Mississippi Valley Division,
Regional Planning and Environment Division South

Tangipahoa Parish, Louisiana Feasibility Study

Appendix G – Tangipahoa Parish Feasibility Study Economic and Social Consideration Appendix

August 2024

CONTENTS

LIST OF TABLES

LIST OF FIGURES

SECTION 1
Background Information

1.1 INTRODUCTION

1.1.1 General

This appendix presents an economic evaluation of the flood risk management Plans for Tangipahoa Parish, Louisiana. It 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).

This appendix consists of a description of the methodology used to determine National Economic Development (NED) damages and benefits under existing and future conditions and the project costs. The analysis used Fiscal Year (FY) 2024 (October 2023) price levels, the FY 2024 Federal discount rate of 2.75 percent, and a 50-year period of analysis with the year 2033 as the base year.

1.1.2 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 Plan 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. Due to the nature of this project, physical flood damages to structures and their contents was the only NED benefit category included in this analysis.

1.1.3 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 Regional Economic Development (RED) account. The input-output macroeconomic model RECONS can be used to address the impacts of the construction spending associated with the project Plans.

1.1.4 Other Social Effects

The Other Social Effects (OSE) account includes impacts to overarching social themes including social vulnerability & resiliency, health & safety, economic vitality, social connectedness, participation, and environmental justice as it relates to the Justice 40 initiative. Impacts to these social themes are prevalent in flood risk management projects and are evaluated and discussed in the OSE account.

The economics team evaluated outcomes of the various Plans on socially vulnerable populations using the Center for Disease Control, Agency for Toxic Substances and Disease Registry's Social Vulnerability Index, and the Council on Environmental Quality's Climate and Economic Justice Screening Tool. Additionally, the PDT evaluated the life safety risk to the study area utilizing submergence criteria from the LifeSim technical manual as well as direct and indirect life-safety risk on roadways using the LifeSim stability criteria.

1.2 DESCRIPTION OF THE STUDY AREA

1.2.1 Geographic Location

The Tangipahoa study area includes the entire Tangipahoa Parish. An inventory of residential and non-residential structures was developed for the Parish. Figure G: 1-1 shows the structure inventory and the boundaries of the Parish/study area.

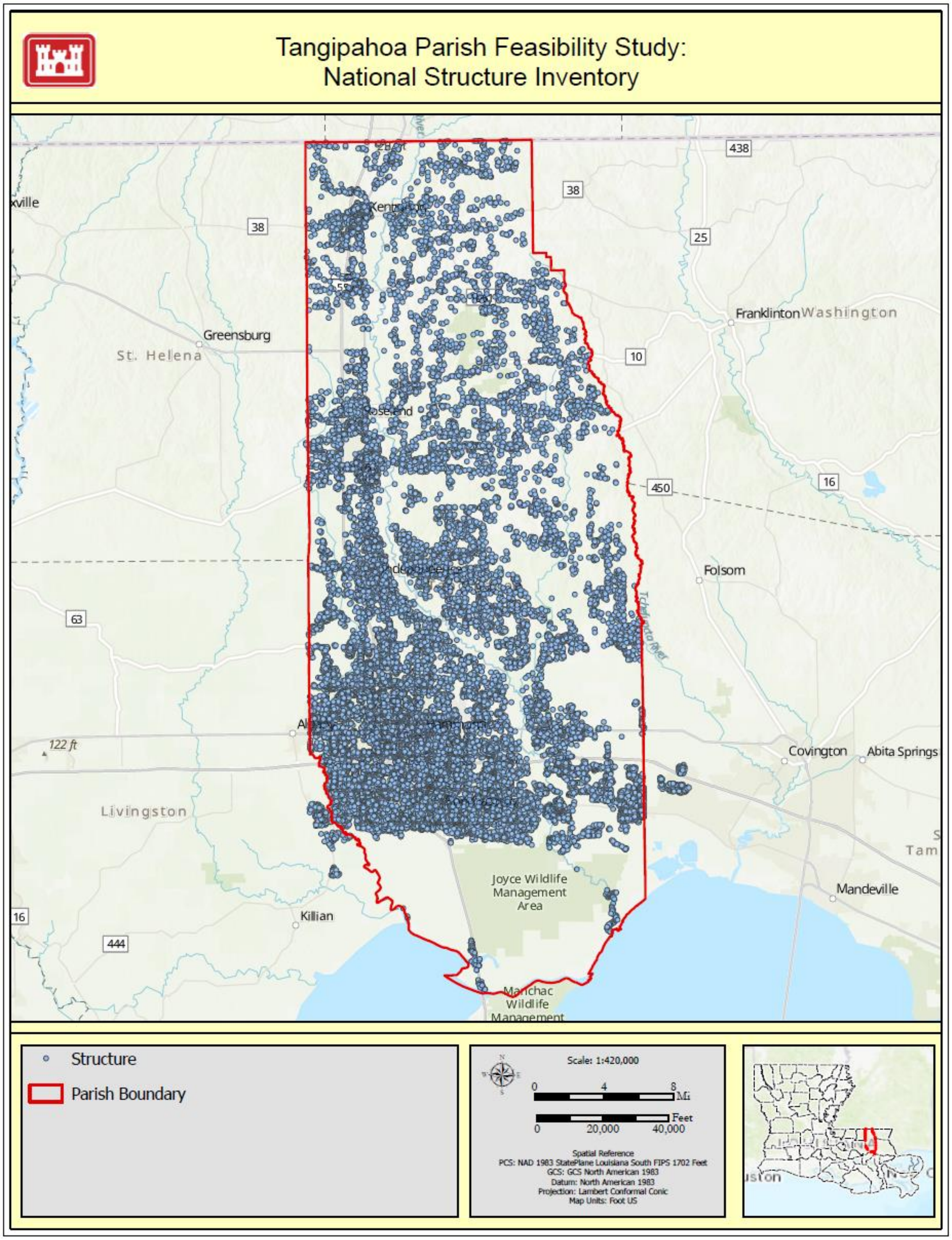

Figure G: 1-1: National Structure Inventory in Tangipahoa Parish

1.2.2 Study Area Reaches and Aggregation Areas

The study area was initially divided into 100 reaches with each of the structure points functioning as a station. These settings were used to calculate flood damages using version 1.4.3 of the HEC-FDA certified model. Five reaches were removed from non-structural action consideration as they were outside of the study area and were within the purview of the Amite and St. Tammany studies. Those areas were kept in the modelling to show the residual risk in those areas. Figure G: 1-2 shows the study area reach boundaries for the Tangipahoa study area.

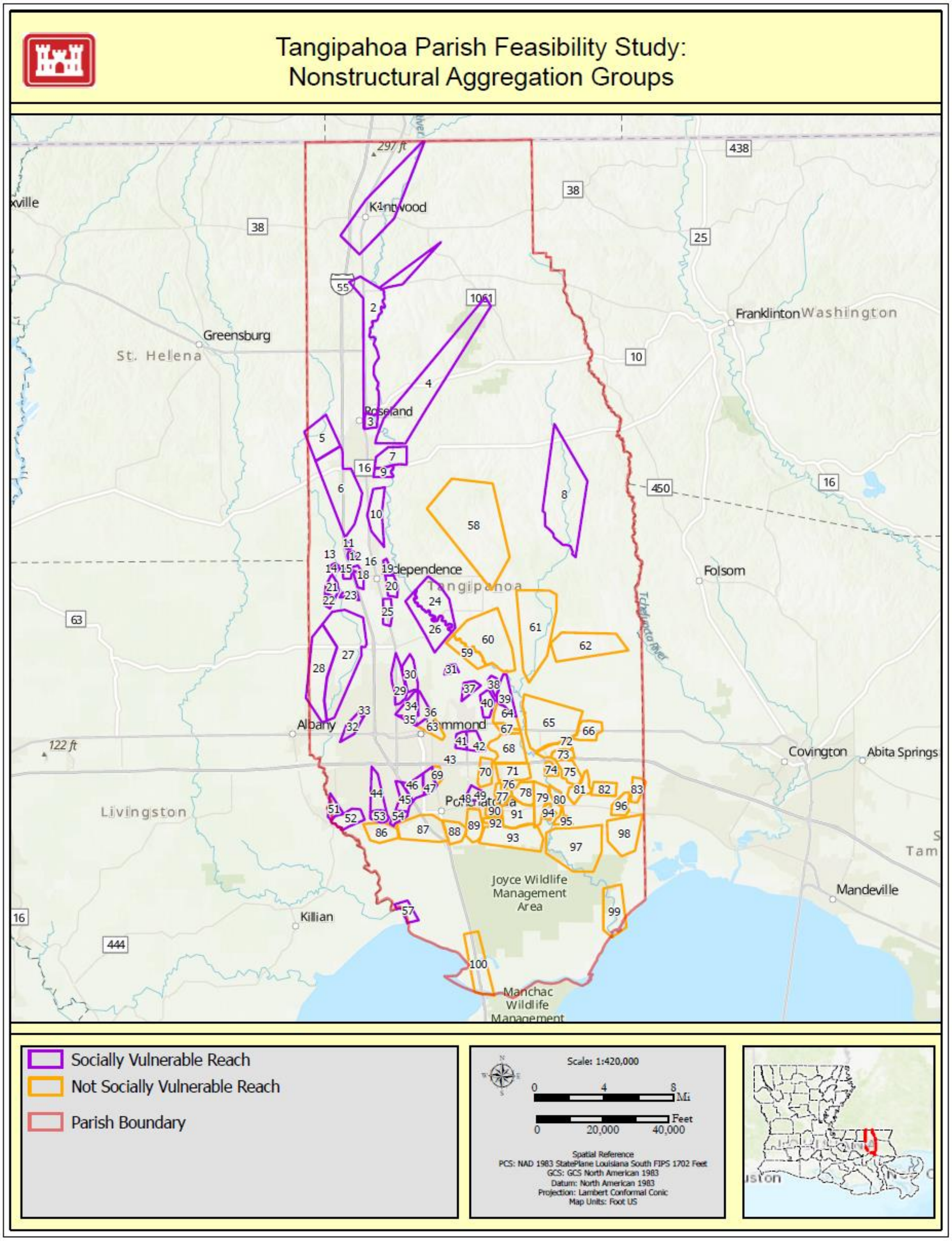

Figure G: 1-2: Nonstructural Aggregation Areas/Reaches

To evaluate the impacts to the OSE account, study area reaches based on hydraulic characteristics shown in the figure above were highlighted based on social vulnerability. The CDC's Social Vulnerability Index (SVI) uses the American Community Survey (BOC) to quantify a community's ability to respond and cope with a hazardous event. Within the overall SVI, there are four subthemes that are incorporated, which include Socioeconomic Status, Household Characteristics, Racial & Ethnic Minority Status, and Housing Type & Transportation. To identify areas experiencing social vulnerability, a 90th percentile threshold was initially applied across the four themes, in addition to the overall vulnerability. However, with the release of the CDC's 2022 SVI information, communities have been grouped into quartiles which delineate social vulnerability into Low (0-0.25 percentile), Low-Medium (0.25 to 0.50), Medium-High (0.5 to 0.75), and High (0.75-1). For the purposes of this study, we considered a community to be experiencing social vulnerability if its SVI percentile fell into the Medium-High or High categories. Additionally, when reevaluating our reaches into aggregation areas, we made note of social vulnerability but did not separate out segments of a community which hit the Medium-High or High SVI thresholds. The reasoning for this is that evaluating flood risk and flood hazard on a community-wide basis was determined to be more appropriate than specifically highlighting and evaluating socially vulnerable portions of the study area on their own.

Figure G: 1-2 above also shows the reaches which went into the HEC-FDA 1.4.3 model.

Upon further evaluation it was determined that some of our reaches, which we also used for our nonstructural aggregation areas were delineated too finely. As a result, the PDT reevaluated the reaches by combining them based on community cohesion while still maintaining an emphasis on keeping hydrologically dissimilar areas separate. The result is that the FDA model uses the initial reaches, and we aggregated results and analyzed them on the basis of the new aggregation groupings which are shown below in Figure G: 1-3.

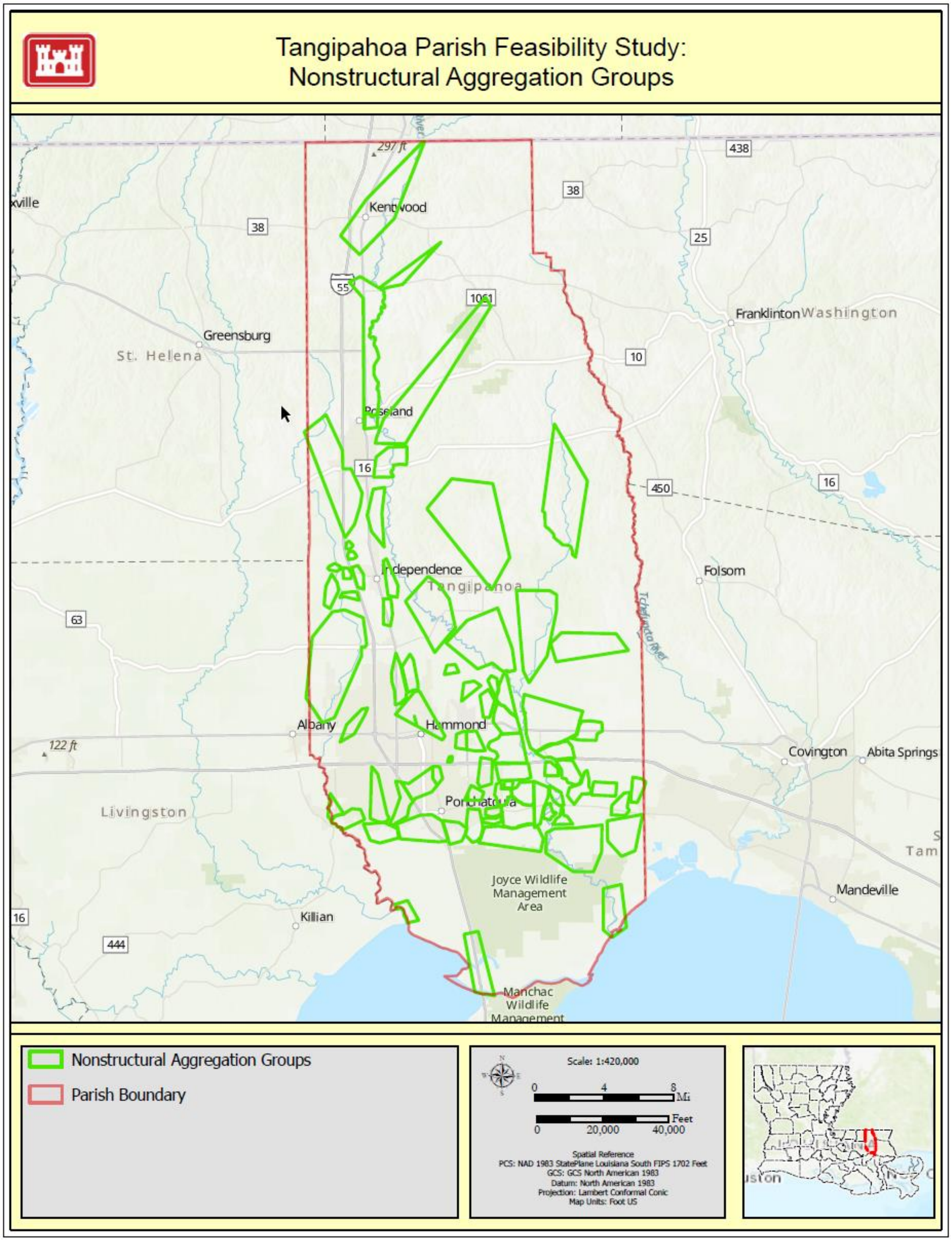

Figure G: 1-3: Refined Nonstructural Aggregation Areas

Figure G: 1-4 shows a zoomed in area of the Amite City portion of the study area with our initial Reach boundaries.

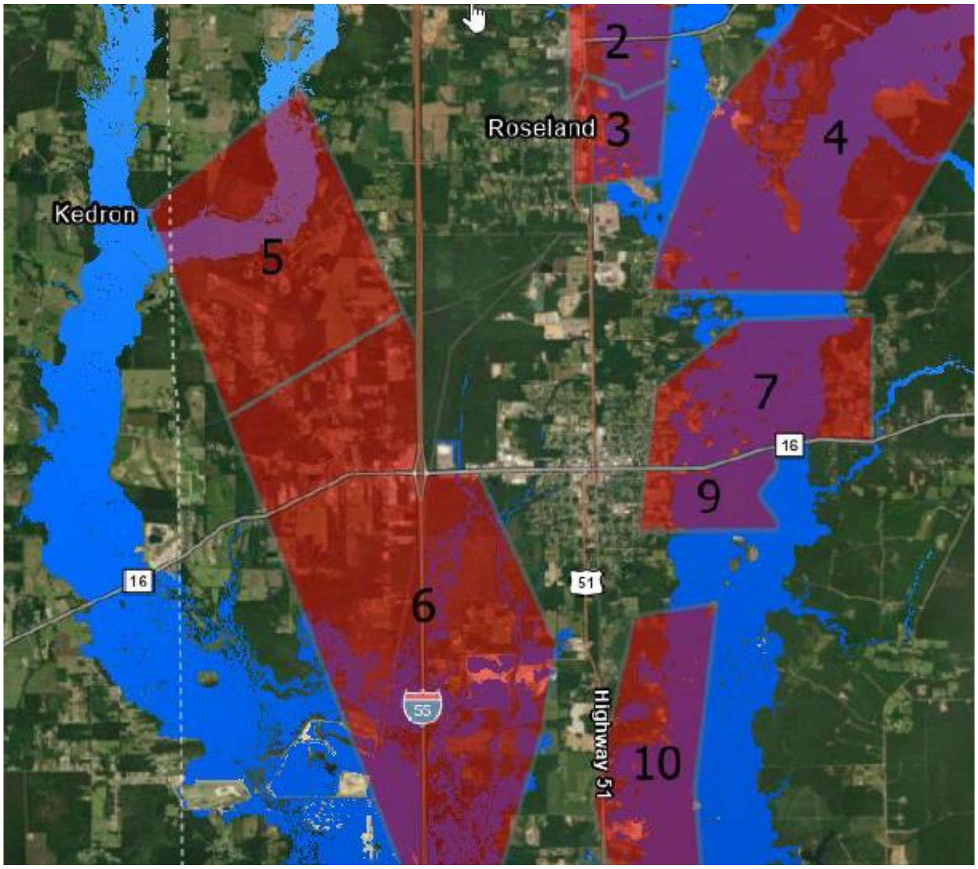

Figure G: 1-4: Initial Nonstructural Aggregation Area - Amite City Zoom-In

Figure G: 1-5 shows an example of the aggregation areas that were developed from our initial reaches.

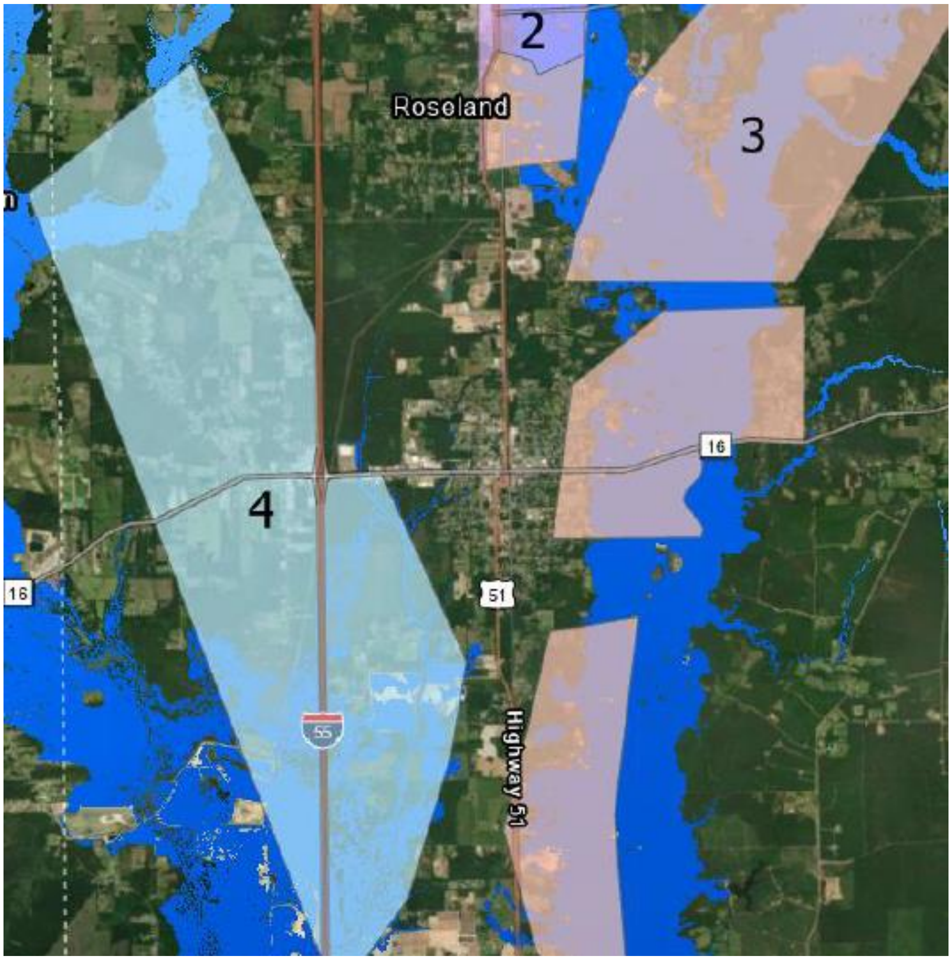

Figure G: 1-5: Refined Nonstructural Aggregation Areas - Amite City Zoom-In

The PDT made the determination that our initial aggregations were too granular. Building upon those initial reaches, we aggregated from 100 reaches down to 61 aggregation areas with a focus on community cohesion and evaluating the community as a whole with regards to potential non-structural flood-risk mitigation actions. The team still wanted to delineate aggregation areas based on H&H considerations such as source of flooding. This is why aggregation area 4, which is a part of the Amite City community, is considered a separate aggregation area and is thus evaluated separate from the east side of Amite City, aggregation area 3.

1.2.3 Land Use

The total number of acres of developed, agricultural, and undeveloped land in the study area is shown in Table G: 1-1 as defined by the USGS in 2021. As shown in the table, undeveloped land makes up the majority of the study area with 13 percent of the total acres categorized as developed land.

Table G: 1-1: Land Use in the Study Area

Land Class Name	Square Miles	Percentage of Total
Developed Land	91.5	10.8%
Agricultural Land	137.03	16.2%
Undeveloped Land	615.46	73.0%
Total	843.99	100%

1.2.4 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 a flood risk management project 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 would not induce development, but would rather reduce the risk of the population being displaced after a major storm event.

1.3 RECENT FLOOD HISTORY

1.3.1 Flood Events

The study area has experienced riverine flooding from excessive rainfall events in addition to incurring flood damages associated with storm surge from hurricanes and tropical storms.

Since 1851, the paths of many tropical events have crossed the study area. The paths and intensities of these storms are shown in Figure G: 1-6.

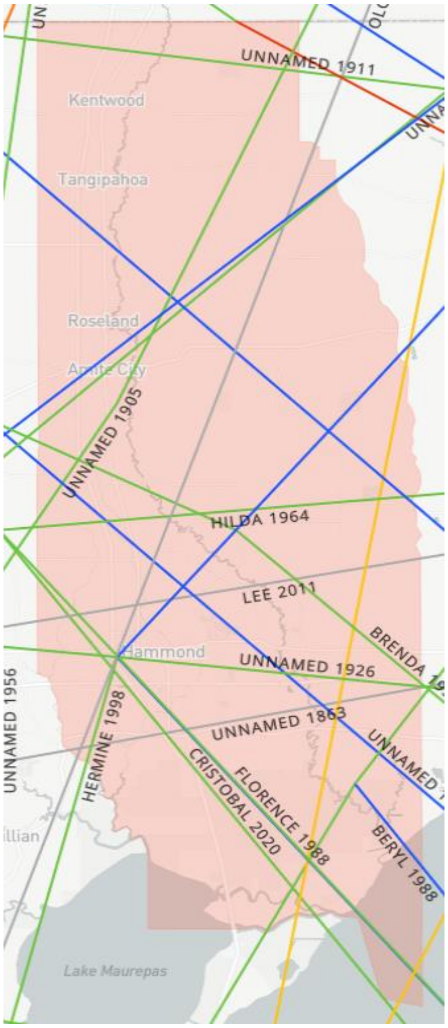

Figure G: 1-6: Hurricane and Tropical Storm Paths

1.3.2 FEMA Flood Claims

The most recent riverine event to affect the study area was the 2016 Louisiana Floods. These events brought catastrophic flooding damage to Tangipahoa Parish and the surrounding areas with both localized flooding and riverine flooding from the Tangipahoa River and its tributaries. The FEMA flood claims for the most recent events to impact the area are shown in Table G: 1-2.

Table G: 1-3 shows the FEMA Repetitive Loss flood claims paid between January 1978 and December 2019 for all counties and parishes in the study area. The table includes the number of claims, number of paid losses, and the total amount paid in the dollar value at the time of the payment. The table excludes losses that were not covered by flood insurance.

Table G: 1-2: Summary of Major Disaster Declaration Events - Tangipahoa Parish

DATE	EVENT	DATE	EVENT
Sep 1965	Hurricane Betsy	June 2001	Tropical Storm Allison
April 1973	Severe Storms and Flooding	September 2002	Tropical Storm Isadore
February 1977	Drought and Freezing	October 2002	Hurricane Lili
May 1977	Severe Storms and Flooding	September 2001	Hurricane Ivan
April 1983	Severe Storms and Flooding	August 2005	Hurricane Katrina
November 1985	Hurricane Juan	September 2005	Hurricane Rita
June 1989	Hurricane, Rain/Storm, Tornado	September 2008	Hurricane Gustav
August 1992	Hurricane Andrew	August 2012	Hurricane Isaac
February 1993	Severe Storms and Flooding	March 2016	Flooding
May 1995	Rainstorm and Flooding	August 2016	Flooding
September 1998	Hurricane Georges	September 2021	Hurricane Ida

Table G:1-3: FEMA Repetitive Loss Flood Claims within Tangipahoa Parish (1978 - 2019)

LOCATION	NUMBER OF CLAIMS	TOTAL PAYMENTS
Amite, City of	17	$508,954.76
Hammond	319	$12,619,358.41
Ponchatoula	574	$30,428,989.27
Kentwood	8	$193,597.61
Independence	54	$2,858,596.97
Village of Tangipahoa	2	$32,716.18
Tickfaw	45	$1,427,911.34
Tangipahoa (unincorporated)	284	$13,246,445.30
Total	1303	$61,316,570.84

1.4 SCOPE OF STUDY

1.4.1 Problem Description

The study area is the entire Tangipahoa Parish. The Parish is primarily rural but has some urban areas such as the city of Hammond. The study area is impacted by riverine flooding from major rainfall events as well as storm surge from tropical events in the southern portion of the study area. Authorization is currently limited to flood risk management. However, project formulation was conducted based on hydraulics associated with riverine flooding as well as coastal flooding as the non-federal sponsor, is currently pursuing WRDA 2022 Section 8106(a) which will allow the PDT to “formulate alternatives to maximize the net benefits from the reduction of the comprehensive flood risk within the geographic scope of the study.”

1.4.2 Nonstructural – Final Array

Four nonstructural plans have been carried forward to the final array; they include elevating residential structures and floodproofing non-residential structures. Elevating residential structures for the plans in the final array relied on a target elevation of the projected 2033 1% AEP stage plus two feet, not to exceed 13 feet and floodproofing non-residential structures up to 3 feet using dry floodproofing strategies. The PDT will reevaluate the proposed elevation heights using projected the 2083 1% AEP stage.

1.4.3 Nonstructural Plan Development

Nonstructural plan development in the final array relied on the comparison of the costs and benefits of floodplain aggregations on a reach level. Eligibility for nonstructural floodplain aggregations was determined using the current (2033) water surface elevations at various flooding events (10% AEP, 4% AEP, 2% AEP, and 1% AEP). Structures with flooding above the first floor at each of the flooding events were included in the floodplain aggregations. To determine the economic benefits for comparison, expected annual damage was calculated in HEC-FDA for each of the four floodplain aggregations (10% AEP, 4% AEP, 2% AEP, and 1% AEP). A detailed description of the HEC-FDA calculations can be found in Section 2. Parametric construction cost estimates including a 49 percent contingency were developed in collaboration with St. Louis District cost engineering and reported out on a reach level initially, and an aggregation group level for the final array for comparison to economic benefits. Table G: 1-4 displays the number of structures included at each floodplain aggregation included in the plans used for nonstructural Plan development.

Table G:1-4: Structures with First Floor Flooding by Floodplain

Floodplain	Residential	Non-Residential	Total Structures
0.1 AEP (10 year)	615	76	691
0.04 AEP (25 year)	950	88	1,038
0.02 AEP (50 year)	1,237	113	1,305
0.01 AEP (100 year)	1,568	133	1,701

1.4.4 Plan 1 – Nonstructural NED Plan

Eligibility for nonstructural measures in Plan 1 relied on the optimization of the floodplain aggregations in Figure G: 1-3. For each area, the floodplain increment that received the highest net NED benefits, when compared to the annualized cost, was selected for inclusion in the plan. Table G: 1-5 displays the number of structures eligible for nonstructural measures. Plan 1 consists of the floodproofing or elevation of 597 structures.

1.4.5 Plan 3a – Flood Frequency

Plan 3a includes the same structures as the NED Plan but was incrementally expanded to be inclusive of similar flood hazard characteristics and not be reliant upon the home’s value.

Each aggregation group increment was evaluated based on social vulnerability, flood hazard depth and frequency, community cohesion, critical infrastructure, and incremental net NED benefits. Plan 3a was developed with more frequency flood events in mind and thus has a higher NED net benefit category than the subsequent non-NED plans. Plan 3a includes the floodproofing or elevation of 675 structures.

1.4.6 Plan 3b – Total Net Comprehensive Benefits Plan

Plan 3b is the plan which the PDT determined to maximize total net benefits. Plan 3b includes the same structures as the Plan 3a but was incrementally expanded. Each aggregation group increment was evaluated based on social vulnerability, flood hazard depth and frequency, community cohesion, critical infrastructure, and incremental net NED benefits. Plan 3b was developed with less frequent flood events than Plan 3a in mind (4% AEP versus 10% AEP). That being said, a balance between incremental net benefits, flood hazard and frequency, as well as social vulnerability, and community cohesion was sought while still ensuring that critical infrastructure was included. The result of this analysis was that on average, structures in socially vulnerable communities were included if the incremental net NED benefits were in excess of (more positive than) -$5,000 annually per structure. The team did not pick this number, but rather this is the result of weighing incremental net NED benefits against various other social effects benefits as well as flood hazard and frequency on an incremental basis. Plan 3b would include the elevation of 1006 residential structures and floodproofing of 82 nonresidential structures.

1.4.7 Plan 3c – Flood Hazard / Other Social Effects

Plan 3c is the largest plan and includes the same structures as the Plan 3b but was expanded across the entire parish based on the same reasons listed above in Plan 3a and 3b. The difference between Plan 3c and Plans 3a/3b is that Plan 3c placed more of an emphasis on Other Social Effects benefits and incremental flood hazard at less frequent events. Thus, Plan 3c is the largest plan as it includes more structures in less frequent flood events which may not have positive NED benefits. While each of our plans do have positive net NED benefits as tables below show, Plan 3c has the lowest net NED benefits of each of the plans in the final array. Plan 3c would include the elevation of 1147 residential structures and floodproofing of 87 nonresidential structures.

Table G: 1-5: Structures eligible for Nonstructural Measures by Plan

Plans in Final Array	Elevate	Floodproof	Total Structures
Plan 1 (NED)	539	58	597
Plan 3a	616	59	675
Plan 3b	1006	82	1088
Plan 3c	1147	87	1234

Table G: 1-6 below shows the net benefits for each aggregation area and incremental floodplain. The areas highlighted in green show the areas and incremental floodplain which maximize Net NED benefits. The areas highlighted in light red show the areas which have negative net NED benefits.

Table G: 1-6: Net NED Benefits by Aggregation Group and Floodplain

Aggregation Group	10 yr Net Benefits	25 yr Net Benefits	50 yr Net Benefits	100 yr Net Benefits
1	$(25,015.80)	$(40,256.10)	$952,030.00	$778,980.00
2	$(22,514.50)	$(41,005.50)	$(46,939.00)	$(138,937.00)
3	$139,599.30	$95,237.81	$17,584.21	$(139,381.99)
4	$1,142.50	$1,142.50	$1,142.50	$1,142.50
5	$(2,384.12)	$(2,384.12)	$(2,384.12)	$(2,384.12)
6	$9,862.90	$(11,761.87)	$(86,498.80)	$(131,028.53)
8	$(31,263.00)	$(63,485.00)	$(63,485.00)	$(115,734.10)
9	$13,306.80	$(258.40)	$(258.40)	$(258.40)
10	$1,162.60	$(20,970.40)	$(20,970.40)	$(77,079.50)
11	$1,871.20	$1,871.20	$(21,987.50)	$(40,241.90)
12	$ -	$(11,283.51)	$(52,247.60)	$(113,361.10)
14	$(17,246.30)	$(28,950.03)	$(42,150.93)	$(42,150.93)
15	$(10,364.24)	$(10,364.24)	$(20,807.84)	$(20,807.84)
16	$(12,423.00)	$(12,423.00)	$(12,423.00)	$(12,423.00)
17	$(29,428.80)	$(29,428.80)	$(35,504.40)	$(35,504.40)
19	$55,929.40	$55,929.40	$55,929.40	$45,315.40
20	$15,367.10	$17,328.40	$5,036.90	$(24,780.40)
21	$1,799,290.00	$ 1,713,420.00	$1,594,180.00	$1,440,530.00
22	$(889.42)	$(7,273.87)	$(7,273.87)	$(7,273.87)
23	$ -	$ -	$ -	$(18,481.60)
24	$22,789.10	$7,456.30	$7,456.30	$7,456.30
25	$17,424.30	$17,424.30	$2,439.20	$(15,181.89)
26	$(5,285.60)	$(10,446.50)	$(10,446.50)	$(10,446.50)
27	$ -	$ -	$ -	$(12,972.88)
29	$95,944.00	$86,910.00	$74,419.00	$52,861.00
30	$44,833.00	$23,089.00	$3,024.00	$(39,757.00)
32	$15,695.30	$15,695.30	$15,695.30	$15,695.30
33	$(15,456.30)	$(28,977.80)	$(56,505.70)	$(56,505.70)
34	$527,945.80	$201,038.20	$(163,970.60)	$(1,578,247.90)
36	$2,968.20	$(22,465.70)	$(67,648.90)	$(262,406.00)
37	$(4,180.02)	$(16,433.10)	$(38,034.30)	$(373,341.70)
38	$3,494.60	$(18,375.80)	$(62,423.00)	$(78,107.00)
39	$ -	$(7,544.08)	$(51,504.70)	$(258,988.50)
40	$ -	$(10,539.22)	$(47,297.80)	$(145,568.80)
41	$(12,485.00)	$(274,415.00)	$(427,420.00)	$(603,240.00)
42	$17,239.00	$(46,215.00)	$(166,546.00)	$(290,001.00)
43	$102,658.00	$102,658.00	$68,080.00	$68,080.00
44	$154,073.00	$154,073.00	$154,073.00	$138,816.00
45	$(5,238.39)	$(27,173.10)	$(27,173.10)	$(27,173.10)
46	$2,586.30	$19,663.80	$14,551.90	$14,551.90

Aggregation Group	10 yr Net Benefits	25 yr Net Benefits	50 yr Net Benefits	100 yr Net Benefits
49	$93,737.00	$55,897.00	$13,336.00	$(63,120.00)
50	$(2,214.50)	$(11,709.00)	$(26,695.00)	$(127,939.00)
51	$133,802.00	$229,126.00	$210,696.00	$210,696.00
52	$14,140.30	$9,529.30	$9,529.30	$(38,832.80)
53	$ -	$(17,377.40)	$(90,179.58)	$(221,953.04)
54	$371,060.00	$257,710.00	$(237,240.00)	$(652,110.00)
55	$22,823.30	$(30,799.00)	$(242,697.00)	$(417,670.00)
56	$262,687.30	$222,186.80	$84,486.80	$8,872.80
57	$ -	$ -	$(27,141.31)	$(40,355.35)
58	$655,780.00	$531,720.00	$218,070.00	$(17,430.00)
59	$194,068.00	$184,506.00	$173,636.00	$173,636.00
60	$1,004,360.00	$1,004,360.00	$991,710.00	$400,470.00
61	$3,287,570.00	$3,240,910.00	$3,350,820.00	$3,350,820.00

SECTION 2

Economic and Engineering Inputs to the HEC-FDA Model

2.1 HEC-FDA MODEL

2.1.1 Model Overview

The Hydrologic Engineering Center Flood Damage Analysis (HEC-FDA) Version 1.4.3 Corps-certified model was used to calculate the damages and benefits for the Tangipahoa Parish FRM evaluation. The economic and engineering inputs necessary for the model to calculate damages include the existing condition structure inventory, contents-to- structure value ratios, foundation heights, ground elevations, depth-damage relationships, 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 maximum, and 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 first-floor elevations. While normal distributions were preferred to represent the uncertainty in the economic variables, triangular distributions were utilized in select variables where not enough observations were known to fully develop a normal distribution. Instead of modeling without uncertainty, the economics team decided to use a triangular distribution to represent known variations in the data. The number of years that stages were recorded at a given gauge 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

2.2.1 Structure Inventory

A structure inventory of residential and non-residential structures for the study area was obtained through the National Structure Inventory (NSI) version 2022. After collection, the following modifications were made:

- Ground elevations were assigned based on the LiDAR data used in the hydraulic model, and foundation heights were assigned based on Google Earth Street View and sampling techniques;
- NSI occupancy types were assigned a corresponding occupancy from the 2024 RSMeans Square Foot Catalog;
- Total depreciated structure values were calculated based on the 2024 RSMeans Square Foot Catalog;

- Depth-damage functions were assigned to structure categories and structure occupancies;
- Stations (smaller geographic areas within a reach having consistent water surface profiles) and study area reaches (larger geographic area, containing stations, used to report damage results) were assigned to individual structures using GIS tools.

The 2024 RSMeans Square Foot Catalog was used to index all structure values to a 2024 price level. Table G: 2-1 shows the total number of structures in the inventory by category which were within the 2083 H&H model extents as developed by the HEC-RAS model. There exist just over 50,000 total structures in the Parish itself, however only 4,631 are located within the largest inundation extent produced by HEC-RAS, the 0.2% AEP event. As a result, only those structures which lie within the largest inundation extent were put into the HEC-FDA 1.4.3 model.

Table G: 2-1: Number of Structures by Category

Residential	Commercial	Industrial	Public	Total Structures
4,381	179	48	23	4,631

2.2.2 Structure Values

The 2024 RSMeans Square Foot Costs Data catalog (RSMeans 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 wall types (wood siding on wood frame, brick veneer on wood frame, stucco on wood frame, and solid masonry) and two sizes (1-story and 2-story) for homes constructed with average quality materials. An average replacement cost per square foot for the four exterior wall types was calculated for each size. Based on windshield surveys, it was determined that the majority of the structures in the study area were in average condition, with an approximate age of 20 years. The associated depreciation proportion was used to calculate a most-likely depreciated square foot cost. An additional regional adjustment factor (86 percent of the national square foot costs for residential structures) for the New Orleans area was then applied to the depreciated cost per square foot. The square footage for each of the individual residential structures was multiplied by the most-likely depreciated cost per square for the average construction class to obtain a total depreciated cost.

Non-residential replacement costs per square foot were provided in the RSMeans catalog for six exterior wall types, which were specific to each occupancy type. An average replacement cost per square foot was calculated for each of the six exterior wall types in each non-residential occupancy. The RSMeans catalog depreciation schedule for non-residential structures provides depreciation percentages for three building materials: frame, masonry on wood, and masonry on masonry or steel. Based on windshield surveys, it was determined that the majority of the structures in the study area were built with masonry on wood, with an observed age of 20 years. The associated depreciation proportion was used to calculate a most-likely depreciated square foot cost. An additional regional adjustment factor (88 percent of the national square foot costs) for the New Orleans area was then applied to the depreciated cost per square foot. The square footage for each of the individual structures was multiplied by the most-likely depreciated cost per square foot for each non-residential occupancy to obtain a total depreciated cost. Tables G: 2-2 and 2-3 show the average depreciated replacement value for residential and non-residential structures by occupancy type.

Table G: 2-2: Residential Structure Inventory (2024 Price Level, $1000s)

Occupancy Type	Number	Average Depreciated Replacement Value
One-Story Slab	2,705	$240.63
One-Story Pier	153	$313.00
Two-Story Slab	1,178	$219.15
Two-Story Pier	217	$233.32
Mobile Home	102	$75.71
Total	4,381	$234.35

Table G: 2-3: Non-residential (Commercial, Public, Industrial) Structure Inventory (2024 Price Level, $1000s)

Occupancy Type	Number	Average Depreciated Replacement Value
Eating and Recreation	13	$1,023.25
Professional	86	$936.83
Repair and Home Use	22	$565.29
Retail and Personal Services	48	$449.54
Multi-Family Occupancy	27	$432.82
Public and Semi-Public	23	$2,181.70
Warehouse	48	$1,180.55
Total	250	$976.39

2.2.3 Structure Value Uncertainty

A triangular probability distribution based on the depreciated replacement costs was used to represent the uncertainty surrounding the residential structure values in each occupancy category. The most-likely depreciated value for residential structures was based a 20 percent depreciation rate (consistent with an estimated age of a 20-year old structure in average condition), the minimum value was based on a 45 percent depreciation rate (consistent with an estimated age of a 30-year old structure in poor condition), and the maximum value was based on a 7 percent depreciation rate (consistent with an estimated 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. The triangular probability distributions were entered into the HEC-FDA model to represent the uncertainty surrounding the structure values in each residential occupancy category.

A triangular probability distribution based on the depreciated replacement costs was used to represent the uncertainty surrounding the non-residential structure values in each occupancy category. The most-likely depreciated value for non-residential structures was based a 25 percent depreciation rate (consistent with an observed age of a 20-year old masonry on wood structure), the minimum value was based on a 40 percent depreciation rate (consistent with an observed age of a 30-year old frame structure), and the maximum value was based on an 8 percent depreciation rate (consistent with an observed age of a 10-year old masonry on masonry or steel structure). 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. The triangular probability distributions were entered into the HEC-FDA model to represent the uncertainty surrounding the structure values in each non-residential occupancy category. Tables G: 2-4 and 2-5 show the minimum and maximum percentages of the most-likely structure values assigned to the various structure categories.

Table G: 2-4: Residential Structure Value Uncertainty Parameters

Occupancy Type	Structure Value Error Lower (%)	Structure Value Error Upper (%)
One-Story Slab	69	116
One-Story Pier	69	116
Two-Story Slab	69	116
Two-Story Pier	67	116
Mobile Home	69	116

Table G: 2-5: Non-residential (Commercial, Public, Industrial) Structure Value Uncertainty Parameters

Occupancy Type	Structure Value Error Lower (%)	Structure Value Error Upper (%)
Eating and Recreation	80	123
Professional	80	123
Repair and Home Use	80	123
Retail and Personal Services	80	123
Grocery and Convenience	80	123
Multi-Family Occupancy	80	123
Public and Semi-Public	80	123
Warehouse	80	123

2.2.4 Residential and Non-Residential Content-to-Structure Value Ratios

The content-to-structure value ratios (CSVRs) applied to the residential and non-residential structure occupancies were taken from an extensive survey of owners in coastal Louisiana for three large CSRM evaluations. These interviews included a sampling from residential and non-residential content categories from each of the three evaluation areas.

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.

2.2.5 Content-to-Structure Value Ratio Uncertainty

For each of the residential and non-residential occupancies, a mean CSVR and a standard deviation was calculated and entered into the HEC-FDA model. 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 residential and non-residential occupancies are shown in Tables G: 2-6 and 2-7.

Table G: 2-6: Content-to-Structure Value Ratios (CSVRs) and Standard Deviations (SDs) by Occupancy (Residential)

Occupancy Type	CSVR (%)	SD (%)
One-Story Slab	71	24
One-Story Pier	71	24
Two-Story Slab	50	30
Two-Story Pier	50	30
Mobile Home	148	69

Table G: 2-7: Content-to-Structure Value Ratios (CSVRs) and Standard Deviations (SDs) by Occupancy (Non-Residential)

Occupancy Type	CSVR (%)	SD (%)
Eating and Recreation	428	703
Professional	78	79
Repair and Home Use	251	215
Retail and Personal Services	148	117
Multi-Family Occupancy	23	13
Public and Semi-Public	82	108
Warehouse	372	540

2.2.6 First-floor elevations

Topographical data based on Light Detection and Ranging (LiDAR) data using the North American Vertical Datum of 1988 (NAVD 88) were 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 2-foot by 2-foot grid resolution developed by the United States Geological Survey (USGS), which was resampled at a 30-foot by 30-foot resolution. This ground elevation raster was obtained from the HEC-RAS hydraulic model to avoid continuity errors between the engineering and economic inputs. 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.

2.2.7 Sampling of Foundation Heights Above Ground

The foundation heights of the residential and non-residential structures above the ground were determined using statistical random sampling procedures. Sampling was necessary due to varying types of structure foundations (slab on grade and pier/pile) and the large variation in the heights of these foundations above the ground elevation. Statistical formulas were used to account for the estimated variation, acceptable error, and level of confidence and to determine a statistically significant number of structures to be surveyed.

A total of 2026 residential and non-residential structures were randomly selected for the sample in Tangipahoa Parish. If a selected structure had been demolished or razed, then an adjacent structure was surveyed in its place. The survey team used Google Earth and Google Streetview to collect the required information including the height of the foundation above ground (measured from the bottom of the front door to adjacent ground). This information was used to develop the average height above ground of slab on grade and pier/pile foundation structures in each portion of the study area. The mean foundation height and proportions of sampled residential 1-story and 2-story pile foundation structures and residential 1-story and 2-story slab foundation structures were applied to all the unsampled residential structures in each Tangipahoa neighborhood. The mean foundation height and proportions of the sampled commercial 1-story and 2-story pile foundation structures and commercial 1-story and 2-story slab foundation structures were randomly applied to the unsampled commercial structures in each neighborhood. Since the commercial depth-damage relationships are only provided for commercial 1-story structures, all the commercial structures were treated as 1-story structures. The remainder of the study area was stratified by the occupancy and foundation types provided in the National Structure Inventory.

2.2.8 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 and commercial structures was estimated by calculating the standard deviations surrounding the sampled mean values for the combined inventory. An overall weighted average standard deviation for the four structure groups was computed for each structure category. The standard deviation was calculated to be 0.63 feet for residential pier foundation structures in areas with riverine flooding and 0.58 feet for slab foundation structures. For residential pier foundation structures in areas with coastal flooding, the standard deviation was calculated to be 2.32 feet. For residential slab foundation structures in areas with coastal flooding, the standard deviation was calculated to be 2.6 feet. The standard deviation for non-residential structures was calculated to be 0.28 for industrial structures, 0.81 feet for commercial structures, and 0.20 feet for public structures.

The combined standard deviations for the ground elevations and foundation heights resulted in a 0.93 feet standard deviation for residential pier foundation structures and 0.88 feet for slab foundation structures in riverine areas. For pier foundations in coastal areas, the combined standard deviation is 2.62 feet. For slab foundations in coastal areas, the combined standard deviation is 2.9 feet. For non-residential structures, the combined standard deviation was calculated to be 0.58 feet for industrial structures, 1.21 feet for commercial structures, and 0.5 feet for public structures. Table G: 2-8 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 and non-residential structures. Table G: 2-9 displays the average foundation heights and standard deviations by occupancy type.

One source of uncertainty is the age of the Google Streetview imagery. Much of the Parish is rural and either lacks Google Streetview imagery or has imagery which may be a decade or more old. The PDT intends to ground truth each structure in the Tentatively Selected Plan in Feasibility Level Design to ensure quality and accuracy surrounding first floor and structure type information. For the purposes of first floor uncertainty calculations, mobile homes were considered residential pier structures. Additionally, it was determined to use a value of 0.6 feet for the first-floor elevation uncertainty leading up to the TSP selection. This value will be refined as the team refines the structure inventory characteristics post-TSP. One additional note is that for automobiles, only the ground elevation uncertainty was included as they don't have foundation heights.

The formula for calculation the standard deviation of the ground elevation LiDAR data is listed below.

$$z = \frac{x - u}{st.deviation}$$

$$1.96 = \frac{0.5895 - 0}{st.deviation}$$

$$Standard\ Deviation = 0.3007\ feet$$

$$Standard\ Deviation\ squared = 0.0904\ feet\ squared$$

Table G: 2-8: First-floor Statistics by Occupancy

Category	Occupancy Type	Average Foundation Height	Ground Stage Standard Deviations	Foundation Height Standard Deviations	First Floor Standard Deviations
Residential	One-Story Slab	0.91	0.3	0.58	0.65
Residential	One-Story Pier	1.5	0.3	0.63	0.70
Residential	Two-Story Slab	0.95	0.3	0.61	0.68
Residential	Two-Story Pier	0.9	0.3	0.63	0.70
Residential	Mobile Home	1.69	0.3	0.46	0.55
Commercial	Eating and Recreation	0.62	0.3	0.35	0.46
Commercial	Professional	0.57	0.3	0.34	0.45
Commercial	Repair and Home Use	0.78	0.3	0.48	0.57
Commercial	Retail and Personal Services	0.65	0.3	0.35	0.46
Commercial	Multi-Family Occupancy	0.66	0.3	0.32	0.44
Public	Public and Semi-Public	0.55	0.3	0.23	0.38
Industrial	Warehouse	0.63	0.3	0.33	0.45

Table G: 2-9: Foundation Height Standard Deviations

Type	Foundation Height Standard Deviation	Foundation Height Standard Deviation Squared	Foundation Height + Ground Elevation Standard Deviation Squared	Square root of Sum of Squared = Combined Std. Deviation
Pier	0.63	0.3969	0.4873	0.6981
Coastal Pier	2.32	5.3824	5.4728	2.3394
Slab	0.58	0.3364	0.4268	0.6533
Coastal Slab	2.60	6.7600	6.8504	2.6173
Commercial	0.81	0.6561	0.7465	0.8640
Industrial	0.28	0.0784	0.1688	0.4109
Public	0.20	0.0400	0.1304	0.3611

2.2.9 Depth-Damage Relationships

The depth-damage relationships, developed by a panel of building and construction experts for the Morganza to the Gulf, Louisiana feasibility study, were used in the economic analysis. These relationships were deemed appropriate because the two study areas are geographically close and have similar structure categories and occupancies. After conferring with the PDT's H&H team members and due to the expected duration of the flooding, most of the study area has long-freshwater depth-damage relationships. For the area of the study which receives a combination of coastal and riverine or predominantly coastal, long duration saltwater depth-damage relationships were used as the Lakes Pontchartrain and Maurepas are not freshwater but are brackish.

Depth-damage relationships indicate the percentage of the total structure and content value that would be damaged at various depths of flooding. For residential structures, damage percentages were provided at each 1-foot increment from 1.5 feet below the first-floor elevation to 15 feet above the first-floor elevation for the structural components and the content components. Damage percentages were determined for each 0.5- foot increment from 0.5-foot below first-floor elevation to 2 feet above first-floor, and for each 1-foot increment from 2 feet to 15 feet above first-floor elevation for non-residential structures.

2.2.10 Uncertainty Surrounding Depth-Damage Relationships

A triangular probability density function was used to determine the uncertainty surrounding the damage percentage associated with each depth of flooding for all occupancy types. 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.

2.3 ENGINEERING INPUTS TO THE HEC-FDA MODEL

2.3.1 Stage-Probability Relationships

Stage-probability relationships were provided for the existing condition (2033) without-project and future without project conditions (2083). Water surface profiles were provided for eight annual exceedance probability (AEP) events: 50% (2-year), 20% (5-year), 10% (10-year), 4% (25-year), 2% (50-year), 1% (100-year), 0.5% (200-year), and 0.2% (500- year). Tangipahoa Parish experiences flooding from riverine rainfall events and coastal storm surge. Relative sea level rise was evaluated and documented in the H&H appendix for the areas impacted by storm surge. A sensitivity analysis of sea level rise impacts to economic evaluation will be performed on the recommended plan post-TSP.

2.3.2 Uncertainty Surrounding the Stage-Probability Relationships

A 20-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. This equivalent record length will be refined post-TSP. It is expected that the equivalent record length will be longer than 20 years. As such, the expected damages and uncertainty bounds surrounding the expected damages are likely to decrease.

SECTION 3

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 100-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.

3.1.1 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 base year (2033) conditions and the future without project (2083) 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 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.

3.1.2 Stage-Probability Relationships with Uncertainty

The HEC-FDA model used an equivalent record length (20 years) for each study area reach to generate a stage-probability relationship with uncertainty for the without-project condition under base year (2033) conditions and future without project (2083) 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.

3.1.3 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 weighing 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 Plan, the EAD were totaled for each study area reach to obtain the total without-project EAD under base year (2033) conditions and future without project (2083) conditions.

Tables G: 3-1 through 3-4 show the number of structures and total damage, respectively, at each of the annual exceedance probability (AEP) events in the base year and the future year without project condition by category.

Table G: 3-1: Structures Damaged Without Project by Probability Event (Base Year 2033)

Annual Exceedance Probability (AEP) Event	Residential	Commercial	Industrial	Public	Total
0.50 (2 yr)	-	1	-	-	-
0.20 (5 yr)	-	1	-	-	-
0.10 (10 yr)	855	71	7	9	942
0.04 (25 yr)	1,239	85	15	12	1,351
0.02 (50 yr)	1,582	99	19	14	1,714
0.01 (100 yr)	2,037	113	25	16	2,191
0.005 (200 yr)	2,689	134	34	21	2,877
0.002 (500 yr)	3,720	175	46	23	3,964

Table G: 3-2: Structures Damaged Without Project by Probability Event (Base Year 2083)

Annual Exceedance Probability (AEP) Event	Residential	Commercial	Industrial	Public	Total
0.50 (2 yr)	-	1	-	-	1
0.20 (5 yr)	-	1	-	-	1
0.10 (10 yr)	977	76	11	9	1,053
0.04 (25 yr)	1,441	91	18	12	1,532
0.02 (50 yr)	1,951	111	26	14	2,073
0.01 (100 yr)	2,451	126	31	16	2,595
0.005 (200 yr)	3,011	146	38	21	3,192
0.002 (500 yr)	3,792	175	46	23	4,010

Table G: 3-3: Structure Damage Without Project by Probability Event (2024 Price Level; $1000s) (Base Year 2033)

Annual Exceedance Probability (AEP) Event	Residential	Commercial	Industrial	Public	Total
0.50 (2 yr)	-	$58	-	-	$58
0.20 (5 yr)	-	$58	-	-	$58
0.10 (10 yr)	$107,085	$31,044	$11,859	$2,563	$152,551
0.04 (25 yr)	$178,565	$42,838	$16,105	$10,810	$248,318
0.02 (50 yr)	$239,395	$56,390	$34,117	$12,685	$342,586
0.01 (100 yr)	$309,981	$70,939	$44,875	$14,235	$440,030
0.005 (200 yr)	$401,614	$87,631	$55,274	$17,689	$562,216
0.002 (500 yr)	$562,677	$121,534	$70,907	$24,138	$779,313

Table G: 3-4: Structure Damage Without Project by Probability Event (2024 Price Level; $1000s) (Base Year 2083)

Annual Exceedance Probability (AEP) Event	Residential	Commercial	Industrial	Public	Total
0.50 (2 yr)	$0	$58	$0	$0	$58
0.20 (5 yr)	$0	$58	$0	$0	$58
0.10 (10 yr)	$143,791	$44,301	$29,235	$2,667	$219,995
0.04 (25 yr)	$223,273	$57,187	$37,085	$10,811	$328,356
0.02 (50 yr)	$303,334	$75,442	$51,260	$12,686	$442,722
0.01 (100 yr)	$410,222	$97,190	$66,514	$14,237	$588,162
0.005 (200 yr)	$521,193	$117,492	$76,911	$17,688	$733,284
0.002 (500 yr)	$680,467	$150,646	$90,809	$24,140	$946,063

3.1.4 Expected and Equivalent Annual Damages and Benefits for the Final Array of Plans

The HEC-FDA model used linear interpolation for the years between 2033 and 2083 to obtain the stream of expected annual damages over the 50-year period of analysis. The FY 2024 Federal interest rate of 2.75 percent was used to discount the stream of expected annual damages and benefits occurring after the base year to calculate the total present value of the damages over the period of analysis. The present value of the expected annual damages was then amortized over the period of analysis using the Federal interest rate to calculate the equivalent annual damages. Expected and equivalent annual damages for the final array are shown by structure category in Tables G: 3-5 to 3-7. Expected and equivalent annual damages and benefits for the final array are shown in Tables G: 3-8 to 3-10. Tables G: 3-11 to 3-13 show the probability benefits for each of the plans exceeds the values indicated at the 0.75, 0.50 and 0.25 confidence levels.

Table G: 3-5: Expected Annual Damage by Plan and Category (2024 Price Level; FY 24 Federal Discount Rate; $1000s) (Base Year 2033)

Plan	Auto	Commercial	Industrial	Public	Residential	Total
No action	$2,315	$11,047	$9,068	$1,429	$28,735	$52,599
Plan 1	$2,315	$8,054	$3,317	$1,192	$14,627	$29,526
Plan 3a	$2,315	$8,049	$3,317	$1,192	$13,419	$28,316
Plan 3b	$2,315	$6,947	$3,058	$730	$9,213	$22,288
Plan 3c	$2,315	$6,878	$3,058	$715	$8,218	$21,210

Table G: 3-6: Expected Annual Damage by Plan and Category (2024 Price Level; FY 24 Federal Discount Rate; $1000s) (Base Year 2083)

Plan	Auto	Commercial	Industrial	Public	Residential	Total
No action	$2,846	$15,085	$15,292	$1,435	$35,689	$70,350
Plan 1	$2,846	$13,124	$7,885	$1,193	$21,433	$46,498
Plan 3a	$2,846	$13,120	$7,885	$1,193	$20,215	$45,279
Plan 3b	$2,846	$11,958	$7,648	$736	$15,691	$38,906
Plan 3c	$2,846	$11,847	$7,648	$721	$14,342	$37,442

Table G: 3-7: Equivalent Annual Damage by Plan and Category (2024 Price Level; FY 24 Federal Discount Rate; $1000s) (Equivalent at 2.75% FY24 Interest Rate)

Plan	Auto	Commercial	Industrial	Public	Residential	Total
No action	$2,517	$12,583	$11,435	$1,431	$31,380	$59,350
Plan 1	$2,517	$9,982	$5,054	$1,192	$17,216	$35,981
Plan 3a	$2,517	$9,978	$5,054	$1,192	$16,004	$34,767
Plan 3b	$2,517	$8,853	$4,804	$732	$11,677	$28,608
Plan 3c	$2,517	$8,768	$4,804	$717	$10,547	$27,384

Table G: 3-8: Expected Annual Damages and Benefits by Plan (2024 Price Level; FY24 Federal Discount Rate; $1000s) (Base Year 2033)

Plan	Damages	Benefits
No action	$52,599	$0
Plan 1	$29,526	$23,072
Plan 3a	$28,316	$24,283
Plan 3b	$22,288	$30,311
Plan 3c	$21,210	$31,388

Table G: 3-9: Expected Annual Damages and Benefits by Plan (2024 Price Level; FY24 Federal Discount Rate; $1000s) (Base Year 2083)

Plan	Damages	Benefits
No action	$70,350	$0
Plan 1	$70,350	$23,851
Plan 3a	$70,350	$25,071
Plan 3b	$70,350	$31,444
Plan 3c	$70,350	$32,907

Table G: 3-10: Equivalent Annual Damages and Benefits by Plan (2024 Price Level; FY24 Federal Discount Rate; $1000s) (Equivalent at 2.75% FY24 Interest Rate)

Plan	Damages	Benefits
No action	$59,350	$0
Plan 1	$59,350	$23,369
Plan 3a	$59,350	$24,853
Plan 3b	$59,350	$30,742
Plan 3c	$59,350	$31,966

Table G: 3-11: Expected Annual Damages and Benefits by Plan and Probability (2024 Price Level; FY24 Federal Discount Rate; $1000s) (Base Year 2033)

Probability Benefits Exceeds Values Indicated:	0.75	0.50	0.25
Plan 1	$14,491	$20,765	$30,511
Plan 3a	$15,321	$21,837	$32,099
Plan 3b	$17,376	$26,640	$40,679
Plan 3c	$17,761	$27,500	$42,223

Table G: 3-12: Expected Annual Damages and Benefits by Plan and Probability (2024 Price Level; FY24 Federal Discount Rate; $1000s) (Base Year 2083)

Probability Benefits Exceeds Values Indicated:	0.75	0.50	0.25
Plan 1	$16,448	$22,034	$30,654
Plan 3a	$17,312	$23,127	$32,248
Plan 3b	$19,896	$28,360	$41,122
Plan 3c	$20,656	$29,644	$43,194

Table G: 3-13: Equivalent Annual Damages and Benefits by Plan and Probability (2024 Price Level; FY24 Federal Discount Rate; $1000s) (Equivalent at 2.75% FY24 Interest Rate)

Probability Benefits Exceeds Values Indicated:	0.75	0.50	0.25
Plan 1	$15,235	$21,247	$30,565

Plan 3a	$16,079	$22,328	$32,150
Plan 3b	$18,335	$27,294	$40,841
Plan 3c	$18,862	$28,315	$42,592

SECTION 4
Project Costs of the TSP

4.1 NONSTRUCTURAL COSTS – ELEVATION & FLOODPROOFING

Nonstructural cost estimates for the final array were developed through a joint effort between the St. Louis and New Orleans Districts Economics and Cost Engineering Branches. A 49 percent 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 this study after reviewing the associated risks.

4.1.1 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 current first floor elevation and the target elevation (the 2033 condition 100-year stage plus two feet) for each structure in the HEC-FDA module. The number of feet that each structure was raised was rounded to the closest 1-foot increment. Elevation costs by structure were summed to yield an estimate of total structure elevation costs.

A sensitivity analysis was performed using 2033 hydraulics, which determined that the target elevation which returned the most NED benefits and thus is most economically justified is using the base flood elevation (100-year) plus two feet. Another sensitivity will be performed using 2083 hydraulics post-TSP to account for expected future conditions including sea level rise. Additionally, the target elevation will be based on projected 2083 hydraulics.

The cost per square foot for raising a structure was based on data obtained from the nonstructural tool using New Orleans labor rates. Composite costs were derived for residential structures by type: slab and pier foundation and square footage of the structure. Mobile homes, for cost estimation purposes, were assumed to have the same cost structure as pier foundations. These composite unit costs also vary by the number of feet that structures may be elevated. Table G: 4-1 displays the costs for each residential category 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 FY 2024 Federal discount rate of 2.75 percent. The square foot costs for elevation were price indexed to FY24 price levels using RSMeans cost catalog.

Table G: 4-1: Nonstructural Elevation Costs for Residential Structures (2024 Price Level; $/sqft)

Height (ft)	1000 – 1999 Sq. ft Slab	1000 – 1999 Sq. ft Pier	2000 – 2999 Sq. ft Slab	2000 – 2999 Sq. ft Pier	3000+ Sq. ft Slab	3000+ Sq. ft Pier
2	$ 156.79	$ 138.52	$ 96.95	$ 78.67	$ 80.68	$ 62.41
3	$ 161.13	$ 142.86	$ 100.89	$ 82.62	$ 83.36	$ 65.09
4	$ 165.47	$ 147.19	$ 104.83	$ 86.56	$ 86.03	$ 67.76
5	$ 169.84	$ 151.57	$ 107.55	$ 89.28	$ 88.70	$ 70.43
6	$ 174.21	$155.94	$ 110.27	$ 92.00	$ 91.37	$ 73.10
7	$ 178.55	$160.28	$ 112.98	$ 94.70	$ 94.05	$ 75.78
8	$ 182.89	$ 164.62	$ 115.68	$ 97.40	$ 96.72	$ 78.45
9	$ 187.27	$ 169.00	$ 118.40	$ 100.12	$ 99.39	$ 81.12
10	$ 191.64	$ 173.37	$ 121.12	$ 102.84	$ 102.05	$ 83.78
11	$ 195.98	$ 177.71	$ 123.82	$ 105.55	$ 104.72	$ 86.45
12	$ 200.32	$ 182.04	$ 126.52	$ 108.25	$ 107.38	$ 89.11

4.1.2 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 G: 4-2 shows a summary of square footage costs for floodproofing. These costs were developed by the Nonstructural Center of Expertise and the Cost MCX using the nonstructural dry floodproofing template. The cost for dry floodproofing a 1053SF structure was determined. From there, a cost per square foot was determined and applied to the structures slated for dry floodproofing. Final cost estimates are expressed at a 2024 price level.

Table G:4-2: Nonstructural Floodproofing Costs for Non-residential Structures (2024 Price Level)(Cost Per Square Foot=$126.31)

Structure Square Footage	Total Cost
1053	$133,000

4.1.3 Annual Project Costs

The initial construction costs (first costs) were used to determine the interest during construction and gross investment cost at the end of the installation period (2033). Interest during construction was calculated in accordance with PB 2019-03 guidance for calculating interest during construction on a nonstructural project. The construction schedule for each of the Tangipahoa nonstructural plans was assumed to be 3 months. The FY 2024 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 using quarterly discounting. Cost engineering provided a 14 percent PED cost and 8 percent CM cost. The annualization of both these estimates are provided for each plan of the final array in Table G: 4-3.

Table G: 4-3: Summary of Project Costs for Final Array (2024 Price Level; FY24 Federal Discount Rate; $1000s)

Final Array	Plan 1 (NED)	Plan 3a	Plan 3b	Plan 3c
Construction First Cost	$345,152,000	$381,222,000	$595,068,000	$665,077,000
Interest During Construction	$1,172,426	$1,294,950	$2,021,351	$2,259,160
Total Construction Cost	$346,324,426	$382,516,950	$597,089,351	$667,336,160
Average Annual Total Construction Cost	$12,828,200	$14,168,800	$22,116,700	$24,718,700

SECTION 5
Results of the Economic Analysis

5.1 NET BENEFIT ANALYSIS

5.1.1 Calculation of Net Benefits

The equivalent annual benefits were compared to the annual costs to develop a benefit-to-cost ratio for each of the plans in the final array. The net benefits for the Plans were calculated by subtracting the annual costs from the base year equivalent annual benefits. Table G:5-1 shows the average annual costs, benefits, net benefits, and benefit-to-cost ratios for the plans in the final array. The National Economic Development (NED) plan is the plan that reasonably maximizes net benefits. This analysis found Plan 1 to be the NED plan and Plan 3b to be the Tentatively Selected Plan (TSP).

Table G: 5-1: Annual Costs and Benefits Summary (2024 Price Level; FY24 Discount Rate; $1000s)

Final Array	Plan 1 (NED)	Plan 3a	Plan 3b	Plan 3c
Construction First Cost	$345,152,000	$381,222,000	$595,068,000	$665,077,000
Interest During Construction	$1,172,426	$1,294,950	$2,021,351	$2,259,160
Total Construction Cost	$346,324,426	$382,516,950	$597,089,351	$667,336,160
Average Annual Construction Cost	$12,828,200	$14,168,800	$22,116,700	$24,718,700
Equivalent Annual Benefits	$23,369,160	$24,583,050	$30,742,290	$31,966,400
Annual Net Benefits	$10,540,960	$10,414,250	$8,625,590	$7,247,700
Benefit-to-Cost Ratio (BCR)	1.82	1.74	1.39	1.29

5.2 RISK ANALYSIS

5.2.1 Benefit Exceedance Probability Relationship

The HEC-FDA model incorporates the uncertainty surrounding the economic and engineering inputs to generate results that can be used to assess the performance of proposed plans. The HEC-FDA model was used to calculate expected annual without-project and with-project damages and the damages reduced for each of the plans in the final array. Table G: 5-2 shows the benefit exceedance probability relationship for each of the plans compared to the point estimate of the average annual cost. As benefits exceeding costs translates to a benefit-to-cost ratio of 1 or more, the table can also be translated as the probability the plan will produce a positive net benefit and BCR greater than 1.

Table G: 5-2: Probability Annual Benefits Exceed Annual Costs (2024 Price Level; FY24 Federal Discount Rate; $1000s)

Plan	Probability Benefits Exceeds Indicated Values: 75%	Probability Benefits Exceeds Indicated Values: 50%	Probability Benefits Exceeds Indicated Values: 25%	Annual Costs	Probability Benefits Exceed Low Cost
Plan 1 (NED)	$15,235	$21,247	$30,565	$ 12,851	>75%
Plan 3a	$16,079	$22,328	$32,150	$ 14,186	>75%
Plan 3b	$18,335	$27,294	$40,841	$ 22,080	>50%
Plan 3c	$18,862	$28,315	$42,592	$ 24,659	>50%

5.2.2 Residual Risk

Nonstructural measures are voluntary, and this analysis assumes 100 percent participation. A participation rate sensitivity analysis will be performed after TSP.

Due to the nature of the nonstructural measures included in this analysis, there is no reduction in residual risk to roads, railways, or vehicles. There is also no reduction in damages associated with debris cleanup or other emergency costs. In addition to the residual risk associated with dollar damages, life safety concerns are not addressed for individuals outside of the structures where nonstructural measures are planned to be implemented. This applies to individuals who decide not to participate since the measures proposed are voluntary. There is no expected transformed risk with the construction of the proposed measures for any plans in the final array.

Changes in analysis after TSP, but before the Agency Decision Milestone include, but are not limited to: refinement of the structure inventory, refinements to the uncertainty model inputs regarding H&H and economics, and conducting on the ground evaluations of structures within the TSP. The team also plans to take into consideration any changes suggested by public comments received during the upcoming comment period. Each of these changes carry the potential to impact the structures eligible for nonstructural measures, as defined by the current methodologies, as well as to change damage and benefit values.

SECTION 6
Regional Economic Development

6.1 RECONS ANALYSIS

6.1.1 Background

The U.S. Army Corps of Engineers (USACE) Institute for Water Resources developed a regional economic impact modeling tool, Regional Economic Systems (RECONS), that provides estimates of jobs and other economic measures such as labor income, value-added, and sales that are supported by USACE programs, projects, and activities. This modeling tool automates calculations and generates estimates of jobs, labor income, value-added, and sales using IMPLAN®'s multipliers and ratios, customized impact areas for USACE project locations, and customized spending profiles for USACE projects, business lines, and work activities. There are three categories of economic impacts that RECONS outputs including the direct effects, indirect effects, and induced effects. Direct effects represent the proportions of USACE expenditure that flows to material and service providers within a given impact area. Indirect effects are the backward-linked suppliers for goods and services used by the directly affected activities. Lastly, induced effects come from household expenditures that are associated with the direct and indirectly affected workers. These measures are collectively identified as secondary effects which include number of jobs, employment earnings, sales, and value added. RECONS allows the USACE to evaluate the regional economic impact and contribution associated with USACE expenditures, activities, and infrastructure.

In order to interpret the results, a description of the metrics is provided:

- Output: The total transactions resulting from the construction project. This includes both the value added and intermediate goods purchased in the economy.
- Labor Income: All forms of employment income including employee compensations (wages and benefits) and proprietor income.
- Value Added: This is also known as the Gross Regional Product and represents the value-added output of the study regions. It captures all final goods and services produced in the study areas due to the project. One dollar of a final good or service can have multiple transactions.
- Jobs: The estimated worker-years of labor required to build the project. Additionally, jobs are presented in full-time equivalence (FTE) terms.

The input-output analysis is based on the following set of assumptions:

1. The production functions of industries have constant returns to scale, so if the output increases, inputs will increase in the same proportion.
2. Industries face no supply constraints; they have access to all the materials they can use.

3. Industries have a fixed commodity input structure; they will not substitute any commodities or services used in the output production in response to price changes.
4. Industries produce their commodities in fixed proportions; therefore, an industry will only increase the production of a commodity if it increases production in every other commodity it produces.
5. Industries are assumed to use the same technology to produce all their commodities.

6.2 RESULTS

The expenditures associated with Plan 1 in Tangipahoa Parish (LA) are estimated to be $345,152,000. Of this total expenditure, $235,507,496 will be captured within the local impact area. The remainder of the expenditures will be captured within the state impact area and the nation. These direct expenditures generate additional economic activity, often called secondary or multiplier effects. The direct and secondary impacts are measured in output, jobs, labor income, and gross regional product (value added) as summarized in the following tables. The regional economic effects are shown for the local, state, and national impact areas. In summary, the expenditures $345,152,000 support a total of 3,406.8 full-time equivalent jobs, $181,258,871 in labor income, $218,668,742 in the gross regional product, and $377,436,412 in economic output in the local impact area. More broadly, these expenditures support 5,964.6 full-time equivalent jobs, $432,577,715 in labor income, $552,517,254 in the gross regional product, and $928,118,861 in economic output in the nation.A summary of the results for Plan 1 can be found in Table G: 6-1.

Table G: 6-1: Plan 1 RECONS Summary

Area	Local Capture	Output	Jobs*	Labor Income	Value Added
Local Direct Impact		$235,507,496	2,426.3	$139,980,053	$141,937,847
Local Secondary Impact		$141,928,917	980.5	$41,278,819	$76,730,896
Local Total Impact	$235,507,496	$377,436,412	3,406.8	$181,258,871	$218,668,742
State Direct Impact		$290,152,957	2,848.0	$210,245,008	$191,525,497
State Secondary Impact		$267,271,855	1,533.2	$81,978,956	$148,729,464
State Total Impact	$290,152,957	$557,424,812	4,381.2	$292,223,963	$340,254,961
US Direct Impact		$332,274,293	3,223.4	$241,451,265	$225,755,312
US Secondary Impact		$595,844,568	2,741.3	$191,126,450	$326,761,942
US Total Impact	$332,274,293	$928,118,861	5,964.6	$432,577,715	$552,517,254

The expenditures associated Plan 3a in Tangipahoa Parish (LA) are estimated to be $381,222,000. Of this total expenditure, $260,119,131 will be captured within the local impact area. The remainder of the expenditures will be captured within the state impact area and the nation. These direct expenditures generate additional economic activity, often called secondary or multiplier effects. The direct and secondary impacts are measured in output, jobs, labor income, and gross regional product (value added) as summarized in the following tables. The regional economic effects are shown for the local, state, and national impact areas. In summary, the expenditures $381,222,000 support a total of 3,762.8 full-time equivalent jobs, $200,201,272 in labor income, $241,520,650 in the gross regional product, and $416,880,284 in economic output in the local impact area. More broadly, these expenditures support 6,588.0 full-time equivalent jobs, $477,784,112 in labor income, $610,257,894 in the gross regional product, and $1,025,111,627 in economic output in the nation.

Table G: 6-2: Plan 3a RECONS Summary

Area	Local Capture	Output	Jobs*	Labor Income	Value Added
Local Direct Impact		$260,119,131	2,679.8	$154,608,624	$156,771,016
Local Secondary Impact		$156,761,153	1,083.0	$45,592,649	$84,749,634
Local Total Impact	$260,119,131	$416,880,284	3,762.8	$200,201,272	$241,520,650
State Direct Impact		$320,475,299	3,145.6	$232,216,595	$211,540,808
State Secondary Impact		$295,203,015	1,693.4	$90,546,140	$164,272,390
State Total Impact	$320,475,299	$615,678,315	4,839.0	$322,762,736	$375,813,198
US Direct Impact		$366,998,512	3,560.2	$266,684,053	$249,347,799
US Secondary Impact		$658,113,115	3,027.7	$211,100,059	$360,910,095
US Total Impact	$366,998,512	$1,025,111,627	6,588.0	$477,784,112	$610,257,894

The expenditures associated with Plan 3b in Tangipahoa Parish (LA) are estimated to be $595,068,000. Of this total expenditure, $406,032,630 will be captured within the local impact area. The remainder of the expenditures will be captured within the state impact area and the nation. These direct expenditures generate additional economic activity, often called secondary or multiplier effects. The direct and secondary impacts are measured in output, jobs, labor income, and gross regional product (value added) as summarized in the following tables. The regional economic effects are shown for the local, state, and national impact areas. In summary, the expenditures $595,068,000 support a total of 5,873.5 full-time equivalent jobs, $312,503,923 in labor income, $377,001,353 in the gross regional product, and $650,728,754 in economic output in the local impact area. More broadly, these expenditures support 10,283.5 full-time equivalent jobs, $745,796,507 in labor income, $952,581,290 in the gross regional product, and $1,600,146,701 in economic output in the nation.

Table G: 6-3: Plan 3b RECONS Summary

Area	Local Capture	Output	Jobs*	Labor Income	Value Added
Local Direct Impact		$406,032,630	4,183.1	$241,336,136	$244,711,520
Local Secondary Impact		$244,696,124	1,690.5	$71,167,787	$132,289,834
Local Total Impact	$406,032,630	$650,728,754	5,873.5	$312,503,923	$377,001,353
State Direct Impact		$500,245,514	4,910.1	$362,478,201	$330,204,358
State Secondary Impact		$460,796,774	2,643.3	$141,337,884	$256,420,779
State Total Impact	$500,245,514	$961,042,289	7,553.5	$503,816,085	$586,625,137
US Direct Impact		$572,865,864	5,557.3	$416,280,136	$389,219,133
US Secondary Impact		$1,027,280,837	4,726.1	$329,516,371	$563,362,157
US Total Impact	$572,865,864	$1,600,146,701	10,283.5	$745,796,507	$952,581,290

The expenditures associated with Plan 3c in Tangipahoa Parish (LA) are estimated to be $665,077,000. Of this total expenditure, $453,801,857 will be captured within the local impact area. The remainder of the expenditures will be captured within the state impact area and the nation. These direct expenditures generate additional economic activity, often called secondary or multiplier effects. The direct and secondary impacts are measured in output, jobs, labor income, and gross regional product (value added) as summarized in the following tables. The regional economic effects are shown for the local, state, and national impact areas. In summary, the expenditures $665,077,000 support a total of 6,564.6 full-time equivalent jobs, $349,269,616 in labor income, $421,355,087 in the gross regional product, and $727,286,171 in economic output in the local impact area. More broadly, these expenditures support 11,493.3 full-time equivalent jobs, $833,538,526 in labor income, $1,064,651,278 in the gross regional product, and $1,788,401,943 in economic output in the nation.

Table G: 6-4: Plan 3c RECONS Summary

Area	Local Capture	Output	Jobs*	Labor Income	Value Added
Local Direct Impact		$453,801,857	4,675.2	$269,729,028	$273,501,522
Local Secondary Impact		$273,484,314	1,889.4	$79,540,588	$147,853,566
Local Total Impact	$453,801,857	$727,286,171	6,564.6	$349,269,616	$421,355,087
State Direct Impact		$559,098,769	5,487.8	$405,123,305	$369,052,484
State Secondary Impact		$515,008,934	2,954.3	$157,966,108	$286,588,361
State Total Impact	$559,098,769	$1,074,107,702	8,442.1	$563,089,412	$655,640,845
US Direct Impact		$640,262,811	6,211.1	$465,254,969	$435,010,273
US Secondary Impact		$1,148,139,132	5,282.2	$368,283,557	$629,641,005
US Total Impact	$640,262,811	$1,788,401,943	11,493.3	$833,538,526	$1,064,651,278

SECTION 7

Other Social Effects

7.1 BACKGROUND

According to the memorandum for the Comprehensive Documentation of Benefits, water resource projects conducted by USACE are to comprehensively evaluate the impact on social well-being within a community. Communities impacted by hazardous events, including frequent and/or severe inundation experience affects both during and after related to their resilience, overall well-being, community cohesion, and their quality of life. Other Social Effects of the Tangipahoa plans are evaluated based on their performance across applicable subthemes, including Social Vulnerability & Resiliency, Health & Safety, Economic Vitality, Social Connectedness, Participation, Leisure & Recreation, and Environmental Justice Considerations.

7.1.1 Basic Social Statistics

Tangipahoa Parish is home to 135,000 residents. The majority of the population impacted by the Tangipahoa study is located in south-eastern portion of the Parish. Table G: 7-1 provides a breakdown of population in the area estimated out to 2045. Table 7-2 provides a breakdown by number of households in the area estimated out to 2045 and Table G: 7-3 provides a breakdown by per capita income in the area estimated out to 2045. The data relating to population within Tangipahoa Parish was sourced from the Census Bureau and Moody's Analytics (ECCA) Forecast.

Table G: 7-1: Population of Tangipahoa Parish (2000 - 2045)

Parish	2000	2010	2017	2025	2045
Tangipahoa	121,425	135,217	131,780	133,060	134,820

Table G: 7-2: Households in Tangipahoa Parish (2000 - 2045)

Parish	2000	2010	2017	2025	2045
Tangipahoa	43,228	49,915	52,430	54,150	57,660

Table G: 7-3: Per Capita Income ($) in Tangipahoa Parish (2010 - 2030)

Parish	2010	2021	2025	2030
Tangipahoa	33,424	47,748	49,847	59,380

7.2 OTHER SOCIAL EFFECTS – EXISTING CONDITION

7.2.1 Social Vulnerability & Resiliency

Social vulnerability is described by 09-R-4 (IWR) as the capacity to be disproportionately damaged or impacted by hazardous events. Certain characteristics relating to a community's population are indicators as to whether a community is more socially vulnerable. The term resiliency refers specifically to a community's ability to cope and recover from hazards or impacts.

Center for Disease Control's Social Vulnerability Index

The CDC's Social Vulnerability Index (SVI) uses American Community Survey (BOC) to quantify a community's ability to respond and cope with a hazardous event. Figure G: 7-1 displays the overall vulnerability of the Tangipahoa Study Area. Within the overall SVI, there are four subthemes that are incorporated, which include Socioeconomic Status, Household Characteristics, Racial & Ethnic Minority Status, and Housing Type & Transportation. In order to identify areas experiencing social vulnerability, a 90th percentile threshold was initially applied across the four themes in addition to the overall vulnerability. However, as the CDC's SVI 2022 information was released, it was updated to reflect social vulnerability in terms of quartiles. The quartiles are identified as Low (0 to 0.25 percentile), Low-Medium (0.25 to 0.5), Medium-High (0.5-0.75), and High (0.75-1). For the purposes of this study, an area was considered to be socially vulnerable if it reached the medium-high or high quartile in at least one category. Out of 31 census tracts within the Tangipahoa study area, there were 30 that were identified as experiencing social vulnerability based on the Medium-High or High criteria in at least one category.

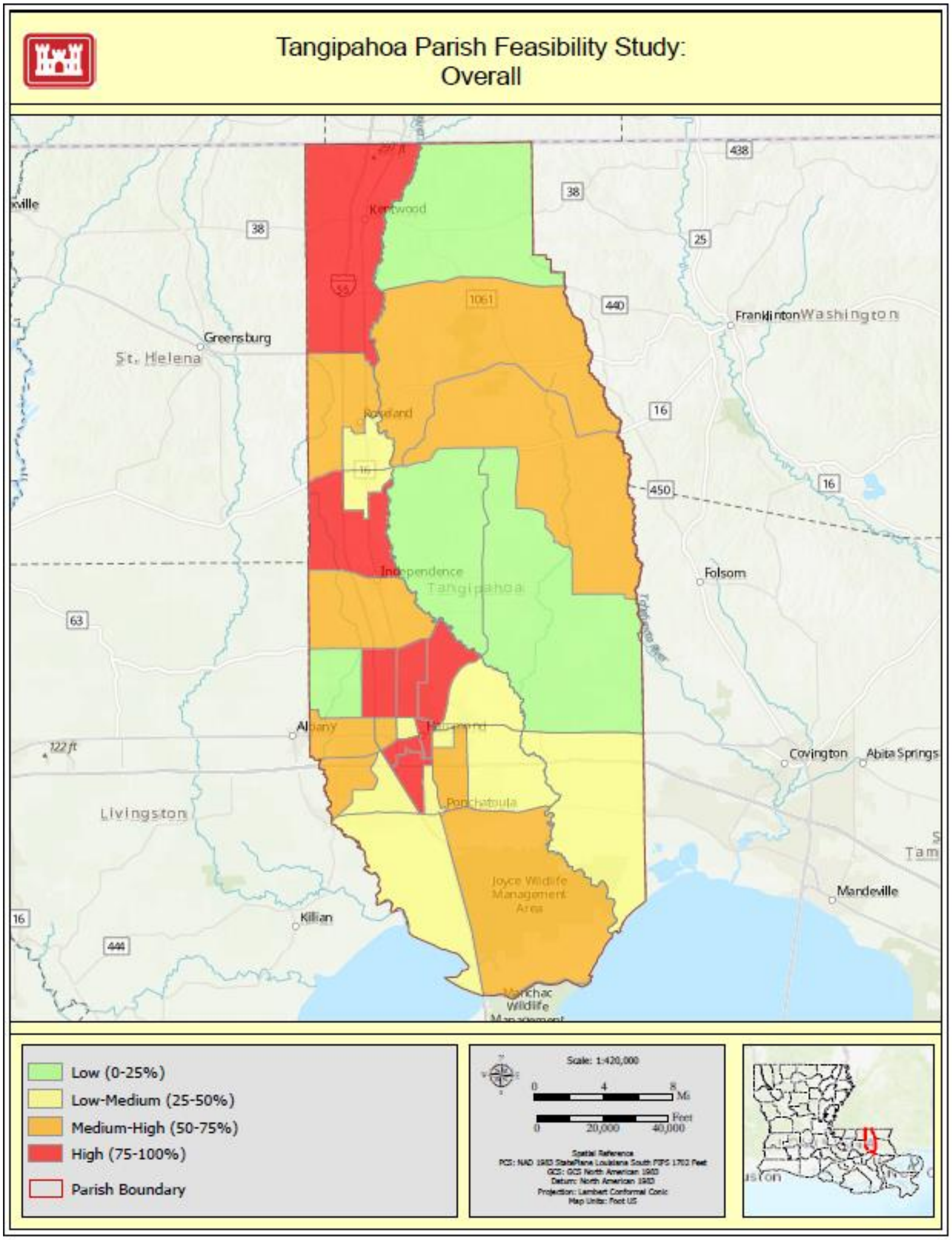

Figure G: 7-1: Tangipahoa Parish Social Vulnerability - Overall (2022)

7.2.2 Health & Safety

According to 09-R-4 (IWR) personal and group safety is a basic human need. Any conditions that are perceived to affect personal health and safety implicate personal stress and dissatisfaction. Areas that are prone to flooding, such as the Tangipahoa study area, have an increased risk of adverse effects on health and safety.

Life Safety

High flood depths and velocities at structures and on roadways during a flooding event can pose a risk to human life safety. Life loss modeling software such as HEC-LifeSim can be used to estimate potential life loss from flood hazards. For the purposes of this study, life safety risk was evaluated using assumptions from the HEC-LifeSim software.

Risk to human life safety during a major flooding event in the Tangipahoa study area was evaluated using stability criteria assumptions from the LifeSim technical manual, 2033 without project H&H depth and velocity grids, and the Tangipahoa structure inventory. Stability criteria refers to the possibility of either vehicles or people being swept off of either the road or their feet by flood waters. It was determined that while there are areas of the Parish which may result in depths, velocities, or the combination therein to present the possibility of sweeping vehicles off of the road, there also exists alternative routes which are not inundated by flood events. Additionally, there were no communities or groups of homes which are completely cut off in the event of a flood from emergency services as alternative routes are available. For these reasons, the PDT decided to screen roadway elevations and instead provide the Parish with the locations of roadways which become inundated for signage and gates to prevent traffic in the event of a flood.

Stability criteria on structures will be evaluated post-TSP with 2083 hydraulic depth and velocity grids.

Critical Infrastructure

Critical infrastructure includes hospitals, emergency services such as EMT, fire stations, and police stations. Flooding impacts to critical infrastructure pose a risk to the health and safety within the study area at the time of inundation via the inability to access individuals in need of assistance. Figure G: 7-2 represents critical infrastructure situated within the Tangipahoa study area which are being included in Plan 3b, the TSP.

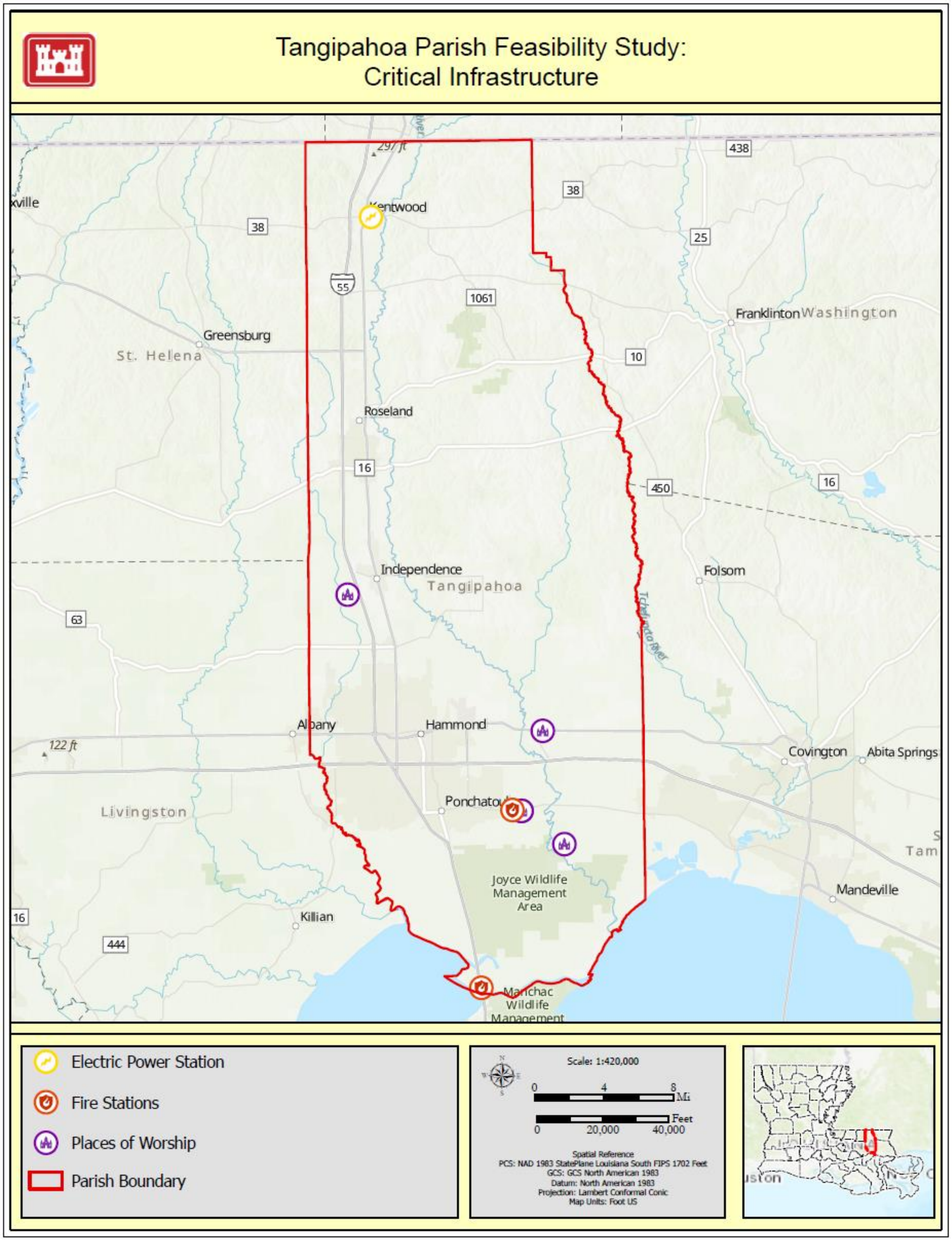

Figure G: 7-2: Critical and Civic Infrastructure

7.2.3 Economic Vitality

Economic vitality refers to the quality of life of the affected population. This is influenced by the economy's ability to provide a good standard of living.

Employment Activity

Employment activity indicates how efficiently a community can respond to hazardous events and is an overall indicator for economic health. Table G: 7-4 shows the top 10 industries employment within the Tangipahoa study area.

Table G: 7-4: Employment by Industry in Tangipahoa Parish

Top 10 Industries In Tangipahoa	Employment Numbers
Junior colleges, colleges, universities, and professional schools	5,190
Employment and payroll of local govt, non-education	2,942
Employment and payroll of local govt, education	2,776
Full-service restaurants	2,029
Employment and payroll of state govt, education	1,872
Limited-service restaurants	1,917
Other real estate	1,694
Retail - General merchandise stores	1,464
All other food and drinking places	1,300
Scientific research and development services	1,493

7.2.4 Social Connectedness

Social Connectedness refers to social networks where community members interact. Strong social connectedness supports meaning and structure to one's life. In addition to social connectedness, identity of an individual or a community provides a sense of self as a member of a group, distinct from other groups.

Civic Infrastructure

Figure G: 7-2 shows a map of physically located civic infrastructure, which includes places of worship, community centers, and parks that are included in Plan 3b, the TSP. In addition to community services that occupy physical space and are affected by inundation, there are community projects and activities that are supported by state and local government, including recreation activities for children and adults, as well as events in support of music and culture within the region. These activities are likely also impacted by inundation in the existing condition via inundation on roadways and recovery delays.

7.2.5 Participation

According to 09-R-04, The Handbook on Applying Other Social Effects, participation refers to the ability of a community to influence social outcomes. In water resource planning, teams partake in conversations with stakeholders to better understand how a community is impacted by current conditions as well as how they could be affected by future outcomes, which includes the public.

Public Involvement

Public involvement in the study process is essential in evaluation of nonstructural plans. After release of the draft report, documentation of all opportunities for affected groups to voice their concerns and/or support for plans, with special emphasis on those areas of Environmental Justice concerns, will occur here. This section will address availability of public documents, meetings, and the ability to influence the outcome of events and actions pertinent to community member.

7.2.6 Environmental Justice

Environmental Justice was first addressed in water resource planning via Executive Order 12898, Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations. The EO directs federal agencies to "identify and address, as appropriate, disproportionately high and adverse human health or environmental effects of its programs, policies, and activities on minority populations and low-income populations." These concepts are addressed in the Environmental Justice Section of the Main Report, section 3.2.3.3.

Executive Order 14008, issued in January of 2021, further addressed environmental justice in federal agency planning, creating a goal where 40 percent of overall benefits of certain Federal Investments flow to economically disadvantaged communities that are marginalized, underserved, and overburdened by pollution.

Justice40 Initiative

The Council on Environmental Quality (CEQ) developed the Climate and Economic Justice Screening Tool (CEJST) to assist in identifying economically disadvantaged communities. The CEJST utilizes several burdens that qualify a census tract as disadvantaged. Burden categories in CEJST include housing, health, climate change, energy, legacy pollution, transportation, water/wastewater infrastructure, and workplace development. In order for a tract to be considered disadvantaged, it must be at or above the 90th percentile in one or more burdens and be at or above the 65th percentile for low income. Detailed methodology can be found on the CEJST website.

Figure G: 7-3 represents those census tracts that are considered to be areas of environmental justice concern as reported by CEJST. Out of 20 census tracts in the Tangipahoa Parish study area, 14 are historically burdened by a CEJST burden category. These identified communities would be impacted disproportionately by inundation events as they may not have the resources to recover from the impacts or be able to properly mitigate prior to the event.

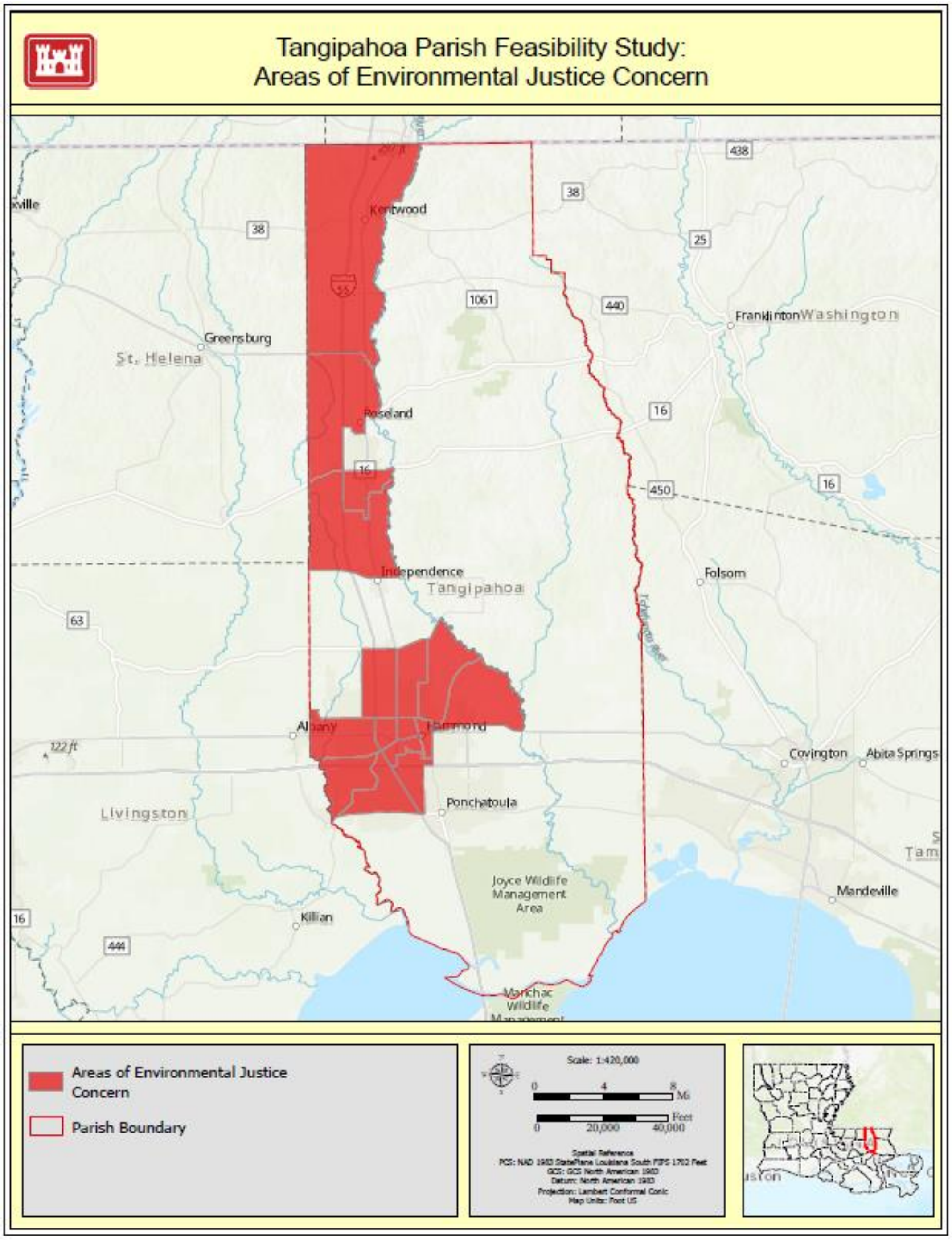

Figure G: 7-3: Areas of Environmental Justice Concern within Tangipahoa Parish

7.3 IMPACT ANALYSIS: FINAL ARRAY

7.3.1 Impact of Plans on Other Social Effect Themes

Table G: 7-5 provides a summary of the other social effects themes.

Table G: 7-5: Other Social Effects Summary Table

OSE Theme	Indicator	Plan 1	Plan 3a	Plan 3b	Plan 3c
Social Vulnerability & Resiliency	Structures included in SV Areas	+	++	+++	+++
Health & Safety	Life Safety	+	+	+	+
Health & Safety	Critical Infrastructure	++	++	++	++
Economic Vitality	Employment Activity	+	+	++	++
Social Connectedness	Civic Infrastructure	+	+	++	++
Participation	Public Involvement	*Evaluated Post-Draft Report Outreach*	*Evaluated Post-Draft Report Outreach*	*Evaluated Post-Draft Report Outreach*	*Evaluated Post-Draft Report Outreach*
Environmental Justice	Structures included in Areas of EJ concern	+	++	++	++

Legend:

(+): Minor Positive Benefits

(++): Moderate Positive Benefits

(+++): Significant Positive Benefits

7.3.2 Social Vulnerability & Resiliency

Socially vulnerable people are disproportionately impacted by flood events. This is in part due to the fact that socially vulnerable communities often lack the capacity in terms of infrastructure and capital, both physical and monetary, to recover quickly. In fact, when compared with non-socially vulnerable communities, socially vulnerable communities recover slower and often never recover to the same levels of productivity, population, and income that those areas experienced prior to a major flood event. Thus, while formulating strategies for non-structural measures, the PDT wanted to keep this information in mind. Essentially, flood risk reduction projects in areas which experience social vulnerability are not fully captured in the traditional NED framework. That is to say, the benefits that these communities experience as a result of federal investment to reduce the risk from flooding are not simply the reduction in damages to structures and contents. The benefits provided to socially vulnerable communities include resiliency and cohesion. In effect, the comprehensive plans beyond the NED plan provide these communities a greater ability to cope with and rebound from flood events. These benefits are non-monetary and were deemed to be just as important as the NED benefits, we have traditionally seen in FRM projects.

Table G: 7-6 presents a summary of benefits to areas experiencing social vulnerability.

Table G: 7-6: Summary of Benefits to Areas Experiencing Social Vulnerability

Plan	1	3a	3b	3c
Structures included in areas experiencing social vulnerability	470	546	860	952
Total Structures included	597	675	1,088	1234
% of structures in areas experiencing social vulnerability	78.7%	80.9%	79%	77.1%

Plan 1: Nonstructural NED Plan

This plan, while not specifically formulated with considerations of comprehensive benefits such as mitigating flood risk for areas experiencing social vulnerability, improving community resiliency, cohesion, and reducing frequent flood hazards. It nonetheless provides significant benefit to socially vulnerable areas as highlighted in the table above. Given that individuals in these communities are historically overburdened by excessive costs related to both hazard mitigation and hazard response, this plan would provide a significant impact to eligible community members experiencing social vulnerability via decreased recovery time and their related expenditures, as well as increased safety of their home, and decreased flood insurance premiums from hazard mitigation.

Plan 3a: NED + Increment 1: 10% AEP Flood Frequency Socially Vulnerable Increment

As mentioned in section 1, Plan 3a includes the same structures as the NED plan but was incrementally expanded to be inclusive of structures in areas which may not maximize or have even positive net NED benefits but nonetheless experience similar or greater levels of flooding at the 10% AEP than those included in the NED plan. Each aggregation group increment was evaluated based on social vulnerability, flood hazard depth and frequency, community cohesion, critical infrastructure, and incremental net NED benefits. As such, each incremental structure included experiences frequent flood hazards which are enough to disrupt the day-to-day life of the people living and working in said structures. This plan would provide a significant impact to eligible community members experiencing social vulnerability via decreased recovery time and their related expenditures, as well as increased safety of their home, and decreased flood insurance premiums from hazard mitigation.

Plan 3b: NED + Increment 2: 4% AEP Flood Frequency Comprehensive Increment

As mentioned previously, each subsequent plan builds incrementally upon the previous. Thus, all of the benefits of the previous increments are still present in Plan 3b. Plan 3b was incrementally expanded to be inclusive of structures in areas which may not maximize or even have positive net NED benefits but nonetheless experience similar or greater levels of flooding at the 4% AEP than those in the NED plan. In some cases, Plan 3b included structures in the 2% AEP event as long as there were compelling comprehensive benefits reasons to do so such as social vulnerability, flood hazard depth and frequency, community cohesion, critical infrastructure, and incremental net NED benefits as mentioned previously. The extra benefits Plan 3b are surrounding critical infrastructure, community cohesion, and increased flood risk mitigation for socially vulnerable and economically disadvantaged populations.

Plan 3c: NED + Increment 3: 2% AEP Flood Frequency Comprehensive Increment

Plan 3c continues to build upon the previous increments. All of the previous benefits are still present and the extra benefits beyond the previous increment are focused on increased other social effects benefits and a wider floodplain. Plan 3c is the most inclusive plan, allowing for more aggregation areas to have a level of inclusion at the 2% AEP floodplain than any of the previous plans while still being constrained by total comprehensive benefits and similar or greater levels of flooding as the NED Plan. That is to say, we did not include areas at the 2% AEP which didn’t at minimum have similar depths of flooding to comparable NED justified areas at the 2% AEP. In developing plans, this plan was determined to have the highest benefits in the other social effects category given that it provides the most benefits for socially vulnerable communities and improves community resiliency and cohesion more than the previous plans. However, it has the lowest net NED benefits of the four plans in the final array while still providing more NED benefits than costs.

7.3.3 Health & Safety

Critical Infrastructure

Plans 1,3a,3b,3c:

Under plan 1, there are two critical infrastructure facilities included for floodproofing mitigation. A fire department and an electric power substation. In an inundation event, facilities would be able to return to operation quicker and thus be able to provide emergency services and care to community members who have previously and will continue to need assistance. The next subsequent increments which include more critical infrastructure for flood risk reduction are Plans 3b and Plan3c. Plan 3b includes the floodproofing of another fire department. Plan 3c includes the same three critical infrastructure facilities which are included in Plan 3b.

7.3.4 Economic Vitality

Plan 1: Nonstructural – Optimized NED Plan:

Under plan 1, it would be expected that the trade, transportation, and utilities sector would continue to be impacted. These impacts would be from continued inundation on roadways and for those structures that remain unmitigated in the with project condition. There are 58 non-residential structures that are included as a part of this plan that would have increased risk reduction via floodproofing and therefore experience less of a pause in operation when inundation occurs. This would directly translate to continued consumption for those business. Employees would also be able to continue working for those businesses that are included in plan 1.

Plan 3a:

Under Plan 3a, the number of commercial structures included in commercial mitigation increases to 59. The increase in floodproofed commercial structures would allow more businesses to return to operation following an inundation event. This would directly decrease the amount of time that employees are temporarily unemployed, and therefore lost personal income, in the study area.

Plan 3b:

Under Plan 3b, the number of commercial structures included in commercial mitigation increases to 82. The increase in floodproofed commercial structures would allow more businesses to return to operation following an inundation event. This would directly decrease the amount of time that employees are temporarily unemployed, and therefore lost personal income, in the study area.

Plan 3c:

Under Plan 3c, the number of commercial structures included in commercial mitigation increases to 87. The increase in floodproofed commercial structures would allow more businesses to return to operation following an inundation event. This would directly decrease the amount of time that employees are temporarily unemployed, and therefore lost personal income, in the study area.

7.3.5 Social Connectedness

Under plan 1 and plan 3a, there are three civic infrastructure facilities included. Each of them is a place of worship. Plan 3b increases this number to five total civic infrastructure buildings and plan 3c includes the greatest number of civic infrastructure buildings at 6. In the with-project condition, these civic infrastructure facilities would be floodproofed, allowing for protection of contents and the structures. This risk reduction would decrease the length of time that operations occur; thus, encouraging and sustaining community places of gathering and increasing opportunities for connectedness and identity among individuals.

7.3.6 Participation – To be evaluated post-draft public meetings.

7.3.7 Environmental Justice

Table G: 7-7 presents a list of the benefits to historically disadvantaged communities and shows the number of structures included in areas of environmental concern for Plan 1, Plan 3a, Plan 3b, and Plan3c.

Table G: 7-7: Benefits to Historically Disadvantaged Communities

Plan	1	3a	3b	3c
Total Structures Included	597	675	1088	1234
Structures included in disadvantaged communities	43	69	94	113
% of structures classified as being within a Disadvantaged Community	7%	10%	9%	9%

Plan 1: NED Plan

Plan 1 includes 597 structures in the nonstructural plan for mitigation. Of these structures, 43, or 7 percent, of structures are in disadvantaged communities. Mitigation in this area would positively impact community members as historically overburdened and disadvantaged communities.

Plan 3a:

Plan 3a includes 675 structures in the nonstructural mitigation plan. Of these structures, 69, or 10 percent of structures are located in disadvantaged communities.

Plan 3b:

Plan 3b includes 1088 structures in the nonstructural mitigation plan. Of these structures, 94, or 9 percent of structures are located in disadvantaged communities.

Plan 3c:

Plan 3a includes 1234 structures in the nonstructural mitigation plan. Of these structures, 113, or 9 percent of structures are located in disadvantaged communities.

SECTION 8
List of Acronyms and Abbreviations

ER	Engineering Regulation
HEC- FDA	Hydrologic Engineering Center Flood Damage Analysis Model
NED	National Economic Development
FY	Fiscal Year
RED	Regional Economic Development
OSE	Other Social Effects
CDC	Centers for Disease Control and Prevention
SVI	Social Vulnerability Index
BOC	American Community Survey
PDT	Project Delivery Team
H&H	Hydraulics and Hydrology
PGL	Policy Guidance Letter
EO	Executive Order
FEMA	Federal Emergency Management Agency
WRDA	Water Resources Development Act
FRM	Flood Risk Management
NSI	National Structure Inventory
GIS	Geographic Information Services/Systems
HEC-RAS	Hydrologic Engineering Center – River Analysis System
CSVRs	**C**ontent-to-Structure Value Ratios
SDs	Standard Deviations
LiDAR	Light Detection and Ranging
NAVD 88	North American Vertical Datum of 1988
DEM	**D**igital Elevation Model
USGS	United States Geological Survey
TSP	Tentatively Selected Plan
EAD	**E**xpected Annual Damages
AEP	Annual Exceedance Probability

MCX	Cost Engineering Center of Expertise
PED	Pre-Construction Engineering and Design
BCR	Benefit-to-Cost Ratio
USACE	United States Army Corps of Engineers
RECONS	Regional Economic Systems
FTE	Full-Time Equivalence
IWR	Institute for Water Resources
HEC-LifeSim	Hydrologic Engineering Center – LifeSim
EMT	Emergency Medical Technicians
CEQ	Council on Environmental Quality
CEJST	Climate and Economic Justice Screening Tool