.0
9.0	90.0	100.0	100.0	9.0	71.9	79.9	95.9	9.0	90.0	100.0	100.0
10.0	90.0	100.0	100.0	10.0	71.9	79.9	95.9	10.0	90.0	100.0	100.0
11.0	90.0	100.0	100.0	11.0	71.9	79.9	95.9	11.0	90.0	100.0	100.0
12.0	90.0	100.0	100.0	12.0	71.9	79.9	95.9	12.0	90.0	100.0	100.0
13.0	90.0	100.0	100.0	13.0	71.9	79.9	95.9	13.0	90.0	100.0	100.0
14.0	90.0	100.0	100.0	14.0	71.9	79.9	95.9	14.0	90.0	100.0	100.0
15.0	90.0	100.0	100.0	15.0	71.9	79.9	95.9	15.0	90.0	100.0	100.0

Debris Depth	Debris Percent Damage	Debris Standard Deviation	Debris Depth	Debris Percent Damage	Debris Standard Deviation	Debris Depth	Debris Percent Damage	Debris Standard Deviation
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.0	95.0	21.0	2.0	95.0	21.0	2.0	95.0	22.0
5.0	97.0	21.0	5.0	97.0	21.0	5.0	96.0	22.0
12.0	100.0	21.0	12.0	100.0	21.0	12.0	100.0	22.0

Supplemental Table 4
South Central Coastal Louisiana Feasibility Study
Depth-Damage Relationships for Structures, Contents and Vehicles including Debris Removal

Commercial Multi-Family Residence, over 5 units (MULT)				Commercial Professional Services (PROF)				Commerical Public Facilities (PUBL)			
Depth in Structure	Structure Lower Percent	Structure Percent Damage	Structure Higher Percent	Depth in Structure	Structure Lower Percent	Structure Percent Damage	Structure Higher Percent	Depth in Structure	Structure Lower Percent	Structure Percent Damage	Structure Higher Percent
-1.0	0.0	0.0	0.0	-1.0	0.0	0.0	0.0	-1.0	0.0	0.0	0.0
-0.5	0.0	0.0	0.0	-0.5	0.0	0.0	0.0	-0.5	0.0	0.0	0.0
0.0	1.0	1.1	1.3	0.0	1.5	1.6	1.9	0.0	1.5	1.6	1.9
0.5	18.7	20.2	24.1	0.5	11.2	12.0	14.4	0.5	11.2	12.0	14.4
1.0	18.7	20.2	24.1	1.0	11.2	12.0	14.4	1.0	11.2	12.0	14.4
1.5	23.2	25.8	31.0	1.5	11.2	12.0	20.6	1.5	11.2	12.0	20.6
2.0	26.9	29.9	36.7	2.0	15.5	17.2	21.4	2.0	15.5	17.2	21.4
3.0	29.9	34.0	40.8	3.0	15.6	17.4	26.9	3.0	15.6	17.4	26.9
4.0	34.6	40.7	50.9	4.0	19.7	22.4	32.9	4.0	19.7	22.4	32.9
5.0	41.7	49.0	61.3	5.0	22.4	26.3	36.9	5.0	22.4	26.3	36.9
6.0	41.7	49.0	61.3	6.0	25.1	29.5	36.9	6.0	25.1	29.5	36.9
7.0	43.2	50.8	63.6	7.0	25.1	29.5	36.9	7.0	25.1	29.5	36.9
8.0	44.5	52.4	65.5	8.0	25.1	29.5	39.9	8.0	25.1	29.5	39.9
9.0	48.7	57.3	71.6	9.0	27.1	31.9	52.8	9.0	27.1	31.9	52.8
10.0	48.7	57.3	71.6	10.0	35.9	42.3	60.6	10.0	35.9	42.3	60.6
11.0	48.7	57.3	71.6	11.0	41.2	48.4	60.6	11.0	41.2	48.4	60.6
12.0	51.3	60.4	75.4	12.0	41.2	48.4	65.5	12.0	41.2	48.4	65.5
13.0	51.3	60.4	75.4	13.0	44.6	52.4	65.5	13.0	44.6	52.4	65.5
14.0	51.3	60.4	75.4	14.0	44.6	52.4	65.5	14.0	44.6	52.4	65.5

Depth in Structure	Contents Lower Percent	Contents Percent Damage	Contents Higher Percent	Depth in Structure	Contents Lower Percent	Contents Percent Damage	Contents Higher Percent	Depth in Structure	Contents Lower Percent	Contents Percent Damage	Contents Higher Percent
-1.0	0.0	0.0	0.0	-1.0	0.0	0.0	0.0	-1.0	0.0	0.0	0.0
-0.5	0.0	0.0	0.0	-0.5	0.0	0.0	0.0	-0.5	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.5	3.0	7.9	10.3	0.5	13.3	14.8	18.4	0.5	36.0	40.0	50.0
1.0	10.9	15.3	18.1	1.0	16.7	18.6	23.2	1.0	64.8	72.0	90.0
1.5	16.6	18.8	20.5	1.5	30.0	33.3	41.6	1.5	64.8	72.0	90.0
2.0	21.9	23.5	26.7	2.0	35.1	39.0	48.8	2.0	64.8	72.0	90.0
3.0	36.6	39.7	41.2	3.0	67.1	74.6	93.2	3.0	89.7	99.7	100.0
4.0	43.8	45.3	46.5	4.0	83.0	92.2	100.0	4.0	90.0	100.0	100.0
5.0	45.7	47.2	48.5	5.0	84.7	94.1	100.0	5.0	90.0	100.0	100.0
6.0	45.7	47.2	48.5	6.0	90.0	100.0	100.0	6.0	90.0	100.0	100.0
7.0	45.7	47.2	50.3	7.0	90.0	100.0	100.0	7.0	90.0	100.0	100.0
8.0	45.7	47.2	50.3	8.0	90.0	100.0	100.0	8.0	90.0	100.0	100.0
9.0	45.7	47.2	50.3	9.0	90.0	100.0	100.0	9.0	90.0	100.0	100.0
10.0	20.6	55.1	72.1	10.0	90.0	100.0	100.0	10.0	90.0	100.0	100.0
11.0	58.4	66.0	72.1	11.0	90.0	100.0	100.0	11.0	90.0	100.0	100.0
12.0	80.2	86.9	90.2	12.0	90.0	100.0	100.0	12.0	90.0	100.0	100.0
13.0	89.5	92.5	95.1	13.0	90.0	100.0	100.0	13.0	90.0	100.0	100.0
14.0	91.4	94.4	97.1	14.0	90.0	100.0	100.0	14.0	90.0	100.0	100.0
15.0	91.4	94.4	97.1	15.0	90.0	100.0	100.0	15.0	90.0	100.0	100.0

Debris Depth	Debris Percent Damage	Debris Standard Deviation	Debris Depth	Debris Percent Damage	Debris Standard Deviation	Debris Depth	Debris Percent Damage	Debris Standard Deviation
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.0	77.0	7.0	2.0	95.0	22.0	2.0	95.0	22.0
5.0	83.0	7.0	5.0	96.0	22.0	5.0	96.0	22.0
12.0	100.0	10.0	12.0	100.0	22.0	12.0	100.0	22.0

Supplemental Table 5
South Central Coastal Louisiana Feasibility Study
Depth-Damage Relationships for Structures, Contents and Vehicles including Debris Removal

Commercial
Eating & Recreation (EAT)

Depth in Structure	Structure Lower Percent	Structure Percent Damage	Structure Higher Percent
-1.0	0.0	0.0	0.0
-0.5	0.0	0.0	0.0
0.0	1.0	1.1	1.3
0.5	18.7	20.2	24.1
1.0	18.7	20.2	24.1
1.5	23.2	25.8	31.0
2.0	26.9	29.9	36.7
3.0	29.9	34.0	40.8
4.0	34.6	40.7	50.9
5.0	41.7	49.0	61.3
6.0	41.7	49.0	61.3
7.0	43.2	50.8	63.6
8.0	44.5	52.4	65.5
9.0	48.7	57.3	71.6
10.0	48.7	57.3	71.6
11.0	48.7	57.3	71.6
12.0	51.3	60.4	75.4
13.0	51.3	60.4	75.4
14.0	51.3	60.4	75.4

Autos
Residential Autos (AUTO)

Depth in Structure	Structure Percent Damage	Structure Standard Deviation
0.0	0.0	0.00
0.5	7.6	2.42
1.0	28.0	1.84
2.0	46.2	1.51
3.0	62.2	1.45
4.0	76.0	1.57
5.0	87.6	1.74
6.0	97.0	1.92
7.0	100.0	2.06
8.0	100.0	2.06
9.0	100.0	2.06

Depth in Structure	Contents Lower Percent	Contents Percent Damage	Contents Higher Percent
-1.0	0.0	0.0	0.0
-0.5	0.0	0.0	0.0
0.0	0.0	0.0	0.0
0.5	16.8	18.7	22.4
1.0	22.5	25.0	30.1
1.5	42.1	46.8	56.1
2.0	45.2	50.2	60.3
3.0	72.3	80.3	96.4
4.0	86.2	95.8	100.0
5.0	88.4	98.2	100.0
6.0	89.2	99.1	100.0
7.0	90.0	100.0	100.0
8.0	90.0	100.0	100.0
9.0	90.0	100.0	100.0
10.0	90.0	100.0	100.0
11.0	90.0	100.0	100.0
12.0	90.0	100.0	100.0
13.0	90.0	100.0	100.0
14.0	90.0	100.0	100.0
15.0	90.0	100.0	100.0

Debris Depth	Debris Percent Damage	Debris Standard Deviation
0.0	0.0	0.0
2.0	96.0	22.0
5.0	98.0	22.0
12.0	100.0	22.0

Supplemental Table 6
South Central Coastal Louisiana Feasibility Study
Average Annual Damages Reduced by Structural Alternative

Levee Raise Without Project Condition

YEAR	FREQUENCY	VALUE
	-	649,023,454
1000	0.001	649,023,454
500	0.002	649,023,454
250	0.004	406,963,939
100	0.010	301,279,292
50	0.020	145,362,127
36	0.028	100,000,000
35	0.029	-
10	0.100	-
5	0.200	-
2	0.500	-
1	1.000	-
AVERAGE ANNUAL VALUE =		**7,706,000**

Ring Levee Without Project Condition

YEAR	FREQUENCY	VALUE
	-	1,232,682,203
1000	0.001	1,232,682,203
500	0.002	1,232,682,203
250	0.004	857,774,538
100	0.010	668,247,575
50	0.020	351,391,390
25	0.040	137,162,699
10	0.100	45,628,432
5	0.200	-
2	0.500	-
1	1.000	-
AVERAGE ANNUAL VALUE =		**26,883,000**

Levee Raise With Project Condition

YEAR	FREQUENCY	VALUE
	-	649,023,454
1000	0.001	649,023,454
500	0.002	649,023,454
250	0.004	406,963,939
101	0.010	301,279,292
100	0.010	-
50	0.020	-
25	0.040	-
10	0.100	-
5	0.200	-
2	0.500	-
1	1.000	-
AVERAGE ANNUAL VALUE =		**4,459,000**
AA DAMAGES REDUCED =		**3,247,000**

Ring Levee With Project Condition

YEAR	FREQUENCY	VALUE
	-	1,232,682,203
1000	0.001	1,232,682,203
500	0.002	1,232,682,203
250	0.004	857,774,538
101	0.010	668,247,575
100	0.010	-
50	0.020	-
25	0.040	-
10	0.100	-
5	0.200	-
2	0.500	-
1	1.000	-
AVERAGE ANNUAL VALUE =		**9,091,000**
AA DAMAGES REDUCED =		**17,792,000**

Supplemental Table 7
South Central Coastal Louisiana Feasibility Study
Average Annual Damages Reduced by Structural Alternative

Ring Levee 2 Without Project Condition		
YEAR	FREQUENCY	VALUE
	-	1,002,277,324
1000	0.001	1,002,277,324
500	0.002	1,002,277,324
250	0.004	652,000,987
100	0.010	494,574,906
50	0.020	237,385,821
25	0.040	88,506,355
10	0.100	26,838,374
5	0.200	-
2	0.500	-
1	1.000	-
AVERAGE ANNUAL VALUE =		18,820,000

Morgan City Without Project Condition		
YEAR	FREQUENCY	VALUE
	-	674,440,782
1000	0.001	674,440,782
500	0.002	674,440,782
250	0.004	435,725,083
100	0.010	378,974,654
51	0.020	231,959,986
50	0.020	-
25	0.040	-
10	0.100	-
5	0.200	-
2	0.500	-
1	1.000	-
AVERAGE ANNUAL VALUE =		7,884,000

Ring Levee 2 With Project Condition		
YEAR	FREQUENCY	VALUE
	-	1,002,277,324
1000	0.001	1,002,277,324
500	0.002	1,002,277,324
250	0.004	652,000,987
101	0.010	494,574,906
100	0.010	-
50	0.020	-
25	0.040	-
10	0.100	-
5	0.200	-
2	0.500	-
1	1.000	-
AVERAGE ANNUAL VALUE =		7,066,000
AA DAMAGES REDUCED =		11,754,000

Morgan City With Project Condition		
YEAR	FREQUENCY	VALUE
	-	674,440,782
1000	0.001	674,440,782
500	0.002	674,440,782
250	0.004	435,725,083
101	0.010	378,974,654
100	0.010	-
50	0.020	-
25	0.040	-
10	0.100	-
5	0.200	-
2	0.500	-
1	1.000	-
AVERAGE ANNUAL VALUE =		4,882,000
AA DAMAGES REDUCED =		3,002,000