Mississippi Valley Division,
Regional Planning and Environment Division South

St. Tammany Parish, Louisiana Feasibility Study

Appendix F – Economics

June 2021

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Section 1
Introduction

1.1 ANALYSIS OVERVIEW

This Appendix contains the economic evaluation of the Final Array of Alternatives for the St. Tammany Parish, Louisiana Feasibility Study (study). This Appendix was prepared in accordance with Engineering Regulation (ER) 1105-2-100, Planning Guidance Notebook, ER 1105-2-101, Planning Guidance, Risk Analysis for Flood Damage Reduction Studies, ER 1110-2-1302 "Civil Works Cost Engineering" and the Coastal Storm Risk Management (CSRM) National Economic Development (NED) Manual. The National Economic Development (NED) Procedures Manual for Flood 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).

This Appendix consists of a description of the methodology used to determine National Economic Development (NED) damages, benefits, and projects costs. The sources of damages for this analysis are structures, contents, and vehicles. The project benefits are accrued due to reducing damages to structures through the lowering of stages caused by coastal flooding and rainfall and riverine flooding. The damages and costs were calculated using fiscal year (FY) 2021 price levels. The FY 2021 Federal Discount rate of 2.5 percent was used to calculate interest during construction from the beginning of construction up to the base year of the project, 2032. This discount rate was also used to discount the future operation and maintenance (O&M) costs occurring throughout the 50-year period of analysis back to the project base year. The coastal flooding was modeled separately from the rainfall and riverine modeling. The study area is divided up into the sub-basins shown in Figure F:5-1. For modeling purposes, some of the sub-basins shown were subdivided into smaller reaches based on hydrologic and hydraulic (H&H) behavior and the alternative locations. Intermediate sea-level rise was used in this analysis for the computation of damages and benefits. Hydrologic conditions are expected to change in the future due to sea-level rise and subsidence. As a result, the discount rate is also used to calculate the equivalent annual damages and benefits between the future condition of 2081 and the base year of 2032. No future development was included in the analysis. As per ER 1105-2-101, uncertainty parameters were estimated for all major variables used in the analysis, such as structure value, first floor elevation, content-to-structure value ratios, and depth-damage functions.

1.2 STUDY AREA OVERVIEW

The study area encompasses all of St. Tammany Parish, which is approximately 1,124 square miles and located in southeastern Louisiana (Figure F:1-1). St. Tammany Parish is located on the northeast shore of Lake Pontchartrain and is home to over 258,111 residents. The parish is uniquely located at the crossroads of three interstates, I-10, I-12, and I-59 and transportation waterways to the Gulf of Mexico.

The State of Mississippi, with the Pearl River creates the eastern boundary of the study area. Lake Pontchartrain serves as the southern border and is one of the largest estuaries in the United States. The Southeastern Louisiana National Wildlife Refuge Complex Headquarters in Lacombe is also located near the southern boundary. Tangipahoa Parish is located along the western boundary and Washington Parish is located to the north. The majority of St. Tammany Parish’s population resides along the edge of Lake Pontchartrain, and many commute into New Orleans, with Mandeville, Slidell, and Covington serving as residential communities. Major communities in the study area include Slidell, Mandeville, Covington, Abita Springs, Pearl River, and Madisonville. St. Tammany Parish is the fastest-growing parish in Louisiana and one of the fastest-growing communities in the nation. Major industries in the study area are health care and social assistance, retail trade, professional, scientific, and technical services, construction, finance, and Insurance.

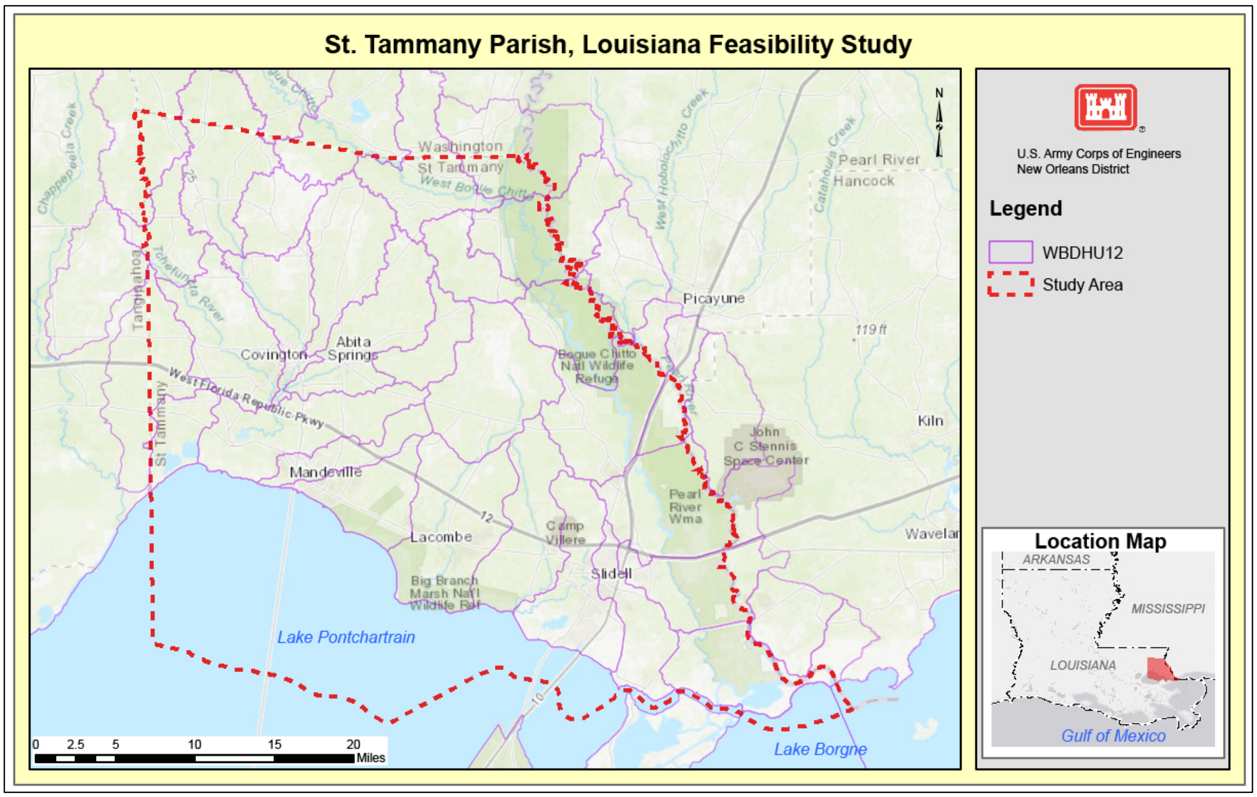

Figure F:1-1. St. Tammany Parish, Louisiana Feasibility Study Area

The total number of acres of developed, agricultural, and undeveloped land in the study area are shown in Table F:1-1.

Table F:1-1, Land Use

Land Class Name	Acres	Percentage of Total
Developed Land	80,190	15%
Agricultural Land	316	0%
Undeveloped Land	455,312	85%
Total	535,817	100%

National Agriculture Statistics Service (NASS), National Cropland Data Layer (CDL), 2020

The significant flood events in the study area are shown in Table F:1-2.

Table F:1-2. St. Tammany Parish Flood Events

Date	Event	Date	Event
Aug-69	Hurricane Camille	Aug-02	Tropical Storm Bertha
Apr-79	Heavy Rainfall	Sep-02	Tropical Storm Isidore
Apr-80	Heavy Rainfall	Oct-02	Hurricane Lili
Dec-82	Heavy Rainfall	Sep-04	Hurricane Ivan
Jan-83	Heavy Rainfall	Aug-05	Hurricane Katrina
Mar-83	Heavy Rainfall	Jan-06	Heavy Rainfall
Apr-83	Heavy Rainfall	Oct-07	Heavy Rainfall
Aug-85	Hurricane Danny	May-08	Heavy Rainfall
Nov-85	Hurricane Juan	Aug-08	Tropical Storm Fay
Feb-88	Heavy Rainfall	Sep-08	Hurricane Ike
Apr-88	Heavy Rainfall	Sep-08	Hurricane Gustav
Jun-89	Heavy Rainfall	Apr-09	Heavy Rainfall
May-91	Heavy Rainfall	Oct-09	Heavy Rainfall
Aug-92	Hurricane Andrew	Nov-09	Heavy Rainfall
Apr-95	Heavy Rainfall	Nov-09	Tropical Storm Ida
May-95	Heavy Rainfall	Dec-09	Heavy Rainfall
Oct-95	Hurricane Opal	Sept-11	Tropical Storm Lee

Aug-96	Heavy Rainfall	Aug-12	Hurricane Isaac
Oct-96	Coastal Flooding	Mar-16	Heavy Rainfall
Jan-98	Heavy Rainfall	Aug-16	Heavy Rainfall
Mar-98	Heavy Rainfall	Dec-18	Heavy Rainfall
Sep-98	Tropical Storm Frances	Feb-20	Pearl River Flooding
Sep-98	Hurricane Georges	Jun-20	Tropical Storm Cristobal
Jun-01	Heavy Rainfall	May -20	Heavy Rainfall
Jun-01	Tropical Storm Allison	Oct-20	Hurricane Zeta

GEC 2012 and Neel Shaffer

Given continued growth in population in the study area, it is expected that development will continue to occur with or without the Tentatively Selected Plan (TSP). The implementation of the TSP will not conflict with PGL 25 Federal Participation in Land development at Structural Flood Damage Reduction Projects, ER 1165-2-26, Implementation of Executive Order 11988 on Floodplain Management, and Executive Order (EO) 11988, generally 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 TSP would not induce development, but would rather reduce the risk of the population being displaced after a major storm event.

Section 2
Asset Inventory in Study Area

2.1 STRUCTURE INVENTORY

There are 100,252 residential structures and 11,440 non-residential structures in the total structure inventory. The source of the inventory is the National Structure Inventory (NSI) version 2. This updated version of the inventory uses Zillow data, ESRI map layer data, and CoreLogic data to improve structure placement and the square footage of structures over the previous version of the NSI. RS Means was used to calculate the depreciated replacement value of structures. The RS Means construction cost index was used to update the depreciated replacement value from FY 2018 to FY 2021. The NSI2 inventory was joined with parcel data in order to improve structure placement. The foundation heights of the structures were updated through stratified sampling by study area sub-basin. Table F:5-1 displays the structure counts by occupancy type.

Table F:2-1. Structure Counts by Occupancy Type

Structure Category	
Residential	**Number**
Single Family 1-Story Slab	20,389
Single Family 1-Story Pier	40,374
Single Family 2-Story Slab	28,105
Single Family 2-Story Pier	778
Mobile Home	10,606
Total	100,252
Non-Residential	**Number**
Multi-Family	2,181
Professional	2,409
Public	973
Repair	921
Restaurants	726
Retail	1,883
Warehouse	2,347
Total	11,440

2.2 STRUCTURE VALUE UNCERTAINTY

The uncertainty surrounding the residential structure values was based on the depreciation percentage applied to the average replacement cost per square foot calculated from the four exterior wall types. A triangular probability distribution was used to represent the uncertainty surrounding the residential structure values in each occupancy category. The most-likely depreciated value was based on the average construction class and a 20 percent depreciation rate (consistent with an observed age of a 20-year old structure in average condition), the minimum value was based on the economy construction class and a 45 percent depreciation rate (consistent with an observed age of a 30-year old structure in poor condition), and the maximum value was based on the luxury construction class and a 7 percent depreciation rate (consistent with an observed age of a 10-year old structure in good condition). 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 occupancy category and the economy and luxury class values equal to a percentage of these values. 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 foot calculated from the six exterior wall types. A triangular probability distribution based on the depreciation percentage associated with an observed age (determined using the professional judgment of personnel familiar with the study area) and the type of frame structure was used to represent the uncertainty surrounding the non-residential structure values in each occupancy category. The most-likely depreciated value was based on the depreciation percentage (25 percent) assigned to structures with an observed age of 20 years for masonry and wood construction, the minimum depreciated value was based on the depreciation percentage (40 percent) assigned to structures with an observed age of 30 years for framed construction, and the maximum depreciated value was based on the on the depreciation percentage (8 percent) assigned to structures with an observed age of 10 years for masonry on masonry or steel construction. 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.

2.3 VEHICLE INVENTORY AND VALUES

Based on 2010 Census information for the New Orleans Metropolitan area, there are an average of 2.0 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 Edmunds.Com, the average value of a used car was $18,800 as of 2nd quarter 2015. The Manheim Used Vehicle Value Index was used to adjust the average value to reflect FY 2019 price levels. According to the Manheim index, the average value of a used car increased 8.0 percent to $20,000 between the years 2015 and 2020. Since only those vehicles not used for evacuation can be included in the damage calculations, an adjusted average vehicle value of $12,000 ($20,000 x 2.0 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. Finally, every apartment building was assumed to contain 50 units, so every apartment building has $600,000 as the average value for vehicles (50 units x $10.6 thousand).

2.4 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, $18,600, was used as the most-likely value. The average value of a new vehicle, $34,000, 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=25 percent, most-likely=100 percent, maximum=183 percent). 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.

2.5 FIRST FLOOR ELEVATIONS

Topographical data based on North American Vertical Datum (NAVD 88) vertical datum was used to assign ground elevations to structures and vehicles in the study area. The assignment of ground elevations and the placement of structures were based on a digital elevation model (DEM) with a 15 feet by 15 feet grid resolution developed by the United States Geological Survey (USGS). The ground elevation was added to the height of the foundation of the structure above the ground 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.

2.6 UNCERTAINTY SURROUNDING ELEVATIONS

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 structure categories and commercial structures was estimated by calculating the standard deviations surrounding the sampled mean values. An overall weighted average standard deviation for all of the sampled structures was computed for each residential and non-residential structure category and for all of the residential and non-residential structures, regardless of structure category. There is also potential uncertainty in the first-floor elevation of a structure that is located on a parcel with a significant slope. In such a case, the first-floor elevation of the structure could vary across its footprint. Such parcels are not common in the study area, so this source of uncertainty is not captured in this analysis.

Uncertainty can only be applied to structure occupancies in the HEC-FDA model. In order to develop a standard deviation for each structure occupancy, first, the structures in each residential category had to be grouped into the structure occupancies; second, a mean foundation height value was the structures within the structure occupancy; third, the standard deviation as a percentage of the mean foundation height value for all the sampled residential structures was calculated and that percentage was applied to the mean foundation value of the residential and non-residential occupancies; fourth, the calculated standard deviation for each structure occupancy was entered into the HEC-FDA model.

2.7 DEPTH-DAMAGE RELATIONSHIPS AND CONTENT-TO-STRUCTURE VALUE RATIO

Depth-damage relationships define the relationship between the depth of flooding and the percent of damage at varying depths that occurs to structures and contents. These mathematical functions are used to quantify the flood damages to a given structure. The content-to-structure value ratio (CSVR) is expressed as a ratio of two values: the depreciated replacement cost of contents and the depreciated replacement cost of the structure. One method to derive these relationships is the “Expert Opinion” method described in the “Handbook of Forecasting Techniques, IWR Contract Report 75-7, December 1975” and “Handbook of Forecasting Techniques, Part II, Description of 31 Techniques, Supplement to IWR Contract Report 75-7, August 1977.” A panel of experts was convened to develop site-specific depth-damage relationships and CSVRS for feasibility studies associated with Jefferson and Orleans Parishes. Professionals in the fields of residential and non-residential construction, general contractors, insurance claims adjusters with experience in flood damage, and a certified restoration expert were selected to sit on the panel. The panel was tasked with developing an array of residential and non-residential structure and content types. Residential structure types were divided into one-story on pier, one-story on slab, two-story on pier, two-story on slab, and mobile homes. Non-residential structure types were categorized as metal-frame walls, masonry bearing walls, and wood or steel frame walls. Residential contents were evaluated as one-story, two-story, or mobile home. Non-residential content categories included the following types: eating and recreation, groceries and gas stations, multi-family residences, repair and home use, retail and personal services, professional businesses, public and semi-public, and warehouse and contractor services. The results of this panel were published in the report “Depth-Damage Relationships for Structures, Contents, and Vehicles and Content-To-Structure Value Ratios (CSVRS) In Support Of the Jefferson and Orleans Flood Control Feasibility Studies, June 1996 Final Report.” The long duration, saltwater depth-damage functions were used to assess the damages from coastal flooding. The long duration, freshwater depth-damage functions were used to assess the damages from rainfall and riverine flooding.

SECTION 3
Damages and Benefits Estimation

3.1 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 study. The economic and engineering inputs necessary for the model to calculate damages and benefits include structure inventory, contents-to-structure value ratios, vehicles, first floor elevations, and depth-damage relationships, ground elevations, and without-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.

3.2 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 study area reaches. 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.

3.3 HYDRAULIC AND HYDROLOGIC UNCERTAINTY PARAMETERS

HEC-FDA requires the input of the standard deviation of error associated with stages determined by the hydraulic modeling. Additionally, a period of record must be input in order to calculate the distribution for the flow data determined in the hydrologic analysis.

3.4 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 2032 and 2081 conditions. The possible occurrences of each economic variable were derived through the use of Monte Carlo simulation. A total of 1,000 iterations were executed by the model for the St. Tammany Parish evaluation. 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.

3.5 STAGE-PROBABILITY RELATIONSHIPS WITH UNCERTAINTY

The HEC-FDA model used an equivalent record length of 50 years for each study area reach to generate a stage-probability relationship with uncertainty through the use of graphical analysis. The model used eight stage-probability events together with the equivalent record length to define the full range of the stage-probability or stage-probability functions by interpolating between the data points. Confidence bands surrounding the stages for each of the probability events were also provided. For the coastal flooding, stages were provided for the 0.05, 0.02, 0.01, 0.005, 0.002, and 0.001 Annual Exceedance Probability (AEP) events. Place holders were used for the 1.0 and 0.1 AEP events. For the rainfall and riverine flooding, stages were provided for the 0.5, 0.2, 0.1, 0.04, 0.02, 0.01, 0.005, and 0.002 AEP events. For both coastal and rainfall/ riverine flooding, the levee function was used to control for anomalous high frequency damages below the 0.1 AEP event. Tables F:3-1 and F:3-2 show the damages by probability event.

Table F:3-1, Coastal Damages by Probability Event ($1,000s)

AEP	Damages 2032	Damages 2081
1	0	0
0.1	399,033	1,194,413
0.05	1,121,638	2,186,365
0.02	2,400,361	3,660,496
0.01	3,506,034	4,941,979
0.005	5,288,887	6,553,190
0.002	8,134,117	9,611,331
0.001	9,235,726	10,788,694

Table F:3-2. Rainfall/Riverine Damages by Probability Event ($1,000s)

AEP	Damages 2032	Damages 2081
0.2	0	0
0.1	714,388	733,745
0.04	1,085,355	1,097,284
0.02	1,462,835	1,467,129
0.01	1,933,523	1,929,314
0.005	2,495,533	2,483,360
0.002	3,397,890	3,381,946

3.6 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 2032 and 2081 conditions. Tables F:3-3 and F:3-4 show the without-project damages by damage category for 2032 and 2081. Tables F:3-5 and F:3-6 show the without-project damages by reach for 2032 and 2081 respectively. The increase in damages from 2032 to 2081 are due to sea-level rise. No future development was included in this analysis.

Table F:3-3. Expected Annual Damages by Year and Damage Category, Coastal, $1,000s

Year	Auto	Commercial	Mobile Homes	Residential	Total
2032	11,618	58,368	2,972	154,304	227,262
2081	17,123	94,124	5,225	243,506	359,978

Table F:3-4. Expected Annual Damages by Year and Damage Category, Rainfall/Riverine, $1,000s

Year	Auto	Commercial	Mobile Homes	Residential	Total
2032	13,405	50,543	2,617	136,167	202,732

2081	14,494	54,008	2,608	148,949	220,059

Table F:3-5. Expected Annual Damages by Reach, Coastal, $1,000s

Reach	2032	2081
1	12,050	18,835
2	13,942	23,696
8	3,391	5,507
10	1	1
13	32,173	49,912
17	2,540	3,389
18	1,246	2,327
22	599	1,027
23	11,039	16,242
25	1,311	1,547
26	3	2
29	103	122
30	1,366	2,971
31	2	2
35	262	590
40	7,429	13,523
41	7,573	12,889
42	104	164
43	164	273
44	9,926	16,064
45	31,505	47,066
46	63,000	96,884
47	15,319	30,878
48	12,213	16,067
Total	227,262	359,978

Table F:3-6. Expected Annual Damages by Reach, Rainfall/Riverine, $1,000s

Reach	2032	2081
1	10,523	13,938
2	26,987	35,186
3	58	58
4	394	394
5	4,557	4,558
6	865	865
7	1,565	1,565
8	1,281	2,252
9	0	0
10	24,357	24,455
12	251	251
13	2,015	2,065
16	753	753
17	4,765	4,878
18	4,100	4,320
19	1,452	1,452
20	22	22
21	183	183
22	4,124	7,781
23	8,778	7,593
24	12,520	12,553
25	1,099	1,173
26	2,346	2,346
27	7,964	7,936
28	29	29
30	3,873	3,901
31	34,660	34,852
32	109	109
34	936	936
35	2,328	2,466
36	4,384	4,387
50	2,702	2,733
51	1,037	1,038

Reach	2032	2081
52	1,825	1,826
53	1,452	1,887
54	790	865
55	446	498
56	207	208
57	40	42
58	4,705	4,809
59	1,493	1,554
60	2,242	2,326
61	307	307
62	6,227	6,451
63	240	244
64	1,192	1,208
65	4,813	4,887
66	2,021	2,076
67	2,367	2,471
68	1,120	1,138
69	226	235
Total	202,732	220,059

3.7 EQUIVALENT ANNUAL DAMAGES

The HEC-FDA model uses the discount rate to discount the future damages and benefits occurring in 2081 back to the base year of 2032. Table F:3-7 shows the Final Array of project measures. Tables F:3-8 and F:3-9 show the equivalent annual damages by reach for the without-project condition and the damages reduced for each structural measure.

Table F:3-7. *Measures included in the Final Array of Alternatives*Final Array

Measure ID	Measure Name	Measure Category (structural, nonstructural, Nature Based)	Measure Type	Location	Type of Flooding Addressed (CSRM/FRM)
NS-08	Buyouts	Nonstructural	Buyouts	Parish wide	FRM or CSRM
NS-09	Flood proofing	Nonstructural	Flood proofing	Parish wide	FRM or CSRM
NS-10	Relocations	Nonstructural	Relocations	Parish wide	FRM or CSRM
NS-11	Structure Raising	Nonstructural	Structure Raising	Parish wide	FRM or CSRM
S-004	Bayou Bonfouca Detention Pond	Structural	Detention Ponds	Bayou Bonfuca	FRM
S-010	Bayou Liberty Channel Improvements	Structural	Channel Improvements	Bayou Liberty	FRM
S-028	Lacombe Levee	Structural	Levee, Flood Wall Pump Station, Flood Gates	Lacombe	CSRM
S-046	Mandeville Seawall	Structural	Seawall Repair/Replacement	Mandeville	CSRM
S-047	Mandeville Seawall with Passive Drainage	Structural	Seawall with Passive Drainage	Mandeville	CSRM
S-048	Mandeville Seawall with Pump Stations	Structural	Seawall with Pump Stations	Mandeville	CSRM
S-057	Mile Branch Channel Improvements	Structural	Channel Improvements	Mile Branch, Covington	FRM
S-060	Pearl River Levee	Structural	Levee, Flood Wall	Pearl River	FRM
S-069	Doubloon Bayou Channel Improvements	Structural	Channel Improvements	Doubloon Bayou	FRM
S-070	Eden Isle Floodwall	Structural	Levee/Flood Wall S-70a. Western Segment; S-70-b Southern Segment; S-70c Eastern Segment	Slidell, Eden Isle	CSRM
S-072	Gum Bayou Diversions Channel Improvements	Structural	Channel Improvements	Slidell, Gum Bayou	FRM
S-073	Poor Boy Canal Channel Improvements	Structural	Channel Improvements	Slidell, Poor Boy Canal	FRM
S-074	Pump Stations	Structural	Pump Stations	Slidell West of 1-10	CSRM
S-075	South Slidell Levee/Floodwall System-West of 1-10	Structural	Levee, Flood Wall	Slidell West of I-10	CSRM

S-076	South Slidell Levee/Floodwall System-East of 1-10	Structural	Levee, Flood Wall	Slidell East of 1-10	CSRM
S-077	Pump Stations	Structural	Pump Stations	Slidell East of 1-10	FRM
S-080	Bayou Patassat Channel Improvements	Structural	Channel Improvements	Slidell, Bayou Patassat	FRM
S-081	West Slidell Levee	Structural	Levee, Flood Wall, Pump Station, Flood Gates	West Slidell	CSRM
S-118	Mandeville Flood Barrier/Floodwall	Structural	Flood Barrier	Mandeville	FRM
S-120	West Slidell Combined with Lacombe Levee	Structural	Levee, Flood Wall Pump Station, Flood Gates	Lacombe to West Slidell	CSRM
S-121	Lateral A Channel Improvements	Structural	Channel Improvements	Lateral A, Covington	FRM
S-122	Mandeville 18ft Seawall with Pump Stations	Structural	Flood Wall 18 ft 100 year	Mandeville	CSRM

The Final Array of Alternatives and the measures were:

- Alternative 1: No Action Alternative
- Alternative 2: Nonstructural (NS-008, NS-009, NS-010, NS-011)
- Alternative 4: Lacombe
  - 4a Lacombe Levee (S-028)
  - 4a.1 Lacombe Levee Short (S-028)
  - 4b Lacombe Levee Combined with West Slidell Levee (S-120)
- Alternative 5: Bayou Liberty/Bayou Vincent/Bayou Bonfouca
  - West Slidell Levee (S-081)
  - Bayou Bonfouca Detention Pond (S-004)
  - Bayou Liberty Channel Improvements (S-010)
  - Bayou Patassat Channel Improvements- Clearing and Snagging (S-080)
- Alternative 6: South Slidell
  - 6a South Slidell Levee and Floodwall System (S-074, S-075, S-076)
  - 6b South Slidell Levee and Floodwall System with Eden Isle (S-070, S-075, S-076)
  - 6c South Slidell and West Slidell Levee and Floodwall System (S-070, S-074, S-075, S-076, S-077, S-081)
- Alternative 7: Eastern Slidell
  - Pearl River Levee (S-060)
  - Doubloon Bayou Channel Improvements-Dredging (S-069)
  - Poor Boy Canal Channel Improvements- Dredging (S-073)
  - Gum Bayou Diversion- Channel Improvements (S-072)
- Alternative 8: Upper Tchefuncte/Covington
  - Mile Branch Channel Improvements (S-057)
  - Lateral A Channel Improvements (S-121)
- Alternative 9: Mandeville Lakefront

- 9a Mandeville Lakefront-Seawall Passive Drainage (S-046, S-047, S-118)
- 9b Mandeville Lakefront-Seawall and Pump Stations (S-046, S-048, S-118, S-022)
- 9c Mandeville Lakefront-18 ft (S-046, S-048 S-118, S-122)

Table F:3-8. Equivalent Annual Damages by Reach and Measure, Coastal, FY 2021 Price Level, FY 2021 Discount Rate, $1,000s

Reach	Without Project Damages	South Slidell Levee (S-74 through S-77)	South Slidell Levee with Eden Isle (S-070, S-74 through S-77)	West Slidell Levee (S-081)	South Slidell with West Slidell Levee (S-74 through S-77, S-080)	Lacombe Levee (S-028)	West Slidell Levee with Lacombe Levee (S-120)	Mandeville Seawall (7.3ft) (S-47)	Mandeville Seawall (18ft) (S-122)
1	14,694	0	0	0	0	0	0	0	0
2	17,743	0	0	0	0	0	0	0	0
8	4,216	0	0	0	0	0	0	0	0
10	0.946	0	0	0	0	0	0	0	0
13	39,085	0	0	0	0	0	0	0	0
17	2,871	0	0	0	0	0	0	0	0
18	1,667	0	0	0	0	0	0	0	0
22	766	0	0	0	0	0	0	0	0
23	13,066	0	0	0	0	0	0	0	0
25	1,403	0	0	0	0	0	0	0	0
26	2.772	0	0	0	0	0	0	0	0
29	111	0	0	0	0	0	0	0	0
30	1,992	0	0	0	0	0	0	0	0
31	2.145	0	0	0	0	0	0	0	0
35	390	0	0	0	0	0	0	0	0
40	9,804	0	0	0	0	0	0	1,404	9,753
41	9,644	0	0	0	0	8,538	8,538	0	0
42	127	0	0	0	0	0	69	0	0
43	207	0	0	0	0	0	112	0	0
44	12,318	0	0	9,497	9,497	0	9,497	0	0
45	37,569	0	0	32,958	32,958	0	32,958	0	0
46	76,204	66,972	66,972	0	66,972	0	0	0	0
47	21,382	0	17,409	0	0	0	0	0	0
48	13,715	8,734	8,734	0	8,734	0	0	0	0
Total	278,978	75,706	93,114	42,455	118,160	8,538	51,173	1,404	9,753

Table F:3-9. Equivalent Annual Damages by Reach and Measure, Rainfall and Riverine, FY 2021 Price Level, FY 2021 Discount Rate, $1,000s

Reach	Without Project Damages	Lateral A Channel Improvements (S-121)	Mile Branch Channel Improvements (S-057)	Bayou Bonfouca Bonfouca Detention Pond (S-004)	Bayou Liberty Channel Improvements (S-010)	Bayou Patassat Channel Improvements (S-080)	Gum Bayou Diversion (S-072)	Poor Boy Canal (S-073)	Doubloon Bayou Channel Improvements (S-069)	Pearl River Levee (S-060)
1	11,854	0	0	844	0	0	0	0	-356	0
2	30,182	0	0	0	0	0	0	0	0	0
3	58	0	0	0	0	0	0	0	0	0
4	394	0	0	0	0	0	0	0	0	0
5	4,557	0	0	0	0	0	0	0	0	0
6	865	0	0	0	0	0	0	0	0	0
7	1,565	0	0	0	0	0	0	0	0	0
8	1,659	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0	0
10	24,395	0	68	0	0	0	0	0	0	0
12	251	0	0	0	0	0	0	0	0	0
13	2,035	0	0	0	0	0	0	0	72	-10
16	753	0	0	0	0	0	0	0	0	0
17	4,809	0	0	0	0	0	3	0	0	-118
18	4,186	0	0	0	0	0	0	0	0	0
19	1,452	0	0	0	0	0	0	0	0	0
20	22	0	0	0	0	0	0	0	0	0
21	183	0	0	0	0	0	0	0	0	0
22	5,549	0	0	0	0	0	0	0	0	0
23	8,316	0	0	0	0	0	0	0	-379	0

Reach	Without Project Damages	Lateral A Channel Improvements (S-121)	Mile Branch Channel Improvements (S-057)	Bayou Bonfouca Bonfouca Detention Pond (S-004)	Bayou Liberty Channel Improvements (S-010)	Bayou Patassat Channel Improvements (S-080)	Gum Bayou Diversion (S-072)	Poor Boy Canal (S-073)	Doubloon Bayou Channel Improvements (S-069)	Pearl River Levee (S-060)
24	12,533	0	0	0	0	0	0	0	0	0
25	1,128	0	0	0	0	0	0	0	0	0
26	2,346	0	0	0	0	0	0	0	0	0
27	7,953	0	0	0	0	0	0	0	0	0
28	29	0	0	0	0	0	0	0	0	0
30	3,884	0	0	0	0	0	0	0	0	0
31	34,735	0	538	0	0	0	0	0	0	0
32	109	0	0	0	0	0	0	0	0	0
34	936	0	0	0	0	0	0	0	0	0
35	2,382	0	0	0	158	0	0	0	0	0
36	4,385	0	0	0	0	0	0	0	0	0
50	2,714	292		0	0	0	0	0	0	0
51	1,037	0	363	0	0	0	0	0	0	0
52	1,826	0	1,253	0	0	0	0	0	0	0
53	1,621	0	0	0	777	0	0	0	0	0
54	819	0	0	212	0	0	0	0	0	0
55	466	0	0	0	0	133	0	0	0	0
56	208	0	0	0	0	0	0	-1	0	5
57	41	0	0	0	0	0	0	-1	0	0
58	4,745	0	0	0	0	0	-46	0	0	3,109
59	1,517	0	0	0	0	0	0	0	-418	0
60	2,275	0	0	0	0	0	0	0	-484	0
61	307	0	0	0	0	0	0	2	0	0
62	6,314	0	0	0	0	0	0	0	439.318	0

Reach	Without Project Damages	Lateral A Channel Improvements (S-121)	Mile Branch Channel Improvements (S-057)	Bayou Bonfouca Bonfouca Detention Pond (S-004)	Bayou Liberty Channel Improvements (S-010)	Bayou Patassat Channel Improvements (S-080)	Gum Bayou Diversion (S-072)	Poor Boy Canal (S-073)	Doubloon Bayou Channel Improvements (S-069)	Pearl River Levee (S-060)
63	241	0	0	0	0	0	0	0	0	188
64	1,198	0	0	0	0	0	0	0	0	565
65	4,842	0	0	0	0	0	0	0	-174.35	0
66	2,042	0	0	0	0	0	0	0	-130.845	0
67	2,408	0	0	0	0	0	0	0	0	0
68	1,127	0	0	0	0	0	0	0	-105	0
69	230	0	0	0	0	0	0	0	0	0
Total	209,484	292	2,221	1,056	935	133	-44	1	-1,537	3,739

Section 4
Project Costs

4.1 AVERAGE ANNUAL COSTS

The initial construction cost, along with the schedule of expenditures, were used to determine the interest during construction and gross investment cost at the end of the installation period (2032). The FY 2021 Federal discount rate of 2.5 percent was used to discount the costs to the base year and then amortize the costs over the 50-year period of analysis. The operations, maintenance, relocations, rehabilitation, and repair (OMRR&R) costs for each alternative was discounted to present value and annualized using the Federal discount rate of 2.5 percent for 50 years. Tables F:4-1 and F:4-2 provide the total project costs for each of the project components, the average annual construction costs, the annual operation and maintenance costs, and the total average annual costs for the alternative structural measures. The total project cost does include the cost of periodic levee lifts to counteract subsidence.

Table F:4-1. Average Annual Costs, Coastal, FY 2021 Price Level, FY 2021 Discount Rate of 2.5%

Alternative	South Slidell Levee (S-74 through S-77)	South Slidell Levee with Eden Isle (S-070, S-74 through S-77)	West Slidell Levee (S-081)	South Slidell with West Slidell Levee (S-74 through S-77, S-080)	Lacombe Levee (S-028)	West Slidell Levee with Lacombe Levee (S-120)	Mandeville Seawall (7.3ft) (S-47)	Mandeville Seawall (18ft) (S-122)
Project First Cost	$1,042,157,886	$1,682,007,777	$888,576,062	$1,732,900,985	$461,933,618	$1,347,852,820	$172,144,015	$519,596,029
Interest During Construction	$67,037,228	$108,195,832	$57,158,000	$111,469,558	$29,714,100	$86,701,200	$11,073,200	$33,423,200
Total Investment Cost	$1,109,195,114	$1,790,203,609	$945,734,062	$1,844,370,543	$491,647,718	$1,434,554,020	$183,217,215	$553,019,229
AA Investment Costs	$39,108,100	$63,119,100	$33,344,700	$65,028,900	$17,334,500	$50,579,600	$6,459,900	$19,498,400
AA O&M Costs	$3,264,200	$3,313,400	$2,691,500	$5,955,700	$1,361,000	$4,150,100	$1,882,100	$2,823,300
Total AA Costs	$42,372,300	$66,432,500	$36,036,200	$70,984,600	$18,695,500	$54,729,700	$8,342,000	$22,321,700
Construction Duration (Years)	5	5	5	5	5	5	5	5

Table F:4-2. Average Annual Costs, Rainfall and Riverine, FY 2021 Price Level, FY 2021 Discount Rate of 2.5%

Alternative	Lateral A Channel Improvements (S-121)	Mile Branch Channel Improvements (S-057)	Bayou Bonfouca Detention Pond (S-004)	Bayou Liberty Channel Improvements (S-010)	Bayou Patassat Channel Improvements (S-080)	Gum Bayou Diversion (S-072)	Poor Boy Canal (S-073)	Doubloon Bayou Channel Improvements (S-069)	Pearl River Levee (S-060)
Project First Cost	$25,625,521	$26,337,370	$151,623,591	$52,655,730	$956,630	$22,174,443	$15,307,082	$34,937,686	$216,511,535
Interest During Construction	$1,648,400	$1,694,200	$9,753,200	$3,387,100	$61,500	$1,426,400	$984,600	$2,247,400	$13,927,200
Total Investment Cost	$27,273,921	$28,031,570	$161,376,791	$56,042,830	$1,018,130	$23,600,843	$16,291,682	$37,185,086	$230,438,735
AA Investment Costs	$961,600	$988,300	$5,689,800	$1,976,000	$35,900	$832,100	$574,400	$1,311,100	$8,124,800
AA O&M Costs	$102,400	$126,800	$12,400	$414,300	$10,000	$107,300	$59,200	$150,700	$1,359,700
Total AA Costs	$1,064,000	$1,115,100	$5,702,200	$2,390,300	$45,900	$939,400	$633,600	$1,461,800	$9,484,500
Construction Duration (Years)	5	5	5	5	5	5	5	5	5

SECTION 5
Economic Justification

5.1 NET BENEFITS

The net benefits of the alternative structural measures were calculated by subtracting the average annual costs from the equivalent annual benefits. The net benefits were used to determine the economic justification of the study alternatives. Tables F:8-1 and F:8-2 summarize the equivalent annual damages and benefits, total first costs, average annual cost, benefit-to-cost ratio, and equivalent annual net benefits for each alternative. Of the coastal measures, the South Slidell Levee (S-074 through S-077), the South Slidell Levee alternate alignment with Eden Isle,(S-070 and S-074 through S-077 the West Slidell Levee, (S-081) and the South Slidell with West Slidell levee (S-074 through S-077 and S-081) are all economically justified, meaning they yield positive net benefits and have a benefit to cost ratio of 1. The South Slidell with West Slidell levee encompasses the same general areas and addresses the same source of flooding as the other justified coastal measures, so it is not mutually exclusive of these other coastal measures. Of the rainfall and riverine measures, the Mile Branch channel improvements(S-057) and the Bayou Patassat channel improvements (S-080) are the only measures that are economically justified. These measures are not located in the same area and do not address the same source of flooding so, these measures are additive.

Table F:5-1. Net Benefit Summary, Coastal, FY 2021 Price Level, FY 21 Discount Rate, $1,000s

Alternative	South Slidell Levee (S-74 through S-77)	South Slidell Levee with Eden Isle (S-070, S-74 through S-77)	West Slidell Levee (S-081)	South Slidell with West Slidell Levee (S-74 through S-77, S-080)	Lacombe Levee (S-028)	West Slidell Levee with Lacombe Levee (S-120)	Mandeville Seawall (7.3ft) (S-47)	Mandeville Seawall (18ft) (S-122)
Project First Cost	$1,042,158	$1,682,008	$888,576	$1,732,901	$461,934	$1,347,853	$172,144	$519,596
Interest During Construction	$67,037	$108,196	$57,158	$111,470	$29,714	$86,701	$11,073	$33,423
Total Investment Cost	$1,109,195	$1,790,204	$945,734	$1,844,371	$491,648	$1,434,554	$183,217	$553,019
AA Investment Costs	$39,108	$63,119	$33,345	$65,029	$17,335	$50,580	$6,460	$19,498
AA O&M Costs	$3,264	$3,313	$2,692	$5,956	$1,361	$4,150	$1,882	$2,823
Total AA Costs	$42,372	$66,432	$36,036	$70,985	$18,696	$54,730	$8,342	$22,322
Without Project EAD	$278,978	278,978	278,978	278,978	278,978	278,978	278,978	278,978
EAD Reduced Benefits	$75,706	93,114	42,455	118,160	8,538	51,173	1,404	9,753
Net Benefits	$33,334	$26,682	$6,419	$47,175	($10,158)	($3,557)	($6,938)	($12,569)
B/C Ratio	1.8	1.4	1.2	1.7	0.5	0.9	0.2	0.4

Table F:5-2. Net Benefit Summary, Rainfall and Riverine, FY 2021 Price Level, FY 21 Discount Rate, $1,000s

Alternative	Lateral A Channel Improvements (S-121)	Mile Branch Channel Improvements (S-057)	Bayou Bonfouca Detention Pond (S-004)	Bayou Liberty Channel Improvements (S-010)	Bayou Patassat Channel Improvements (S-080)	Gum Bayou Diversion (S-072)	Poor Boy Canal (S-073)	Doubloon Bayou Channel Improvements (S-069)	Pearl River Levee (S-060)
Project First Cost	$25,626	$26,337	$151,624	$52,656	$957	$22,174	$15,307	$34,938	$216,512
Interest During Construction	$1,648	$1,694	$9,753	$3,387	$62	$1,426	$985	$2,247	$13,927
Total Investment Cost	$27,274	$28,032	$161,377	$56,043	$1,018	$23,601	$16,292	$37,185	$230,439
AA Investment Costs	$962	$988	$5,690	$1,976	$36	$832	$574	$1,311	$8,125
AA O&M Costs	$102	$127	$12	$414	$10	$107	$59	$151	$1,360
Total AA Costs	$1,064	$1,115	$5,702	$2,390	$46	$939	$634	$1,462	$9,485
Without Project EAD	209,484	209,484	209,484	209,484	209,484	209,484	209,484	209,484	209,484
EAD Reduced Benefits	292	2,221	1,056	935	133	-44	1	-1,537	3,739
Net Benefits	-772	1,106	-4,646	-1,455	87	-983	-633	-2,999	-5,746
B/C Ratio	0.3	2.0	0.2	0.4	2.9	0.0	0.0	-1.1	0.4

SECTION 6
Nonstructural Analysis

6.1 NONSTRUCTURAL OVERVIEW

According to PB 2019-03, nonstructural analyses are to be conducted using a “logical aggregation method.” Rather than the individual structure, this selected aggregate is the unit of analysis and each such aggregate is a separable element that must be incrementally justified. Such aggregates could be structures that share a common floodplain or share other common flood characteristics among others. For this analysis, structures were aggregated according to shared floodplain across St. Tammany Parish. Each incremental floodplain aggregate, the combination of structures being elevated and floodproofed within an incremental floodplain, must be economically justified. Floodplain aggregation across the Parish was employed as a manageable means to account for a large inventory of structures spread out over a large study area. As the study progresses, the floodplain aggregates will likely be broken down by source of flooding. Incorporating the source of flooding into the floodplain aggregation will result in a larger number of smaller aggregates to be assessed.

For the nonstructural analysis, structure elevations for residential structures (NS-11) and dry floodproofing for nonresidential structures (NS-09) were the measures considered. Structures were aggregated by incremental floodplain. A comprehensive nonstructural alternative was analyzed across the entire study area, and the subsections of the comprehensive nonstructural alternative that correspond to areas where the economically justified structural measures are located were compared to determine the measures that would be included in the TSP. The damages reduced by incremental floodplain across the entire study area are displayed in Tables F:6-1 and F:6-2. The damages reduced by incremental floodplain occurring within the estimated boundary of risk reduction provided by the justified structural measures are displayed in Table F:6-3.

Table F:6-1. Damages Reduced by Incremental Floodplain, Coastal, $1,000s

Reach	Without Project Damages	10% AEP	5% AEP	2% AEP	1% AEP
1	14,694	8,558	2,588	624	113
2	17,743	5,178	3,665	1,935	1,184
8	4,216	741	358	426	492
10	1	0	0	0	0
13	39,085	10,079	6,021	5,337	3,457
17	2,871	103	0	68	324
18	1,667	869	97	288	116
22	766	254	20	147	21
23	13,066	5,187	1,530	1,937	159
25	1,403	247	127	248	7
26	2.772	0	0	0	0
29	111	84	0	3	0
30	1,992	211	261	318	218
31	2.145	0	0	0	0
35	390	23	0	31	0
40	9,804	2,047	2,090	2,027	757
41	9,644	3,776	1,953	1,409	603
42	127	47	0	0	7
43	207	14	0	3	22
44	12,318	2,483	2,826	2,235	811
45	37,569	17,368	8,963	2,974	1,462
46	76,204	18,360	21,228	13,679	2,900
47	21,382	4,063	1,209	3,979	3,600
48	13,715	1,070	1,132	1,589	1,317
Total	278,978	80,763	54,069	39,256	17,570

Table F:6-2. Damages Reduced by Incremental Floodplain, Rainfall and Riverine, $1,000's

Reach	Without Project Damages	10% AEP	4% AEP	2% AEP	1% AEP
1	11,854	322	43	26	35
2	30,182	13,866	700	186	78
3	58	6	1	2	0
4	394	99	10	2	0
5	4,557	2,621	14	0	0
6	865	474	2	21	2
7	1,565	1,012	1	0	0
8	1,659	308	8	4	0
9	0	0	0	0	0
10	24,395	10,249	900	297	185
12	251	33	0	0	4
13	2,035	18	1	0	0
16	753	294	15	4	3
17	4,809	1,169	20	23	14
18	4,186	1,281	5	2	4
19	1,452	913	12	0	0
20	22	3	0	0	0
21	183	85	22	0	0
22	5,549	954	5	7	1
23	8,316	2,465	150	17	21
24	12,533	5,061	213	54	95
25	1,128	18	0	0	0
26	2,346	1,103	10	11	15
27	7,953	2,683	98	27	24
28	29	8	0	0	0
30	3,884	2,137	86	45	46
31	34,735	16,980	2,488	353	316
32	109	39	0	0	0
34	936	309	268	4	22
35	2,382	304	7	17	17

Reach	Without Project Damages	10% AEP	4% AEP	2% AEP	1% AEP
36	4,385	2,126	183	131	61
50	2,714	528	303	187	122
51	1,037	235	97	14	18
52	1,826	1,325	45	35	2
53	1,621	706	18	5	7
54	819	18	1	0	1
55	466	0	0	0	0
56	208	0	5	0	0
57	41	0	0	0	0
58	4,745	1,021	195	36	12
59	1,517	23	0	0	0
60	2,275	0	0	0	0
61	307	31	0	0	0
62	6,314	41	0	0	0
63	241	12	1	0	0
64	1,198	184	101	34	32
65	4,842	269	53	38	30
66	2,042	0	0	0	0
67	2,408	0	0	0	0
68	1,127	6	5	2	0
69	230	0	0	0	0
Total	209,484	71,337	6,086	1,585	1,167

Table F:6-3. Damages Reduced by Incremental Floodplain, Justified Structural Measure Boundaries, $1,000s

Alternative Area	10% AEP	5% AEP	2% AEP	1% AEP
South Slidell/West Slidell Levee (S-074 through S-077, S-080)	39,281	34,149	20,477	6,490
Mile Branch Channel Improvements (S-057)	1,560	142	49	20
Bayou Patassat Channel Improvements (S-080)	18	1	0	1

6.2 NONSTRUCTURAL IMPLEMENTATION COSTS

Residential Structures

Elevation costs were based on the difference in the number of feet between the original first-floor elevation and the target elevation (the 100-year future-without project stage) for each structure. The number of feet that each structure was raised was rounded to the closest 1-foot increment, with the exception that structures less than 1 foot below the target elevation were rounded-up to 1 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 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. 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. A labor estimate of $15,000 per structure to complete required administrative activities by the Federal sponsor in implementing this nonstructural measure was added to the cost of implementation. Additionally, real estate cost of $15,000 per structure was added to the cost of implementation. Also, a contingency of 34.5 percent was added to the cost of implementation. Table F:6.2-1 shows the cost per square foot of structure raising by occupancy type and height raised.

Table F:6.2-1. Cost per Square Foot of Structure Raising by Occupancy Type and Number of Feet raised, FY 2021 Price Level

	1STY-SLAB			2STY-SLAB			1STY-PIER			2STY-PIER			MOBILE HOME		
Ft. Raised	Min	Most Likely	Max	Min	Most Likely	Max	Min	Most Likely	Max	Min	Most Likely	Max	Min	Most Likely	Max
1	$78	$88	$97	$88	$97	$107	$68	$78	$87	$76	$86	$95	$38	$43	$48
2	$78	$88	$97	$88	$97	$107	$68	$78	$87	$76	$86	$95	$38	$43	$48
3	$80	$90	$99	$90	$99	$109	$71	$81	$90	$79	$89	$99	$38	$43	$48
4	$83	$93	$102	$96	$106	$115	$71	$81	$90	$79	$89	$99	$38	$43	$48
5	$83	$93	$102	$96	$106	$115	$71	$81	$90	$79	$89	$99	$48	$53	$57
6	$85	$95	$104	$98	$107	$117	$73	$83	$92	$81	$91	$100	$48	$53	$57
7	$85	$95	$104	$98	$107	$117	$73	$83	$92	$81	$91	$100	$48	$53	$57
8	$88	$98	$107	$101	$111	$120	$75	$85	$94	$83	$93	$102	$48	$53	$57
9	$88	$98	$107	$101	$111	$120	$75	$85	$94	$83	$93	$102	$48	$53	$57
10	$88	$98	$107	$101	$111	$120	$75	$85	$94	$83	$93	$102	$48	$53	$57
11	$88	$98	$107	$101	$111	$120	$75	$85	$94	$83	$93	$102	$48	$53	$57
12	$88	$98	$107	$101	$111	$120	$75	$85	$94	$83	$93	$102	$48	$53	$57
13	$92	$101	$111	$107	$117	$127	$77	$86	$96	$85	$95	$104	$48	$53	$57

Non-Residential Structures.

The dry flood proofing measure was applied to all non-residential structures. Separate cost estimates were developed to flood proof these structures based on their relative square footage. If the square footage was between 0 and 20,000, then the total cost equaled $115,255; between 20,000 and 100,000 square feet equaled $357,050; and greater than 100,000 square feet equaled $899,648. These costs were developed by contacting local contractors and were escalated to FY 2021 prices. Also, a labor estimate of $15,000 per structure to complete required administrative activities by the Federal sponsor in accomplishing this nonstructural measure was added to the cost of implementation. Additionally, a real estate cost of $15,000 per structure was added to the cost of implementation. Also, a contingency of 34.5 percent was added to the cost of implementation.

Operations, Maintenance, Relocations, Rehabilitation, and Repair

For elevation measures, there are no further resources necessary to ensure that the engineered activity operates as intended. For flood proofing measures, periodic inspection of the work, which may be required, is expected to be insignificant (approximately $500 per structure over several years). Such inspection costs are an extremely small percentage of the overall cost of implementation and can be considered capitalized in the initial cost of implementation.

6.3 NONSTRUCTURAL RESULTS

Net Benefits

The damages reduced, project cost, net benefits, and benefit/cost (b/c) ratio for each floodplain increment across the entire study area are displayed in Tables F:6.3-1 and F:6.3-2. The damages reduced, project cost, net benefits, and b/c ratio for each floodplain increment occurring within the estimated boundary of risk reduction provided by the justified structural measures are displayed in Tables F:6.3-3, F:6.3-4, and F:6.3-5. Although the nonstructural alternatives for the South Slidell/West Slidell levee (S-74 through S-77 and S-081) and the Mile Branch Channel Improvements (S-057) both have economically justified increments, the corresponding structural measures have higher net benefits. As a result, the nonstructural alternatives in these subsections are not included in the broader nonstructural portion of the TSP. The combined coastal and rainfall/riverine nonstructural results by incremental floodplain less the subareas covered by the South Slidell/West Slidell Levee (S-74 through S-77 and S-081), the Mile Branch Channel Improvements (S-057), and the Bayou Patassat Channel Improvements (S-080) are displayed in Table F:6.3-6. The incremental floodplains are economically justified up to the 2 percent AEP floodplain. This cumulative 2 percent AEP floodplain nonstructural plan consists of elevating (NS-11) 6,643 residential structures and dry floodproofing (NS-09)1,855 nonresidential structures.

Table F:6.3-1. Net Benefits by Incremental Floodplain, Coastal, $1,000s

Alternative	10% AEP	5% AEP	2% AEP	1% AEP
Project First Cost	$605,805	$720,123	$1,059,004	$1,060,449
Interest During Construction	$1,872	$2,226	$3,274	$3,278
Total Investment Cost	$607,677	$722,349	$1,062,277	$1,063,727
AA Investment Costs	$21,426	$25,469	$37,454	$37,505
EAD Reduced Benefits	80,763	54,069	39,256	17,570
Net Benefits	$59,337	$28,600	$1,802	($19,935)
B/C Ratio	3.8	2.1	1.0	0.5

Table F:6.3-2. Net Benefits by Incremental Floodplain, Rainfall and Riverine, $1,000s

Floodplain	10% AEP	4% AEP	2% AEP	1% AEP
Project First Cost	$1,065,499	$189,850	$76,161	$48,506
Interest During Construction	$3,294	$587	$235	$150
Total Investment Cost	$1,068,793	$190,437	$76,397	$48,656
AA Investment Costs	$37,684	$6,714	$2,694	$1,716
EAD Reduced Benefits	71,337	6,086	1,585	1,167
Net Benefits	$33,653	($628)	($1,109)	($549)
B/C Ratio	1.9	0.9	0.6	0.7

Table F:6.3-3. South Slidell/West Slidell Benefit Area, Net Benefits by Incremental Floodplain, $1,000s

	10% AEP	5% AEP	2% AEP	1% AEP
Project First Cost	328,116	475,623	646,094	462,593
Interest During Construction	1,014	1,470	1,997	1,430
Total Investment Cost	329,131	477,093	648,091	464,023
AA Investment Costs	11,605	16,821	22,850	16,361
EAD Reduced Benefits	39,281	34,149	20,477	6,490
Net Benefits	27,676	17,328	-2,373	-9,871
B/C Ratio	3.4	2.0	0.9	0.4

Table F:6.3-4. Mile Branch Channel Improvements, Net Benefits by Incremental Floodplain, $1,000s

	10% AEP	4% AEP	2% AEP	1% AEP
Project First Cost	15,895	5,452	3,243	1,402
Interest During Construction	49	17	10	4
Total Investment Cost	15,944	5,469	3,253	1,406
AA Investment Costs	562	193	115	50
EAD Reduced Benefits	1,559	142	48	20
Net Benefits	997	(51)	(67)	(30)
B/C Ratio	2.8	0.7	0.4	0.4

Table F:6.3-5. Bayou Patassat, Net Benefits by Incremental Floodplain, $1,000s

	10% AEP	4% AEP	2% AEP	1% AEP
Project First Cost	739	172	0	175
Interest During Construction	2	1	0	1
Total Investment Cost	742	173	0	176
AA Investment Costs	26	6	0	6
EAD Reduced Benefits	18	1	0	1
Net Benefits	(8)	(5)	0	(5)
B/C Ratio	0.7	0.2	0.0	0.2

Table F:6.3-6, Net Benefits by Incremental Floodplain, Combined, $1,000s

	10% AEP	5% AEP	2% AEP	1% AEP
Project First Cost	1,326,554	428,726	485,828	644,785
Interest During Construction	4,101	1,325	1,502	1,993
Total Investment Cost	1,330,653	430,051	487,330	646,778
AA Investment Costs	46,917	15,163	17,183	22,804
EAD Reduced Benefits	111,242	25,863	20,316	12,226
Net Benefits	64,325	10,700	3,133	-10,578
B/C Ratio	2.4	1.7	1.2	0.5

SECTION 7

Tentatively Selected Plan

7.1 TENTATIVELY SELECTED PLAN COMPONENTS

The TSP is a combination of structural measures and nonstructural measures. The South Slidell/West Slidell levee (S-074 through S-077 and S-081), the Mile Branch Channel Improvements (S-057), and the Bayou Patassat Channel Improvements (S-080) are all measures that provide higher net benefits than the nonstructural alternatives in the competing benefit areas, so these structural measures are a part of the TSP. The nonstructural component of the TSP consists of elevating (NS-11) 6,643 residential structures and dry floodproofing (NS-09) 1,855 nonresidential structures located in the cumulative 2 percent AEP floodplain. Table F:7-1 displays the net benefit summary for the TSP. Figure F:7-1 contains a map of the structural and nonstructural features included in the TSP.

Table F:7-1. Net Benefit Summary of the TSP, FY21 Price Level, FY 21 Discount Rate, $1,000s

Alternative	South Slidell with West Slidell Levee (S-74 through S-77, S-080)	Mile Branch Channel Improvements (S-057)	Bayou Patassat Channel Improvements (S-080)	2% AEP Non structural (NS-09, NS-11)	TSP
Project First Cost	$1,732,901	$26,337	$957	$2,241,108	$4,001,303
Interest During Construction	$111,470	$1,694	$62	$6,928	$120,154
Total Investment Cost	$1,844,371	$28,032	$1,018	$2,248,034	$4,121,455
AA Investment Costs	$65,029	$988	$36	$79,263	$145,316
AA O&M Costs	$5,956	$127	$10	$0	$6,093
Total AA Costs	$70,985	$1,115	$46	$79,263	$151,409
Without Project EAD	488,462	488,462	488,462	488,462	488,462
EAD Reduced Benefits	118,160	2,221	133	157,421	277,935
Net Benefits	47,175	1,106	87	78,158	126,526
B/C Ratio	1.7	2.0	2.9	2.0	1.8

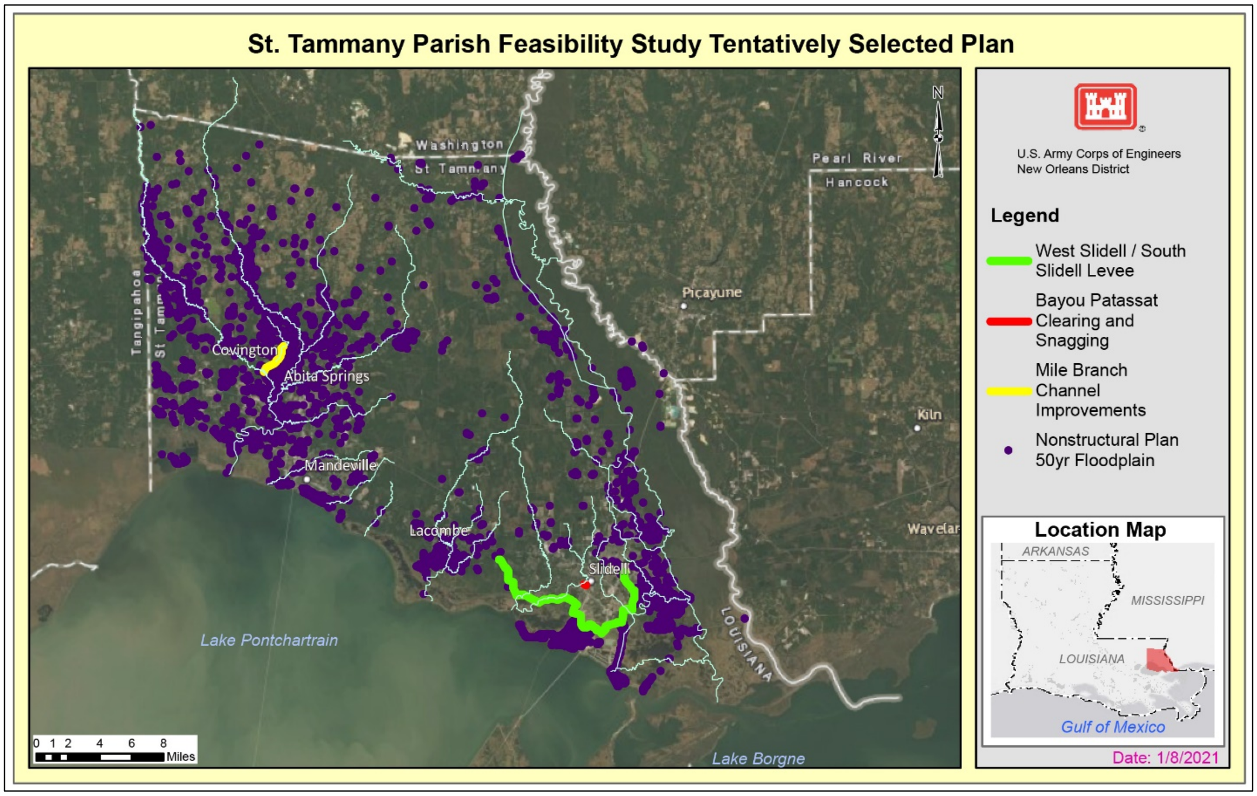

Figure F:7-1. Map of the TSP

7.2 RESIDUAL RISK

Of the $488 million in without project expected annual damages (EAD) in the study area, about $280 million is due to coastal flooding and $208 million is due to rainfall and riverine flooding. The TSP is currently estimated to reduce the EAD caused by coastal flooding by about 70 percent and reduce the EAD caused by rainfall and riverine flooding by about 40 percent. However, the 40 percent reduction of rainfall and riverine damages is underestimated. Many of the structures that would be elevated or floodproofed to address coastal flooding would also address flooding from rainfall and riverine sources as well. In order to avoid double counting, these structures were not elevated or floodproofed in the rainfall/riverine model. As a result, the residual damages for rainfall and riverine sources are exaggerated.