Mississippi Valley Division,
Regional Planning and Environment Division South

Amite River and Tributaries East of the Mississippi River, Louisiana

Appendix G - Economic and Social Consideration
December 2023

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Background Information

1.1 INTRODUCTION

1.1.1 General

This appendix presents an economic evaluation of the flood risk management Plans for the Amite River and Tributaries (ART) Study East of the Mississippi River, 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 2023 Federal discount rate of 2.75 percent, and a 50-year period of analysis with the year 2026 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 US. Census Bureau statistics, United States Geological Survey Food Atlas, 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.

1.2 DESCRIPTION OF THE STUDY AREA

1.2.1 Geographic Location

The ART study area includes the Amite River Basin in addition to an influence area directly south of the basin, which extends to the Mississippi River. The area includes portions of four Mississippi counties: Amite, Lincoln, Franklin, and Wilkinson in the upper portion of the basin; and portions of eight Louisiana parishes: East Feliciana, St. Helena, East Baton Rouge, Livingston, Iberville, St. James, St. John the Baptist, and Ascension in the mid- to lower-basin. An inventory of residential and non-residential structures was developed for the portions of these counties and parishes within the HEC-RAS modeled area. The West Shore Lake Pontchartrain (WSLP) project, which covers the portions of the St. James and St. John the Baptist Parishes within the ART study area, was not included in the ART hydraulic modeling. To avoid double counting benefits that will be realized by construction of WSLP, structures within the St. James and St. John the Baptist were removed from the ART structure inventory. Figure G:1-1 shows the structure inventory and the boundaries of the counties/parishes along with the study area boundary.

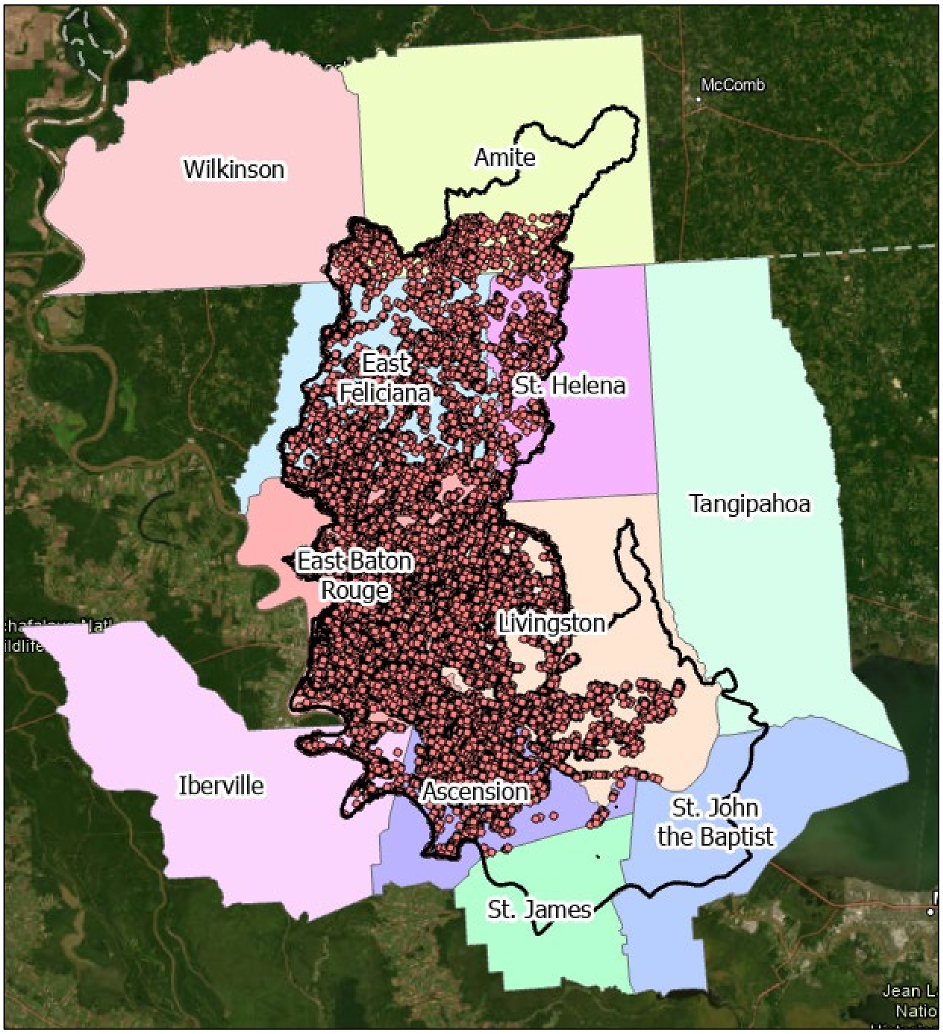


Figure G:1-1. Parish/County Boundaries, Structure Inventory, & Study Area Boundary

1.2.2 Study Area Reaches

The portion of the study area included in the hydraulic model was divided into 106 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. Figure G:1-2 shows the study area reach boundaries for the ART study area.

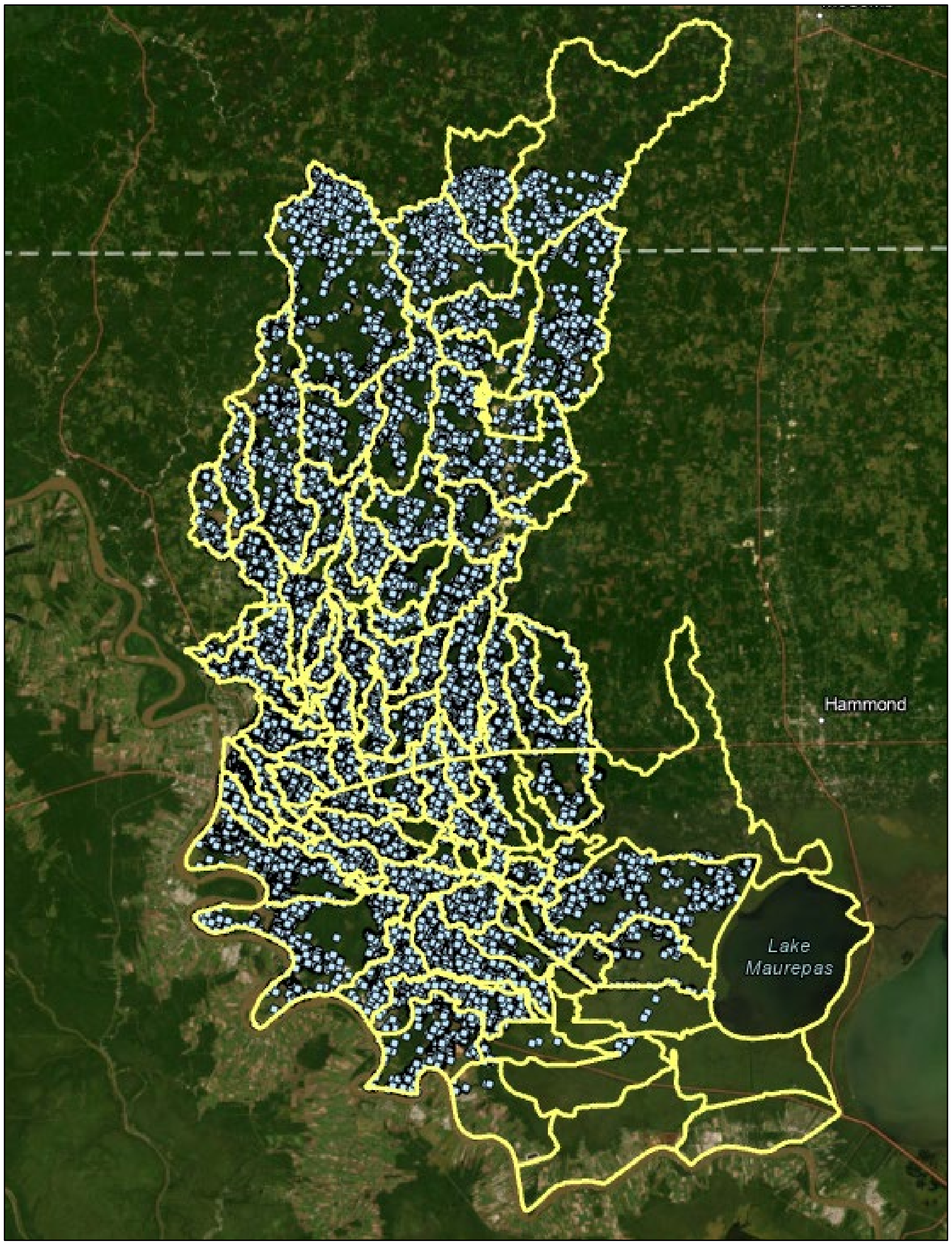


Figure G:1-2. Reach Boundaries, Structure Inventory

Sub-Reaches with Social Vulnerability Considerations

To evaluate the impacts to the OSE account, study area reaches based on hydraulic characteristics shown in Figure G:1-3 were further divided into sub-reaches 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 applied across the four themes, in addition to the overall vulnerability. Out of 191 Louisiana Census Tracts within the ART study area, there were 46 that were identified as experiencing social vulnerability. Economic reaches intersecting with tracts experiencing social vulnerability were divided into sub-reaches in the HEC-FDA model to evaluate how the existing and future without project conditions will affect areas experiencing social vulnerability and develop Plans that specifically target these areas.

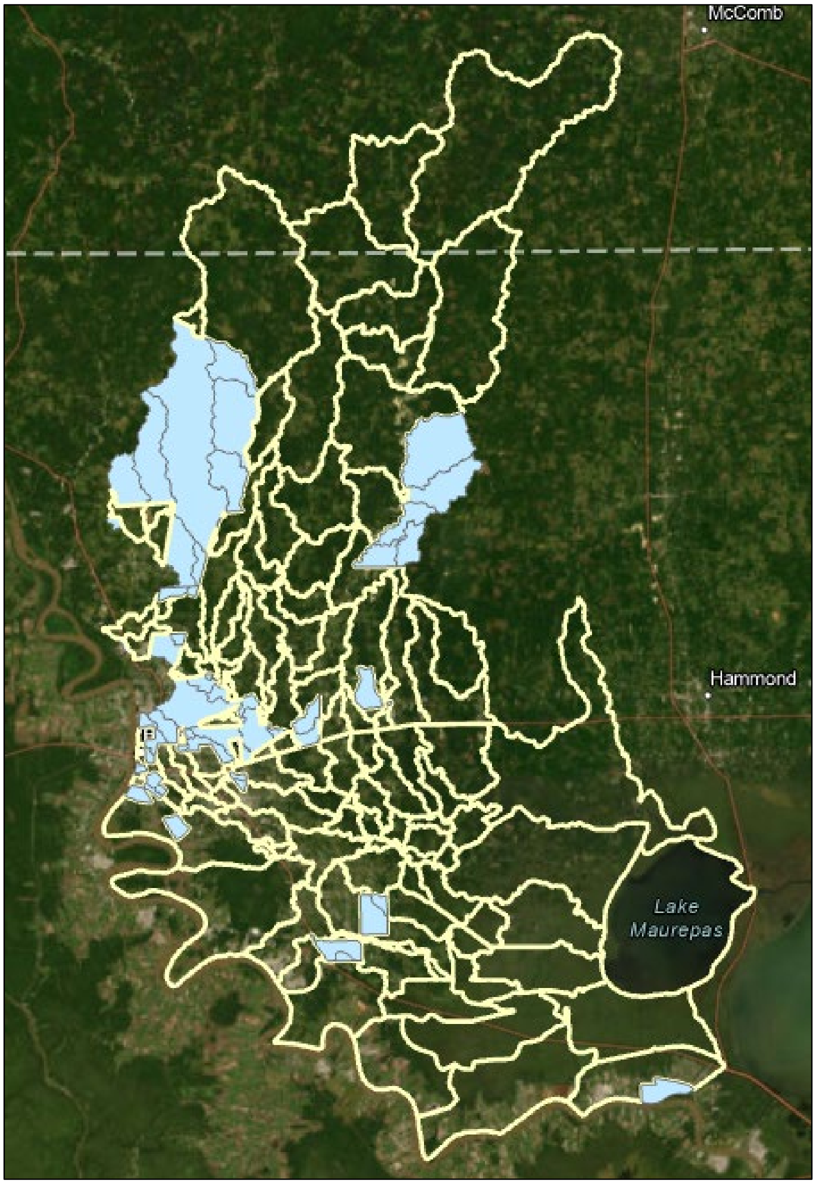


Figure G:1-3. Reach Boundaries, Sub-reaches with Social Vulnerability

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 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	Acres	Percentage of Total
Developed Land	945,085	13%
Agricultural Land	986,813	14%
Undeveloped Land	5,097,445	73%
Total	7,029,343	100%

Source: USGS National Land Cover Database 2015

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 51 tropical events have crossed the study area. The paths and intensities of these storms are shown in Figure G:1-4.

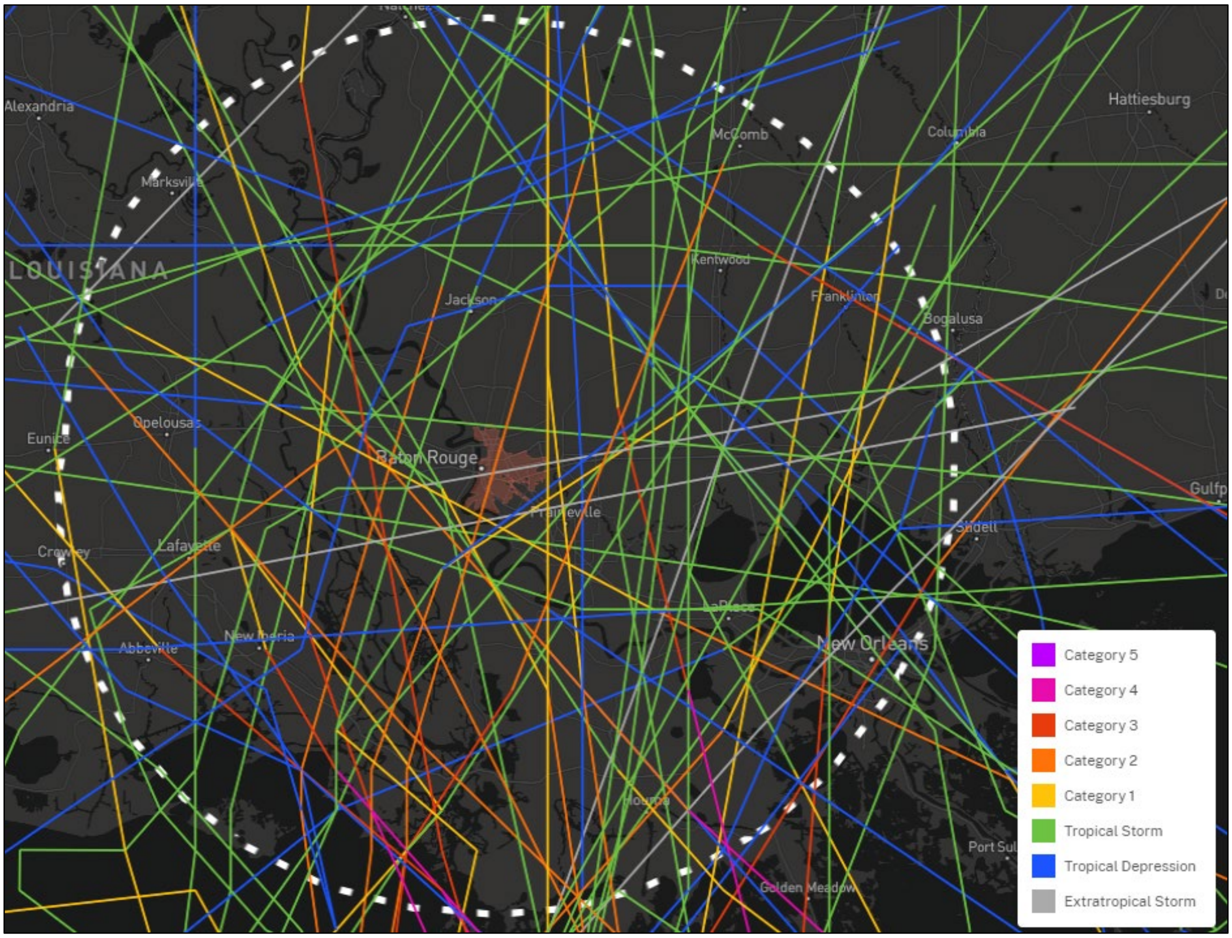


Figure G:1-4. Hurricane and Tropical Storm Paths Since 1851

1.3.2 FEMA Flood Claims

The most recent riverine event to affect the study area was the 2016 Louisiana Floods. This event brought catastrophic flooding damage to Baton Rouge and the surrounding areas with both localized flooding and riverine flooding from the Amite and Comite Rivers and their 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 flood claims paid between January 1978 and September 2023 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:1-1. Top Tropical Storms by Amount Paid by FEMA

Event	Month & Year	Number of Paid Claims	Total Amount Paid (millions)
Hurricane Andrew	August 1992	5,242	$128.9
Hurricane Rita	September 2005	8,921	$348.7
Hurricane Gustav	September 2008	4,396	$88.9
Hurricane Ike	September 2008	45,374	$2,074.1
Tropical Storm Lee	September 2011	9,725	$377.6
2016 Louisiana Floods	August 2016	20,641	$1,689.2
Hurricane Zeta	October 2020	1,041	$17.3
Hurricane Ida	September 2021	21,637	$1,112.0
Tropical Storm Nicholas	September 2021	254	$5.6

Source: Federal Emergency Management Agency (FEMA)

Note 1: Total amount paid is at price level at time of the event.
Note 2: Claims and amount paid are for entire event, which may include areas outside of the study area.

Table G:1-2. FEMA Flood Claims by Parish/County (January 1978-September 2023)

Parish	Total Number of Claims	Number of Paid Claims	Total Payments (millions)
Ascension	6,005	5,141	$285.7
East Baton Rouge	18,958	15,792	$948.5
East Feliciana	14	12	$0.6
Iberville	544	439	$7.3
Livingston	10,270	8,829	$477.2
St. Helena	51	36	$1.7
St. James	206	144	$3.4
St. John the Baptist	8,725	7,209	$483.4
Total	44,773	37,602	$2,207.8

Source: Federal Emergency Management Agency (FEMA)

1.4 SCOPE OF STUDY

1.4.1 Problem Description

The study area is urban with pockets of rural communities scattered among the eight-county area. Flood risk management is the only authorized purpose for the study. 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. Since authorization is limited to flood risk management, project formulation was conducted based on hydraulics associated with just riverine flooding. After formulation, damage analysis for both without project and with project conditions was conducted based on predominant condition hydraulics that incorporate both riverine flooding and storm surge to accurately capture project performance and residual risk. The predominant condition hydraulics takes the higher of the water surface elevation at a certain probability generated by two hydrologic boundary condition scenarios: one condition accounts for basin-wide extreme rainfall events with normal highwater downstream boundary condition, and a secondary condition that has negligible basin rainfall with storm surge downstream boundary conditions. The details of these HEC-RAS models used to compute predominant condition hydraulics is available in the H&H Appendix.

1.4.2 Nonstructural – Final Array

Three 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 future 0.01 AEP stage, not to exceed 13 feet and floodproofing non-residential structures up to 3 feet using dry floodproofing strategies.

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 future (2076) riverine water surface elevations at various riverine flooding events (0.1 AEP, 0.04 AEP, and 0.02 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 three floodplain aggregations (0.1 AEP, 0.04 AEP, and 0.02 AEP). A detailed description of the HEC-FDA calculations can be found in Section 2. Parametric construction cost estimates including a 32 percent contingency were developed in collaboration with New Orleans District cost engineering and reported out on a reach level 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:1-3. Structures with First-Floor Flooding by Floodplain

Floodplain	Residential	Non-Residential	Total Structures
0.1 AEP (10 year)	2,654	331	2,985
0.04 AEP (25 year)	3,866	474	4,340
0.02 AEP (50 year)	5,428	672	6,100

Plan 2 Nonstructural NED Plan

Eligibility for nonstructural measures in Plan 2 relied on the optimization of the floodplain aggregations in Table G:1-4. For each reach, the floodplain aggregation that received the highest net benefits, when compared to cost, was selected for inclusion in the plan. Table G:1-5 displays the number of structures eligible for nonstructural measures. Of the total reaches, 46 reaches were optimized at the 0.1 AEP floodplain, 5 reaches were optimized at the 0.04 AEP floodplain, and 6 were optimized at the 0.02 AEP floodplain.

Plan 3 Nonstructural NED + OSE Increment 1

Eligibility for nonstructural measures in Plan 3 relied on the sub-reaches developed using social vulnerability described in Section 1.2. Structures included in Plan 2 were also included in Plan 3, with the addition of structures within sub-reaches that retained positive net benefits. For Plan 3, 54 reaches with structures within the 0.1 AEP floodplain, 8 reaches with structures within the 0.04 AEP, and 6 reaches with structures within the 0.02 AEP floodplain were included in the plan. The total number of structures included in Plan 3 is shown in Table G:1-5.

Plan 4 Nonstructural NED + OSE Increment 2

Eligibility for nonstructural measures in Plan 4 also relied on the sub-reaches developed using social vulnerability. Structures included in Plan 2 were included in Plan 4, with the addition of structures within socially vulnerable sub-reaches within the next highest floodplain aggregation. For example, if the reach was optimized at the 0.1 floodplain for Plan 2, if the sub-reach was socially vulnerable then in Plan 4 that sub-reach was bumped up the 0.04 AEP floodplain and additional structures were included in the plan. Plan 4 includes 19 additional reaches and 182 additional structures. Plan 4 includes 59 reaches with structures within the 0.1 AEP floodplain, 13 reaches with structures within the 0.04 AEP floodplain, and 7 reaches with structures within the 0.02 AEP floodplain.

Table G:1-4. Structures Eligible for Nonstructural Measures by Plan

Plans in Final Array	Elevate	Floodproof	Total Structures
Plan 2	2,748	369	3,117
Plan 3	2,815	374	3,189
Plan 4	2,918	380	3,298

SECTION 2

Economic and Engineering Inputs to the HED-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 Amite River and Tributaries 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 2023 RSMeans Square Foot Catalog;

- Total depreciated structure values were calculated based on the 2023 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.

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

Residential	Commercial	Industrial	Public	Total Structures
180,141	16,767	5,157	1,577	203,642

Structure Values. The 2023 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 walls types (wood siding on wood frame, brick veneer on wood frame, stucco on wood frame, and solid masonry) and three sizes (1-story, 2-story, and split-level) 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 (85 percent of the national square foot costs) for the Baton Rouge 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 (85 percent of the national square foot costs) for the Baton Rouge 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. Table G:2-2 shows the average depreciated replacement value for residential and non-residential structures by category and occupancy type.

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

Category	Occupancy Type	Number	Average Depreciated Replacement Value
Residential	One-Story Slab	148,175	$230.6
	One-Story Pier	8,169	$218.0
	Two-Story Slab	50,221	$169.1
	Two-Story Pier	2,805	$163.1
	Mobile Home	21,750	$64.2
Commercial	Eating and Recreation	2,121	$1,411.6
	Professional	14,073	$1,087.1
	Repair and Home Use	2,490	$929.8
	Retail and Personal Services	18	$4,106.7
	Grocery and Convenience	2,608	$1,191.6
	Multi-Family Occupancy	1,661	$1,436.2
Public	Public and Semi-Public	2,234	$2,308.2
Industrial	Warehouse	6,561	$690.7
Total Residential		231,120	$169.0
Total Non-residential		31,766	$1,645.2

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. Table G:2-3 shows the minimum and maximum percentages of the most-likely structure values assigned to the various structure categories.

Table G:2-3. Structure Value Uncertainty Parameters

Category	Occupancy Type	Structrue Value Error	
		Lower (%)	Upper (%)
Residential	One-Story Slab	69	116
	One-Story Pier	69	116
	Two-Story Slab	69	116
	Two-Story Pier	67	116
	Mobile Home	69	116
Commercial	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	Public and Semi-Public	80	123
Industrial	Warehouse	80	123

2.2.2 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.

2.2.3 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 Table G:2-4.

Table G:2-4. Content-to-Structure Value Ratios (CSVRs) and Standard Deviations (SDs) by Occupancy

Category	Occupancy Type	CSVR (%)	SD (%)
Residential	One-Story Slab	69	37
	One-Story Pier	69	37
	Two-Story Slab	67	35
	Two-Story Pier	67	35
	Mobile Home	114	79
Commercial	Eating and Recreation	170	293
	Professional	54	54
	Repair and Home Use	236	295
	Retail and Personal Services	119	105
	Grocery and Convenience	134	78
	Multi-Family Occupancy	28	17
Public	Public and Semi-Public	55	80
Industrial	Warehouse	207	325

2.2.4 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 40-foot by 40-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.

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 focused Agency Technical Review (ATR) was conducted in on this process in April of 2017 to confirm the adequacy of the sampling techniques used to develop the results.

The East Baton Rouge portion of the study area was divided into 58 neighborhoods, which were used to stratify the sample and ensure the entire area was sampled from. A total of 347 residential and non-residential structures were randomly selected for the sample in East Baton Rouge 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 to collect the required information including the height of the foundation above ground (measured from the bottom of the front door to adjacent ground), the foundation type (slab or pier), and the number of stories (1-story, and 2 or more stories). This information was used to develop the average height above ground of slab on grade and pier/pile foundation structures in each neighborhood, the proportion of slab on grade foundations and pier/pile foundations, and the proportion of 1-story and 2-story structures in each neighborhood.

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 East Baton Rouge 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. A total of 357 residential and non-residential structures were randomly selected for the sample outside of East Baton Rouge 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 to collect the required information including the height of the foundation above ground (measured from the bottom of the front door to adjacent ground) and the foundation type (slab or pier). This information was used to develop the average height above ground of slab on grade and pier/pile foundation structures and the proportion of slab on grade foundations and pier/pile foundations.

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 outside East Baton Rouge Parish. 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. Since the commercial depth-damage relationships are only provided for commercial 1-story structures, all the commercial structures were treated as 1-story structures.

2.2.5 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 0.75 feet for residential pier foundation structures and 0.25 feet for slab foundation structures. The standard deviation for non-residential structures was calculated to be 0.64 feet.

The standard deviations for the ground elevations and foundation heights were combined, which resulted in a 0.81 feet standard deviation for residential pier foundation structures and 0.439 for slab foundation structures. For non-residential structures, the combined standard deviation was calculated to be 0.71 feet. Table G:2-5 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:2-6 displays the average foundation heights and standard deviations by occupancy type.

Table G:2-5. First-floor Stage Uncertainty Standard Deviation (SD) Calculation

Ground - LiDAR (conversion cm to inches to feet)	
+/- 18 cm @ 95% confidence	18cm
	x 0.393
z = (x - u)/ std. dev.	7.074in
	÷ 12
1.96 = (0.5895 - 0)/ std.dev.	0.5895ft
0.3007 = std.dev.	

Foundation Height (shown in feet)			
Residential		Commercial	Industrial
Pier	Slab	All	All
0.75	0.25	0.64	0.64

Combined First Floor (shown in feet)				
Residential		Commercial	Industrial	
Pier	Slab	All	All	
0.30	0.30	0.30	0.30	ground std. dev.
0.09	0.09	0.09	0.09	ground std. dev. Squared
0.75	0.25	0.64	0.64	1st floor std. dev.
0.56	0.06	0.41	0.41	1st floor std. dev. squared
0.65	0.15	0.50	0.50	Sum of Squared
0.81	**0.39**	**0.71**	**0.71**	**Square Root of Sum of Squared = Combined Std. Dev.**

Note 1: Mobile Homes are assigned the same uncertainty as Residential Pier.
Note 2: Autos do not have foundations, so only ground uncertainty is used.

Table G:2-6. Average Foundation Heights and Standard Deviations (SD) by Occupancy Type (feet)

Category	Occupancy Type	Average Foundation Height	Standard Deviations		
			Ground Stage SD	Foundation Height SD	First Floor SD
Residential	One-Story Slab	0.58	0.30	0.25	0.39
	One-Story Pier	2.17	0.30	0.75	0.81
	Two-Story Slab	0.63	0.30	0.25	0.39
	Two-Story Pier	1.93	0.30	0.75	0.81
	Mobile Home	3.14	0.30	0.75	0.81
Commercial	Eating and Recreation	0.65	0.30	0.64	0.71
	Professional	0.64	0.30	0.64	0.71
	Repair and Home Use	0.64	0.30	0.64	0.71
	Retail and Personal Services	0.5	0.30	0.64	0.71
	Grocery and Convenience	0.65	0.30	0.64	0.71
	Multi-Family Occupancy	0.62	0.30	0.64	0.71
Public	Public and Semi-Public	0.51	0.30	0.64	0.71
Industrial	Warehouse	0.64	0.30	0.64	0.71

2.2.6 Depth-Damage Relationships

The depth-damage relationships, developed by a panel of building and construction experts for the Lower Atchafalaya and Morganza to the Gulf, Louisiana feasibility studies, 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. Because the ART study area is mainly impacted by riverine and rainfall flooding, the short-duration freshwater (less than 24 hours) depth-damage curves were selected.

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 2 feet below the first-floor elevation to 16 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.

2.2.7 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 (2026) without-project and future without project conditions (2076). Water surface profiles were provided for eight annual exceedance probability (AEP) events: 0.50 (2-year), 0.20 (5-year), 0.10 (10-year), 0.04 (25-year), 0.02 (50-year), 0.01 (100-year), 0.005 (200-year), and 0.002 percent (500-year). The ART experiences flooding from riverine rainfall events and coastal storm surge. Due to these circumstances, the water surface profiles were based on predominant condition hydraulics. 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 after TSP.

2.3.2 Uncertainty Surrounding the Stage-Probability Relationships

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

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

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

3.1.1 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 (2026) conditions and the future without project (2076) 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 (50 years) for each study area reach to generate a stage-probability relationship with uncertainty for the without-project condition under base year (2026) conditions and future without project (2076) 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 (2026) conditions and future without project (2076) conditions.

Tables G:3-1 and G:3-2 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

Annual Chance Exceedance (ACE) Event	Residential	Commercial	Industrial	Public	Total
Base Year 2026					
0.50 (2 yr)	-	-	-	-	-
0.20 (5 yr)	-	-	-	-	-
0.10 (10 yr)	4,868	300	277	27	5,445
0.04 (25 yr)	8,082	537	436	47	9,055
0.02 (50 yr)	12,240	874	674	74	13,788
0.01 (100 yr)	18,204	1,363	917	108	20,484
0.005 (200 yr)	25,508	2,100	1,168	181	28,776
0.002 (500 yr)	35,956	3,185	1,534	286	40,675
Future Year 2076					
0.50 (2 yr)	-	-	-	-	-
0.20 (5 yr)	-	-	-	-	-
0.10 (10 yr)	7,185	435	462	38	8,082
0.04 (25 yr)	11,564	830	732	70	13,126
0.02 (50 yr)	16,207	1,282	947	107	18,436
0.01 (100 yr)	23,217	1,901	1,198	158	26,316
0.005 (200 yr)	29,124	2,474	1,419	222	33,017
0.002 (500 yr)	39,551	3,413	1,784	325	44,748

Table G:3-2 Structure Damage Without Project by Probability Event (2024 Price Level; $1000s)

Annual Chance Exceedance (ACE) Event	Residential	Commercial	Industrial	Public	Total
Base Year 2026					
0.50 (2 yr)	-	-	-	-	-
0.20 (5 yr)	-	-	-	-	-
0.10 (10 yr)	$342,333	$47,870	$41,003	$10,579	$431,206
0.04 (25 yr)	$658,857	$96,640	$83,877	$23,136	$839,374
0.02 (50 yr)	$1,118,695	$186,027	$151,083	$39,535	$1,455,806
0.01 (100 yr)	$1,842,667	$382,785	$250,767	$85,340	$2,476,220
0.005 (200 yr)	$2,759,383	$684,133	$372,783	$136,691	$3,816,299
0.002 (500 yr)	$4,278,138	$1,357,116	$581,354	$304,466	$6,216,608
Future Year 2076					
0.50 (2 yr)	-	-	-	-	-
0.20 (5 yr)	-	-	-	-	-
0.10 (10 yr)	$595,949	$86,594	$85,760	$18,354	$768,303
0.04 (25 yr)	$1,089,241	$184,856	$169,056	$52,938	$1,443,152
0.02 (50 yr)	$1,709,650	$368,787	$278,946	$79,383	$2,357,383
0.01 (100 yr)	$2,603,172	$632,318	$397,241	$142,511	$3,632,731
0.005 (200 yr)	$3,445,718	$1,052,054	$540,719	$262,417	$5,038,492
0.002 (500 yr)	$4,929,996	$1,723,931	$779,927	$397,545	$7,433,854

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 2026 and 2076 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 Table G:3-3. Expected and equivalent annual damages and benefits for the final array are shown in Table G:3-4. Table G:3-5 shows 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:3-3 Expected and Equivalent Annual Damage by Plan and Category (2024 Price Level; FY24 Federal Discount Rate; $1000s)

Plan	Commercial	Industrial	Public	Residential	Total
Base Year 2026					
No action	$36,954	$26,553	$6,903	$126,147	$196,557
Plan 2	$30,148	$20,136	$5,730	$82,125	$138,139
Plan 3	$30,105	$20,141	$5,729	$81,395	$137,370
Plan 4	$30,000	$20,106	$5,729	$80,652	$136,487
Future Year 2076					
No action	$56,728	$44,840	$10,456	$179,891	$291,914
Plan 2	$50,164	$39,062	$9,526	$131,168	$229,921
Plan 3	$50,119	$39,067	$9,526	$130,426	$229,137
Plan 4	$50,009	$39,030	$9,525	$129,668	$228,233
Equivalent at 2.75% FY24 Interest Rate					
No action	$44,474	$33,508	$8,255	$146,587	$232,824
Plan 2	$37,760	$27,335	$7,174	$100,778	$173,046
Plan 3	$37,717	$27,339	$7,173	$100,043	$172,272
Plan 4	$37,610	$27,303	$7,173	$99,294	$171,381

Table G:3-4 Expected and Equivalent Annual Damages and Benefits by Plan (2024 Price Level; FY24 Federal Discount Rate; $1000s)

Plan	Damages	Benefits
Base Year 2026		
No action	$196,557	$0
Plan 2	$138,139	$58,418
Plan 3	$137,370	$59,187
Plan 4	$136,487	$60,070
Future Year 2076		
No action	$291,914	$0
Plan 2	$229,921	$61,993
Plan 3	$229,137	$62,777
Plan 4	$228,233	$63,681
Equivalent at 2.75% FY24 Interest Rate		
No action	$232,824	$0
Plan 2	$173,046	$59,778
Plan 3	$172,272	$60,552
Plan 4	$171,381	$61,444

Table G:3-5 Expected and Equivalent Annual Damages and Benefits by Plan and Probability (2024 Price Level; FY24 Federal Discount Rate; $1000s)

Plan	Probability Benefits Exceeds Values Inidcated		
	0.75	0.50	0.25
Base Year 2026			
Plan 2	$44,013	$55,563	$71,124
Plan 3	$44,535	$56,275	$72,087
Plan 4	$45,042	$57,080	$73,267
Base Year 2076			
Plan 2	$47,793	$60,168	$74,669
Plan 3	$48,324	$60,898	$75,649
Plan 4	$48,840	$61,727	$76,864
Equivalent at 2.75% FY24 Interest Rate			
Plan 2	$45,447	$57,308	$72,466
Plan 3	$45,973	$58,027	$73,435
Plan 4	$46,483	$58,841	$74,629

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 New Orleans District Economics and Cost Engineering Branches. A 32 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 the South-Central Coastal Louisiana Feasibility Study and was applied to this study after reviewing the associated risks and concluding they were similar for both studies. Due to uncertainty surrounding Planning, Engineering, and Design costs there is a range of costs displayed in Section 5.

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 original first-floor elevation and the target elevation (the future condition 100-year stage, including sea level rise) for each structure in the HEC-FDA module. The number of feet that each structure was raised was rounded to the closest 1-foot increment, with the exception that structures less than 1 foot below the target elevation were rounded-up to 1 foot. Elevation costs by structure were summed to yield an estimate of total structure elevation costs.

The cost per square foot for raising a structure was based on data obtained during interviews in 2008 with representatives of three major metropolitan New Orleans area firms that specialize in the structure elevation. Composite costs were derived for residential structures by type: slab and pier foundation, 1- story and 2- story configuration, and for mobile homes. 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 of the five residential categories analyzed and by the number of feet elevated.

The cost per square foot to raise an individual structure to the target height was multiplied by the footprint square footage of each structure to compute the costs to elevate the structure. The footprint square footage for each structure was determined by applying the average square footage estimated for each residential structure. Added to the elevation cost was the cost of performing an architectural survey, which is associated with cultural resources concerns. The total costs for all elevated structures were annualized over the 50-year period of analysis of the project using the FY 2024 Federal discount rate of 2.75 percent. The square foot costs for elevation were price indexed to FY23 price levels using RSMeans cost catalog.

Table G:4-1. Nonstructural Elevation Costs for Residential Structures (2023 Price Level; $/Sq ft)

Height (ft)	1-Story Pier	1-Story Slab	2-Story Pier	2-Story Slab	Mobile Home
1	61	99	50	78	80
2	61	99	50	78	80
3	62	103	52	81	83
4	65	107	55	84	86
5	68	110	58	87	88
6	71	115	60	91	91
7	92	130	77	102	104
8	97	135	82	106	110
9	98	140	83	110	113
10	105	145	89	114	118
11	110	149	92	118	121
12	113	155	94	122	125
>=13	117	158	100	126	129

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 for the Draft Nonstructural Plans Feasibility Study, Donaldsonville, LA to the Gulf evaluation (September 14, 2012) by contacting local contractors and were adopted for this study due to the similarity in the structure types between the two study areas. Added to the floodproofing cost was the cost of performing an architectural survey, which is associated with cultural resources concerns. Again, final cost estimates are expressed at a 2024 price level.

Table G:4-2. Nonstructural Floodproofing Costs for Non-residential Structures (2023 Price Level)

Structure Square Footage	Total Cost
up to 20,000	$179,334
20,001 to 109,999	$447,469
110,000 or more	$1,072,242

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 (2026). 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 ART 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 midyear discounting. Cost engineering provided both a low estimate with a 10 percent PED cost and a high estimate with an 18 percent PED 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 2		Plan 3		Plan 4	
	Low	High	Low	High	Low	High
Construction First Cost	$1,469,853	$1,560,803	$1,510,378	$1,603,866	$1,561,330	$1,657,967
Interest During Construction	$4,993	$5,302	$5,131	$5,448	$5,304	$5,632
Total Construction Cost	$1,474,846	$1,566,105	$1,515,509	$1,609,314	$1,566,634	$1,663,599
Average Annual Total Construction Cost	$54,630	$58,010	$56,136	$59,610	$58,030	$61,621

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 2 to be the NED plan and Plan 4 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 2 (NED)		Plan 3		Plan 4 (TSP)	
	Low Cost	High Cost	Low Cost	High Cost	Low Cost	High Cost
Construction First Cost	$1,469,853	$1,560,803	$1,510,378	$1,603,866	$1,561,330	$1,657,967
Interest During Construction	$4,993	$5,302	$5,131	$5,448	$5,304	$5,632
Total Construction Cost	$1,474,846	$1,566,105	$1,515,509	$1,609,314	$1,566,634	$1,663,599
Average Annual Construction Cost	$54,630	$58,010	$56,136	$59,610	$58,030	$61,621
Equivalent Annual Benefits	$59,778		$60,552		$61,444	
Annual Net Benefits	$5,148	$1,768	$4,416	$942	$3,414	-$178
Benefit-to-Cost Ratio (BCR)	1.094	1.030	1.079	1.016	1.059	0.997

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 for Low and High Cost Estimates (2024 Price Level; FY24 Federal Discount Rate; $1000s)

Plan	Probability Benefits Exceeds Indicated Values			Low Annual Costs	Probability Benefits Exceed Low Cost
	75%	50%	25%		
Plan 2 (NED)	$45,447	$57,308	$72,466	$54,630	50% to 75%
Plan 3	$45,973	$58,027	$73,435	$56,136	50% to 75%
Plan 4 (TSP)	$46,483	$58,841	$74,629	$58,030	50% to 75%
Plan	**Probability Benefits Exceeds Indicated Values**			**High Annual Costs**	**Probability Benefits Exceed High Cost**
	75%	**50%**	**25%**		
Plan 2 (NED)	$45,447	$57,308	$72,466	$58,010	25% to 50%
Plan 3	$45,973	$58,027	$73,435	$59,610	25% to 50%
Plan 4 (TSP)	$46,483	$58,841	$74,629	$61,621	25% to 50%

5.2.2 Residual Risk

The ART study area is impacted by riverine flooding and coastal storm surge. The ART study is authorized as a flood risk reduction study, therefore nonstructural Plans were developed using riverine water surface elevation. This excludes structures impacted solely by coastal storm surge from inclusion in the final array. Table G:5-3 shows the number of structures with first-floor flooding by flood source and frequency. The final array of plans, developed using riverine water surface elevations, reduces approximately 30 percent of the existing condition damages.

Table G:5-3 Number of Structures with First-floor Flooding Based on Source of Flooding

Annual Exceedance Probability	Structures with first-floor flooding from predominantly…	
	Rainfall (currently included in analysis)	Coastal Storm Surge (currently not included in analysis)
0.1 (10 year)	2985	2970
0.04 (25 year)	4340	5801
0.02 (50 year)	6100	8791

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, smoothing of hydraulic data between 1D and 2D model boundaries, and inclusion of saltwater depth-damage relationships for structures predominately impacted by coastal surge. 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.

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.

6.1.2 Results

The expenditures associated with the Nonstructural NED Plan in Baton Rouge, Louisiana are estimated to be $1,560,787,745. The spending profile percentages were adjusted to better characterize a nonstructural project. More specifically, construction of buildings and residential structures became more heavily weighted as well as the amount of cement materials used. Lastly, private sector labor was more heavily weighted in comparison to the architectural, design, and engineering services. Of this total expenditure, $1,216,348,366 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). The regional economic effects are shown for the local, state, and national impact areas. In summary, the expenditures $1,560,787,745 support a total of 14,524.3 full-time equivalent jobs, $1,088,217,997 in labor income, $1,391,463,839 in the gross regional product, and $2,160,209,177 in economic output in the local impact area. More broadly, these expenditures support 23,627.4 full-time equivalent jobs, $1,736,532,656 in labor income, $2,401,503,673 in the gross regional product, and $3,989,244,014 in economic output in the nation. A summary of the results for Plan 2 can be found in Table G:6-1.

Table G:6-1. Plan 2: Nonstructural NED Plan Overall Summary

Area	Local Capture	Output	Jobs*	Labor Income	Value Added
Local					
Direct Impact		$1,216,348,366	9,361.9	$785,725,840	$851,512,231
Secondary Impact		$943,860,811	5,162.3	$302,492,157	$539,951,608
Total Impact	$1,216,348,366	$2,160,209,177	14,524.3	$1,088,217,997	$1,391,463,839
State					
Direct Impact		$1,308,758,568	10,431.2	$825,344,685	$909,988,594
Secondary Impact		$1,073,907,227	5,863.3	$333,659,723	$601,542,313
Total Impact	$1,308,758,568	$2,382,665,795	16,294.4	$1,159,004,409	$1,511,530,907
US					
Direct Impact		$1,502,926,045	12,480.2	$943,669,425	$1,043,021,062
Secondary Impact		$2,486,317,969	11,147.3	$792,863,231	$1,358,482,611
Total Impact	$1,502,926,045	$3,989,244,014	23,627.4	$1,736,532,656	$2,401,503,673

** Jobs are presented in full-time equivalence (FTE)*

The expenditures associated with the Nonstructural NED + OSE Increment 1 plan in Baton Rouge, Louisiana are estimated to be $1,603,850,324. More specifically, construction of buildings and residential structures became more heavily weighted as well as the amount of cement materials used. Lastly, private sector labor was more heavily weighted in comparison to the architectural, design, and engineering services. Of this total expenditure, $1,249,907,764 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). The regional economic effects are shown for the local, state, and national impact areas. In summary, the expenditures $1,603,850,324 support a total of 14,925.0 full-time equivalent jobs, $1,118,242,242 in labor income, $1,429,854,723 in the gross regional product, and $2,219,809,964 in economic output in the local impact area. More broadly, these expenditures support 24,279.3 full-time equivalent jobs, $1,784,444,087 in labor income, $2,467,761,844 in the gross regional product, and $4,099,308,395 in economic output in the nation. A summary of results for Plan 3 can be found in Table G:6-2.

Table G:6-2. Plan 3: Nonstructural NED + OSE Increment 1

Area	Local Capture	Output	Jobs*	Labor Income	Value Added
Local					
Direct Impact		$1,249,907,764	9,620.2	$807,404,240	$875,005,696
Secondary Impact		$969,902,200	5,304.8	$310,838,002	$554,849,026
Total Impact	$1,249,907,764	$2,219,809,964	14,925.0	$1,118,242,242	$1,429,854,723
State					
Direct Impact		$1,344,867,590	10,719.0	$848,116,181	$935,095,439
Secondary Impact		$1,103,536,634	6,025.0	$342,865,490	$618,139,037
Total Impact	$1,344,867,590	$2,448,404,224	16,744.0	$1,190,981,671	$1,553,234,476
US					
Direct Impact		$1,544,392,203	12,824.5	$969,705,533	$1,071,798,310
Secondary Impact		$2,554,916,191	11,454.8	$814,738,554	$1,395,963,534
Total Impact	$1,544,392,203	$4,099,308,395	24,279.3	$1,784,444,087	$2,467,761,844

** Jobs are presented in full-time equivalence (FTE)*

The expenditures associated with the Nonstructural NED + OSE Increment 1 plan in Baton Rouge, Louisiana are estimated to be $1,657,950,796. More specifically, construction of buildings and residential structures became more heavily weighted as well as the amount of cement materials used. Lastly, private sector labor was more heavily weighted in comparison to the architectural, design, and engineering services. Of this total expenditure, $1,292,069,179 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). The regional economic effects are shown for the local, state, and national impact areas. In summary, the expenditures $1,657,950,796 support a total of 15,428.5 full-time equivalent jobs, $1,155,962,366 in labor income, $1,478,086,040 in the gross regional product, and $2,294,687,753 in economic output in the local impact area. More broadly, these expenditures support 25,098.3 full-time equivalent jobs, $1,844,636,279 in labor income, $2,551,003,451 in the gross regional product, and $4,237,584,712 in economic output in the nation. A summary of the results for Plan 4 can be found in Table G:6-3.

Table G:6-3. Plan 4: Nonstructural NED + OSE Increment 2

Area	Local Capture	Output	Jobs*	Labor Income	Value Added
Local					
Direct Impact		$1,292,069,179	9,944.8	$834,639,294	$904,521,057
Secondary Impact		$1,002,618,574	5,483.7	$321,323,072	$573,564,984
Total Impact	$1,292,069,179	$2,294,687,753	15,428.5	$1,155,962,366	$1,478,086,040
State					
Direct Impact		$1,390,232,154	11,080.5	$876,724,514	$966,637,724
Secondary Impact		$1,140,760,713	6,228.3	$354,430,899	$638,989,868
Total Impact	$1,390,232,154	$2,530,992,867	17,308.8	$1,231,155,413	$1,605,627,592
US					
Direct Impact		$1,596,487,056	13,257.1	$1,002,415,273	$1,107,951,805
Secondary Impact		$2,641,097,656	11,841.2	$842,221,006	$1,443,051,647
Total Impact	$1,596,487,056	$4,237,584,712	25,098.3	$1,844,636,279	$2,551,003,451

** Jobs are presented in full-time equivalence (FTE)*

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 ART 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

Population

The ART study area is home to nearly 800,000 residents spanning from the Mississippi-Louisiana state line at St. Helena Parish in the north, to St. James and St. John the Baptist Parishes in the south. The majority of the population impacted by the ART study is located in East Baton Rouge Parish. Table G:7-1 provides a breakdown of population in the area estimated out to 2045. Table G: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.

Table G:7-1. Population (2000 - 2045) by Parish/County

Parish	2000	2010	2017	2025	2045
Ascension	76,627	107,215	122,948	136,988	161,973
East Baton Rouge	412,852	440,171	446,268	441,495	415,720
East Feliciana	21,360	20,267	19,412	18,140	15,910
Iberville	33,320	33,387	33,027	31,166	27,428
Livingston	91,814	128,026	138,228	150,306	166,260
St. Helena	10,525	11,203	10,363	9,681	8,592
St. James	21,201	22,006	21,790	22,599	23,727
St. John the Baptist	43,248	45,621	44,078	45,713	47,995

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

Households

Table G:7-2. Households (2000 - 2045) by Parish/County

Parish	2000	2010	2017	2025	2045
Ascension	26,995	38,050	44,890	51,815	66,244
East Baton Rouge	156,740	172,440	179,910	184,008	186,082
East Feliciana	6,694	6,996	6,922	6,752	6,411
Iberville	10,697	11,075	11,229	11,137	10,643
Livingston	32,997	46,297	52,184	57,891	69,149
St. Helena	3,890	4,323	4,116	3,995	3,810
St. James	7,002	7,691	7,945	8,561	9,727
St. John the Baptist	14,381	15,875	16,005	17,249	19,602

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

Income

Table G:7-3. Per Capita Income ($) by Parish/County

Parish/County	2000	2010	2017	2025
Ascension	24,052	39,416	47,628	60,180
East Baton Rouge	27,228	39,651	48,120	60,048
East Feliciana	20,049	33,122	39,908	53,331
Iberville	18,681	32,342	38,960	50,288
Livingston	21,521	32,621	39,883	51,341
St. Helena	16,821	34,136	41,273	55,046
St. James	18,722	38,421	45,219	60,576
St. John the Baptist	20,002	33,894	41,505	57,423

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 ART 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 applied across the four themes in addition to the overall vulnerability. Out of 191 Louisiana Census Tracts within the ART study area, there were 46 that were identified as experiencing social vulnerability.

In order to incorporate social vulnerability into economic benefit analysis, economic subunits, or reaches, were delineated based on the same criteria shown in Figure G:7-1. Structures in these areas are within the 90^{th} percentile or higher for any of the CDC's Social Vulnerability Index themes. Through this process, an additional 46 areas were identified as socially vulnerable reaches.

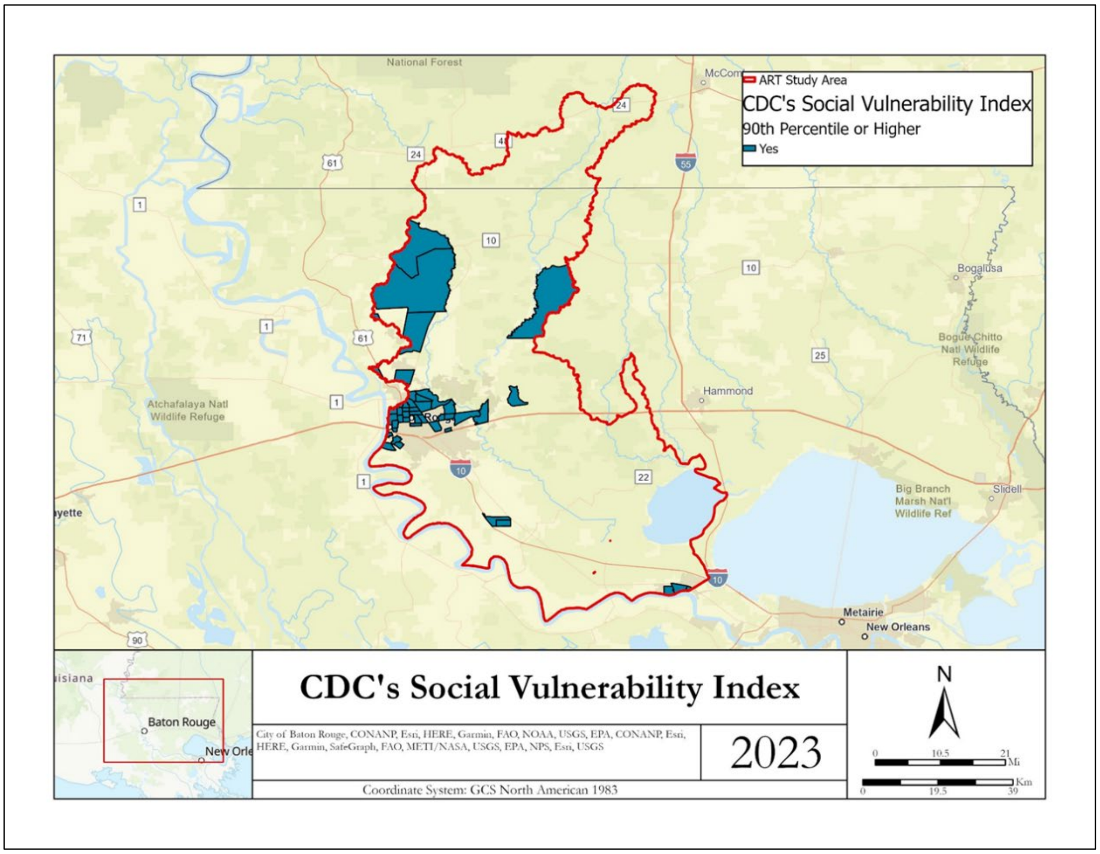


Figure G:7-1. Social Vulnerability in the ART Study Area

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 ART study area, have an increased risk of adverse effects on health and safety.

<u>Life Safety</u>

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 ART study area was evaluated using submergence criteria assumptions from the LifeSim technical manual, future without project hydraulic depth grids, and the ART structure inventory. Submergence is defined as a water level at a structure that can affect probability of survival. Submergence criteria are used to define the threshold between high hazard and low hazard conditions when people are trapped in a flooded structure (USACE 2020). Three hydraulic events (0.04 AEP, 0.01

AEP, and 0.02 AEP) were analyzed for their potential high hazard conditions on structures. Structures were considered to be experiencing ‘high hazard conditions’ if the first-floor elevation at the structure exceeded thresholds in any of the three high hazard conditions defined in Table G:7-4. The number of structures in high hazard conditions is are listed in Table G:7-5.

Table G:7-4. Submergence Criteria (LifeSim Technical Manual)

Submergence criteria	Description	Applied to	Default Values
A. High hazard depth from floor	If depth from floor is above the threshold, then people will be place in the high hazard zone.	Limited mobility occupants	4-6 feet, triangular distribution with 5ft best estimate
B. High hazard depth from ceiling	If depth from top of ceiling is above the threshold, then people will be placed in the high hazard zone.	Able-bodied occupants	0.5 - 1.5 feet, Triangular distribution with 1 ft best estimate
C. High hazard depth on roof	If depth over the roof is greater than the threshold, then people caught on roof will be placed in the high hazard zone.	Able-bodied occupants	3-5 feet, Triangular distribution with 4ft best estimate

Table G:7-5. Number of Structures in High Hazard Conditions

Future Without Project Conditions (2076) Number of Structures in High Hazard Conditions			
	0.04 AEP	**0.01 AEP**	**0.02 AEP**
High Hazard - Limited Mobility	600	2793	8260
High Hazard - Depth from Ceiling	32	280	2182
High Hazard - Depth on Roof	3	11	22

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 ART study area.

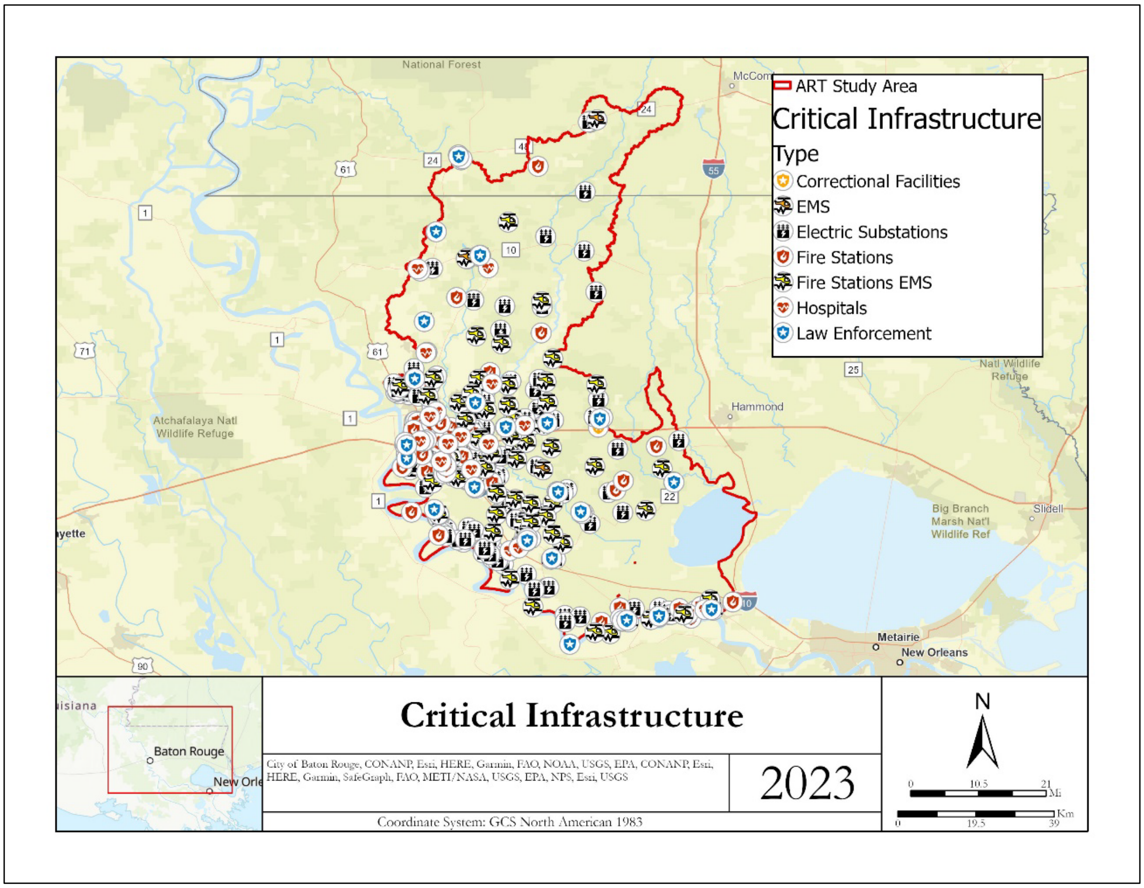


Figure G:7-2. Critical Infrastructure in ART Study Area

Food Insecurity

The Food Access Research Atlas from the US Department of Agriculture details census tracts that are determined to be low income and low access to fresh food and grocers. In communities where residents to not have grocers within a reasonable distance, for urban areas, 1 mile, there is often a surplus of convenient stores and gas stations that are present to try and fill some nutritional needs. These locations are typically less healthy and more expensive.

Figure G:7-3 details the census tracts in the ART study area that are low income and low access. During inundation events, there would be additional strain on the grocers that are within a walking or commutable distance as a result of increased inundation on roadways as well as damages to grocery structures themselves.

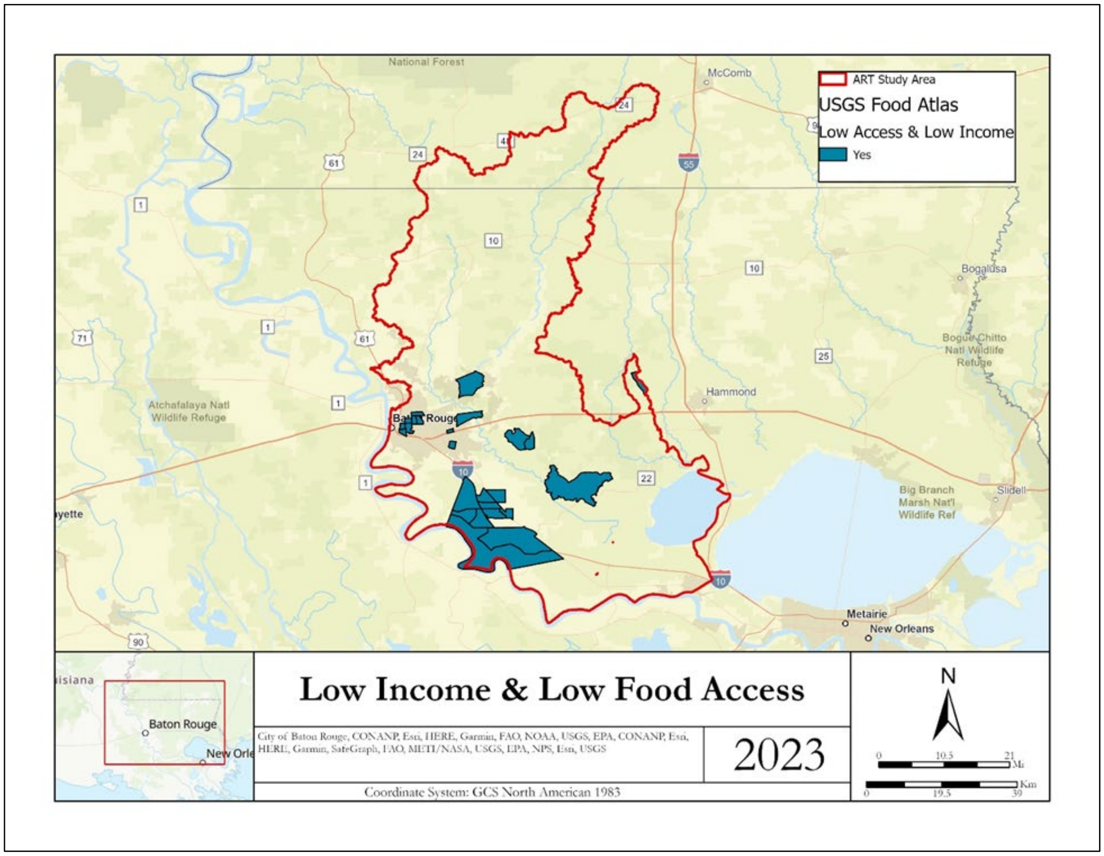


Figure G:7-3. Food Insecurity in the ART Study Area

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. There are several factors within the ART study area that exemplify a lower-than-average quality of life.

Employment Activity

Employment activity indicates how efficiently a community can respond to hazardous events and is an overall indicator for economic health. Figure G:7-4 shows the aggregated employment between all of the counties within the ART study area. Following 1990, the largest employment industry shifted from manufacturing to trade, transportation, and utilities. Between 1990 and 2000, local government surpassed that of manufacturing to become the second largest industry for employment.

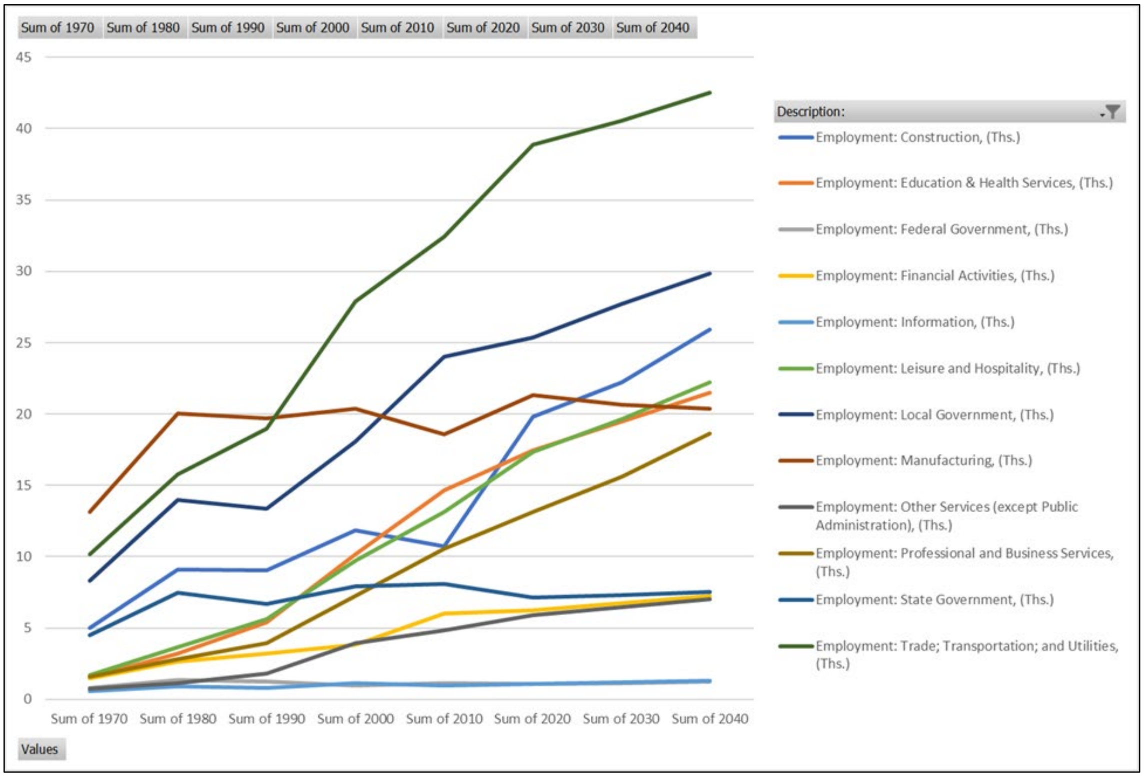


Figure G:7-4. Employment by Industry (1970 - 2045)

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:7-5 shows a map of physically located civic infrastructure, which includes places of worship, community centers, and parks that receive any inundation in the 1 percent event in the without project condition. 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.

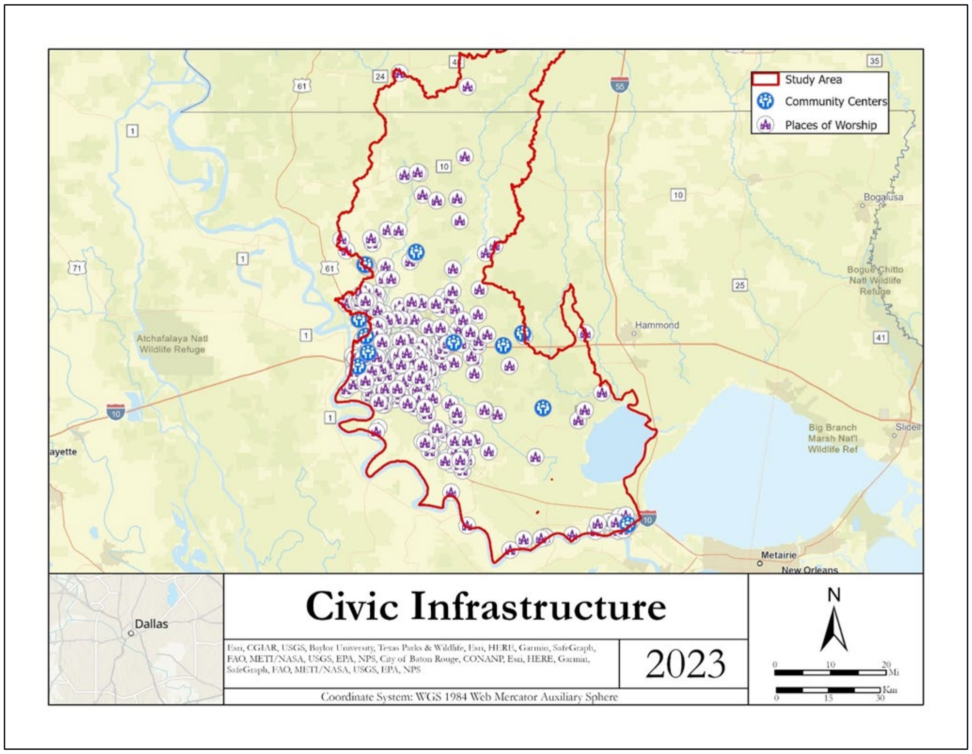


Figure G:7-5. Civic Infrastructure in the ART Study Area

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[1]. 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[2] 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.

[1] Executive Order 12898 utilizes the terms “minority” and “low income.” Recent Executive Orders use a broader term, “disadvantaged,” which includes communities that are historically and currently marginalized, underserved, and overburdened by pollution.
[2] The phase “economically disadvantaged” is used in addition to “low-income.” Note that EJ SCREEN tools specifically use “low-income” in their demographic indicators.

Figure G:7-6 represents those census tracts that are considered to be areas of environmental justice concern as reported by CEJST. Out of 146 census tracts in the ART study area, 57 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.

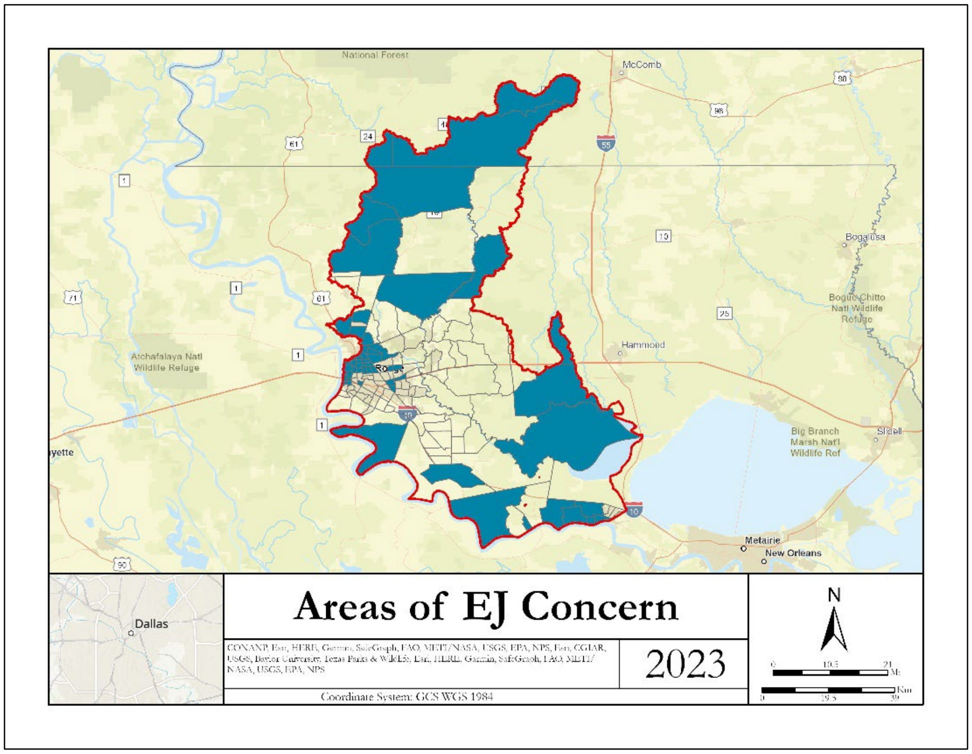


Figure G:7-6. Areas of Environmental Justice Concern (CEJST) in the ART Study Area

7.3 IMPACT ANALYSIS: FINAL ARRAY

7.3.1 Impact of Plans on Other Social Effects Themes

Table G:7-6 provides a summary of the “other social effects themes.”

Table G:7-6. Other Social Effects Theme Summary Table

OSE Theme	Indicator	Plan 2	Plan 3	Plan 4
Social Vulnerability & Resiliency	Structures included in SV Areas	+	++	++
Health & Safety	Life Safety	+	+	+
	Critical Infrastructure	+	+	+
	Food Insecurity	+	++	++
Economic Vitality	Employment Activity	+	+	+
Social Connectedness	Civic Infrastructure	+	+	+
Participation	Public Involvement	*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

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

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

	Plan 2	Plan 3	Plan 4
Structures included in areas experiencing social vulnerability	235	307	392
Total Structures included	3,117	3,189	3,298
Total Benefits (Millions)	$55.1	$55.9	$56.6
% of Benefits in areas experiencing social vulnerability	11.7%	12.8%	14.0%

Plan 2: Nonstructural NED Plan

Plan 2 optimized the number of eligible structures based on the net benefits of the entire reporting reach. These reporting reaches did not specifically incorporate the social vulnerability characteristics and were included as a part of the reporting reach. In this plan, there were total benefits of around $55.1 million dollars. This plan, while not specifically formulated with considerations of social vulnerability, did attribute $6.4 million dollars to structures that are in areas experiencing social vulnerability as stated in section 7.2.1 of this appendix. Therefore, this plan provides 11.7 percent of total benefits to socially vulnerable areas. 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 3: Nonstructural NED + OSE Increment 1

Plan 3 optimized the number of eligible structures based on the net benefits of reporting reaches in addition to their subset of identified socially vulnerable areas. To capture additional mitigation for communities that experience social vulnerability, reaches that had social vulnerability incorporated into them were evaluated at the next cumulative AEP above the optimized level for which positive net benefits were still identified. For example, if a reach was optimized (received the largest net benefits) at the 10 year event, but still had positive, but decreasing, net benefits at the 25 year, then the 25 year eligibility was included in plan 3.

Through this eligibility process, an additional 157 structures were identified and included in the plan. In this plan, there were $55.9 million dollars of benefits achieved overall and $7.2 million were attributed to areas experiencing social vulnerability. Therefore, this plan provides 12.8 percent of total benefits to socially vulnerable reaches. 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 4: Nonstructural NED + OSE Increment 2

Plan 4 utilizes the Social Vulnerability Index threshold to increase cumulative floodplain eligibility, regardless of net benefits, if the reach meets the determined threshold for social vulnerability – 90th percentile or higher for any of the four themes or the overall theme. For example, if a socially vulnerable reach had the largest net benefits at the 10 year cumulative floodplain, it incorporated the structures eligible in the 25 year cumulative flood plain, regardless of what the net benefits were in the 25 year flood plain.

Under this plan, $56.6 million dollars of benefits were achieved overall and $7.9 million were attributed to areas experiencing social vulnerability. Therefore, this plan provides 14.0 percent of total benefits to those socially vulnerable reaches. 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.

7.3.3 Health & Safety

<u>*Life Safety*</u>

Plan 2: Nonstructural NED Plan

Plan 2 is a nonstructural only plan that includes the elevation of 2,748 residential structures and dry floodproofing 369 commercial and industrial structures. Table G:7-8 shows the number of structures no longer experiencing high hazard conditions with the construction of nonstructural measures in Plan 2. Nonstructural measures included in Plan 2 are voluntary, and this analysis assumes 100 percent participation.

Nonstructural measures included in Plan 2 do not mitigate life safety risk on roadways. High flood depths and velocities associated with hazardous driving conditions will remain with the construction of Plan 2.

Table G:7-8. Plan 2: Number of Structures in High Hazard Conditions

	Number of Structures Remaining in High Hazard Conditions			**Number of Structures removed from High Hazard Conditions**		
	0.04 AEP	**0.01 AEP**	**0.02 AEP**	**0.04 AEP**	**0.01 AEP**	**0.02 AEP**
HH Limited Mobility	15	919	6139	585	1874	2121
HH Depth from Ceiling	2	12	431	30	268	1751
HH Depth on Roof	1	1	1	2	10	21

Plan 3: Nonstructural NED + OSE Increment 1

Plan 3 is a nonstructural only plan that includes the elevation of 2,815 residential structures and dry floodproofing 374 commercial and industrial structures. Table G:7-9 shows the number of structures no longer experiencing high hazard conditions with the construction of nonstructural measures in Plan 2. Nonstructural measures included in Plan 3 are voluntary, and this analysis assumes 100 percent participation.

Nonstructural measures included in Plan 2 do not mitigate life safety risk on roadways. High depths and velocities associated with hazardous driving conditions would remain with the construction of Plan 3.

Table G:7-9: Plan 3: Number of Structures in High Hazard Conditions

	Number of Structures Remaining in High Hazard Conditions			Number of Structures removed from High Hazard Conditions		
	0.04 AEP	**0.01 AEP**	**0.02 AEP**	**0.04 AEP**	**0.01 AEP**	**0.02 AEP**
HH Limited Mobility	11	901	6121	589	1892	2139
HH Depth from Ceiling	2	8	417	30	272	1765
HH Depth on Roof	1	1	1	2	10	21

Plan 4: Nonstructural NED + OSE increment 2

Plan 4 is a nonstructural only plan that includes the elevation of 2,918 residential structures and dry floodproofing 380 commercial and industrial structures. Table G:7-10 shows the number of structures no longer experiencing high hazard conditions with the construction of nonstructural measures in Plan 4. Nonstructural measures included in Plan 4 are voluntary, and this analysis assumes 100 percent participation.

Nonstructural measures included in Plan 4 do not mitigate life safety risk on roadways. High depths and velocities associated with hazardous driving conditions would remain with the construction of Plan 3.

Table G:7-10. Plan 4: Number of Structures in High Hazard Conditions

	Number of Structures Remaining in High Hazard Conditions			Number of Structures with Reduced Risk from High Hazard Conditions		
	0.04 AEP	**0.01 AEP**	**0.02 AEP**	**0.04 AEP**	**0.01 AEP**	**0.02 AEP**
HH Limited Mobility	11	900	6118	589	1893	2142
HH Depth from Ceiling	2	8	416	30	272	1766
HH Depth on Roof	1	1	1	2	10	21

<u>*Critical Infrastructure*</u>

Critical infrastructure receiving benefits is shown on Figure G:7-7.

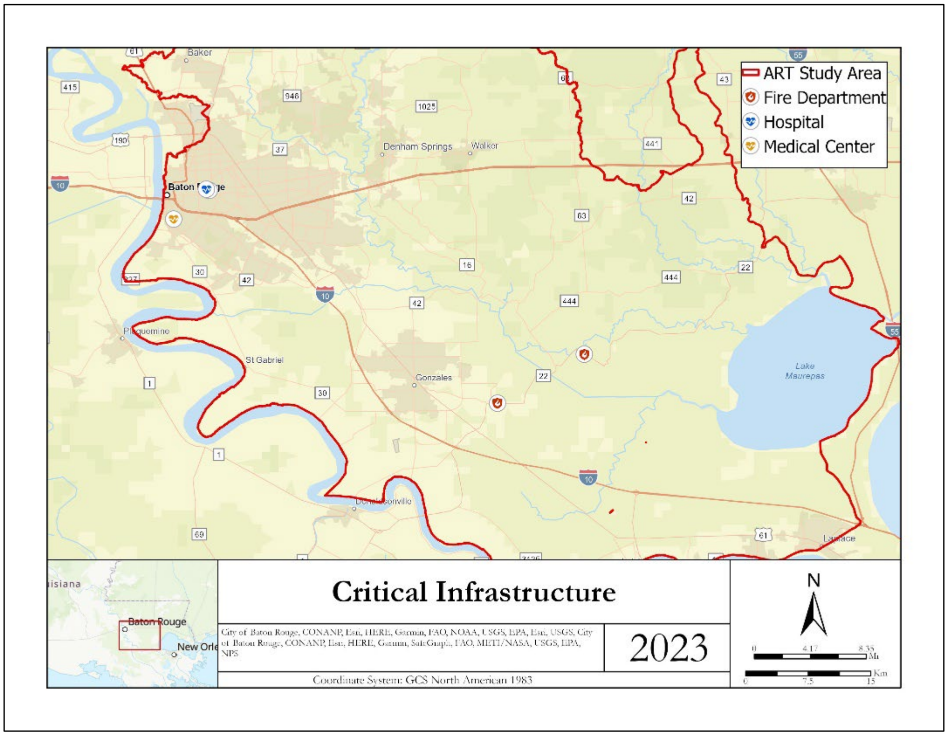


Figure G:7-7. Critical Infrastructure Receiving Benefits

Plan 2: Nonstructural NED Plan

Under plan 2, there are five critical infrastructure facilities included for floodproofing mitigation. Two of these facilities are medical centers, two of them are fire departments, and the remaining is a hospital. 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. Reference Figure G:7-7 for the physical location of mitigated critical infrastructure.

Plan 3: Nonstructural NED + OSE Increment 1

Plan 3 does not present any additional protection to critical infrastructure facilities than is presented in plan 1. The five facilities would experience a shorter pause on operation, allowing services and assistance to be resumed for community members. Reference Figure G:7-7 for the physical location of mitigated critical infrastructure.

Plan 4: Nonstructural NED + OSE Increment 2

Plan 4 does not present any additional protection to critical infrastructure facilities than is presented in plan 1. The five facilities would experience a shorter pause on operation, allowing services and assistance to be resumed for community members. Reference Figure G:7-7 for the physical location of mitigated critical infrastructure.

Food Insecurity

Plan 2: Nonstructural – Optimized NED Plan

In the with project condition of plan 2, there are 14 grocery stores that are included. Two of these grocery stores are within areas that are considered low access and low income according the USGS Food Atlas. Figure G:7-8 shows where the identified grocery stores are located in proximity to areas experiencing food insecurity. Increased protection from inundation damages for these grocery stores would lead to a shorter recovery period, allowing community members to access fresh food and grocers following an inundation event.

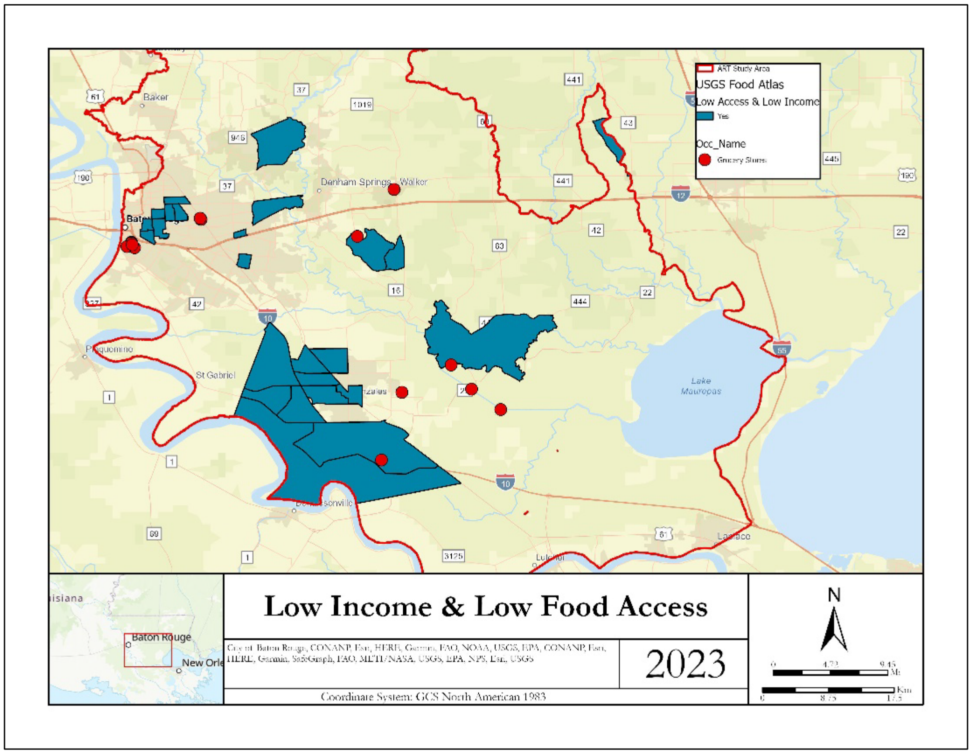


Figure G:7-8. Benefits to Food Insecurity

Plan 3: Nonstructural - NED Plan + OSE Increment 1

In the with project condition of plan 3, there is one additional grocery store that is included as a part of the plan, mitigating for a total of 15 grocery stores, with increased risk reduction for an additional facility in an area that experiences social vulnerability. Two stores remain included in areas identified as low income and low access according to the USGS Food Atlas. Impacts of these measures would include a shorter recovery period following inundation in several areas within the ART study area, but specifically allow accessibility to communities that are experiencing food insecurity. Figure G:7-8 represents identified grocery stores for mitigation and their proximity to communities experiencing food insecurity.

Plan 4: Nonstructural NED + OSE Increment 2

The with project condition of plan 4 does not provide additional impacts to areas experiencing food insecurity in accordance with the USGS Food Atlas from what is provided in plan 2. The same grocers would benefit and be able to resume service to community members that have limited geographical access to fresh food. Figure G:7-8 represents identified grocery stores for mitigation and their proximity to communities experiencing food insecurity.

7.3.4 Economic Vitality

Plan 2: Nonstructural – Optimized NED Plan

Under plan 2, 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 369 commercial 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 2.

Plan 3: Nonstructural - NED Plan with increased eligibility for positive net benefits

Under Plan 3, the number of commercial structures included in commercial mitigation increases to 374. 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 4: Nonstructural – NED Plan with increased eligibility for all SV reaches

Under Plan 4, the number of commercial structures included in commercial mitigation increases to 380. 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

Plan 2: Nonstructural – Optimized NED Plan

Under plan 2, there are eight civic infrastructure facilities included. Three of them are community centers situated among the area and five of them are places of worship. In this 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. Reference Figure G:7-9 for the location of civic infrastructure included in all three of the plans in the final array.

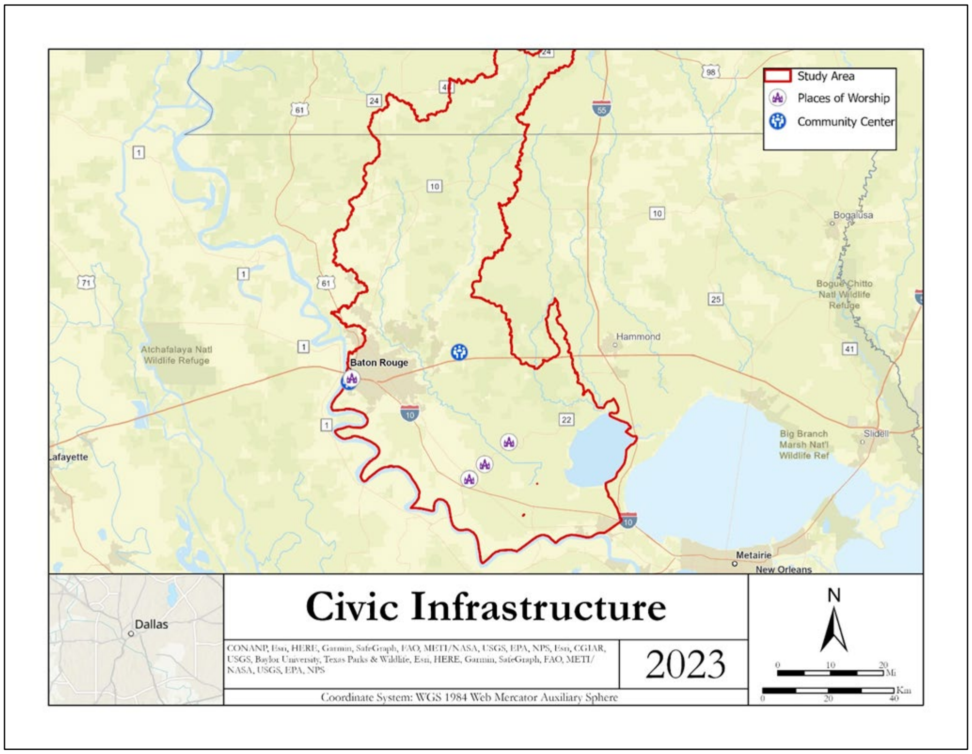


Figure G:7-9. Civic Infrastructure Receiving Benefits

Plan 3: Nonstructural - NED + OSE Increment 1

Under Plan 3, there would not be any additional positive or negative impacts to social connectedness from what is included in Plan 2. This plan would present the same level of opportunity for community cohesion and gathering. Reference Figure G:7-9 for the location of civic infrastructure included in all three of the plans in the final array.

Plan 4: Nonstructural – NED + OSE Increment 2

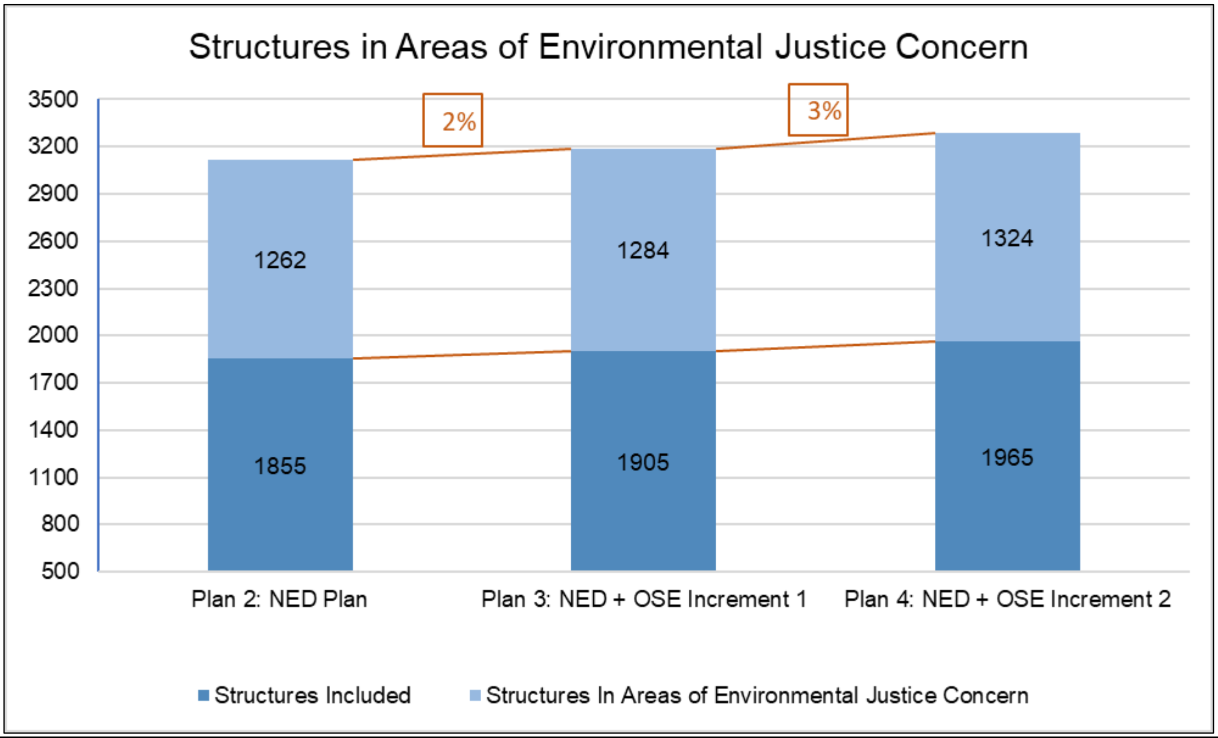
Under Plan 4, there would not be any additional positive or negative impacts to social connectedness from what is included in Plan 2. This plan would present the same level of opportunity for community cohesion and gathering. Reference Figure G:7-9 for the location of civic infrastructure included in all three of the plans in the final array.

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

7.3.7 Environmental Justice

Table G:7-11 presents a list of the benefits to historically disadvantaged communities and Figure G:7-10 shows the number of structures included in areas of environmental concern for Plan 2, Plan 3, and Plan 4.

Table G:7-11. Benefits to Historically Disadvantaged Communities



	Plan 2	Plan 3	Plan 4
Structures Included	1,262	1,284	1,324
% of Benefits to Disadvantaged Communities	40%	40%	40%

Figure G:7-10. Structures Included in Areas of Environmental Concern

Plan 2: Nonstructural – Optimized NED Plan

Plan 2 includes 3,117 structures in the nonstructural plan for mitigation. Of these structures, 1,262, or 40 percent, of structures are in disadvantaged communities. Mitigation in this area would positively impact community members as historically overburdened and disadvantaged communities.

Plan 3: Nonstructural - NED + OSE Increment 1

Plan 3 includes 3,189 structures in the nonstructural mitigation plan. Of these structures, 1,284, or 40 percent of structures are located in disadvantaged communities. Structures located in disadvantaged communities encompass 22 of the 72 structures incrementally increased from Plan 2. Figure G:7-10 graphically represents the additional structures included in this plan.

Plan 4: Nonstructural – NED + OSE Increment 2

Plan 4 includes 3,289 structures in the nonstructural mitigation plan. Of these structures, 1,324 or 40 percent of structures are located in disadvantaged communities. Structures located in disadvantaged communities encompass 40 of the increase in 100 structures from Plan 3, and therefore include 62 of the of the 172 structures that increased from plan 2. Figure G:7-10 graphically represents the additional structures included in this plan.