Appendix I
Economics

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Appendix I. Economics

1 BACKGROUND INFORMATION

1.1 INTRODUCTION

General. This appendix presents an economic evaluation of the riverine flood risk reduction measures for the River des Peres General Re-Evaluation Report. The evaluation area includes the section of the River des Peres watershed within University City, Missouri, as well as a small portion upstream in Overland and Olivette. The report was prepared in accordance with Engineering Regulation (ER) 1105-2-100, Planning Guidance Notebook, and ER 1105-2-101, Planning Guidance, Risk Analysis for Flood Damage Reduction Studies. The National Economic Development Procedures Manual for Flood Risk Management and Coastal Storm Risk Management, prepared by the Water Resources Support Center, Institute for Water Resources, was also used as a reference, along with the User's Manual for the Hydrologic Engineering Center Flood Damage Analysis Model (HEC-FDA).

The economic appendix consists of a description of the methodology used to determine National Economic Development (NED) damages and benefits under existing conditions and the projects costs. The damages and costs were calculated using FY 2021 price levels. Costs were annualized using the FY 2021 Federal discount rate of 2.5 percent and a period of analysis of 50 years with the year 2025 as the base year. The expected annual damage and benefit estimates were compared to the annual construction costs and the associated OMRR&R costs for each of the project measures.

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

Physical Flood Damage Reduction. Physical flood damage reduction benefits include the decrease in potential damages to residential and commercial structures and their contents.

Emergency Cost Reduction Benefits. Emergency costs are those costs incurred by a community during and immediately following a major storm. Emergency costs for this study include travel, meal, cleanup supplies, unpaid labor, and vandalism costs. These costs were applied to residential structures.

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

- Indirect losses to the national economy as a result of disruptions in the production of goods and services by industries affected by the storm or riverine flooding
- Increased cost of operations for industrial facilities following a flood event relative to normal business operations
- Physical loss of agricultural crops grown to be sold for commercial profit
- Traffic detour time due to flooded roadways

Regional Economic Development. When the economic activity lost in a flooded region can be transferred to another area or region in the national economy, these losses cannot be included in the NED account. However, the impacts on the employment, income, and output of the regional economy are considered part of the RED account. The input-output macroeconomic model RECONS is used to address the impacts of the construction spending associated with the project alternatives. The Economic Consequences Model (ECAM) is another RED model that will be utilized by this study to measure the effects of unmitigated floodwaters on regional production and employment.

Other Social Effects. The other social effects (OSE) account includes impacts to life safety, vulnerable populations, local economic vitality, and community optimism. Impacts on these topics are a natural outcome of civil works projects and are most qualitatively discussed in the OSE account. Life loss modeling software such as HEC-LifeSim can quantify loss of life for a given alternative to determine if life safety risk decreases or is induced as a result of federal investment. Depth and velocity flood forces are examined to determine critical road segments that pose a risk of life loss in the existing condition. With-project conditions are discussed qualitatively.

1.2 DESCRIPTION OF THE STUDY AREA

Geographic Location. The study area is located on the eastern border of St. Louis County and includes the University City portion of the River des Peres, as well as a small portion of the river upstream in Overland and Olivette. The study area is largely urban with mostly residential structures. An inventory of residential and non-residential structures was developed using the National Structure Inventory (NSI) version 2.0 for the portions of the county impacted by riverine flooding. The structure inventory for the economic analysis includes all structures within the extent of inundation for the 0.2% annual exceedance probability (AEP) event in the future without project condition. Figure 1 shows the structure inventory and the boundaries of the counties and municipalities.

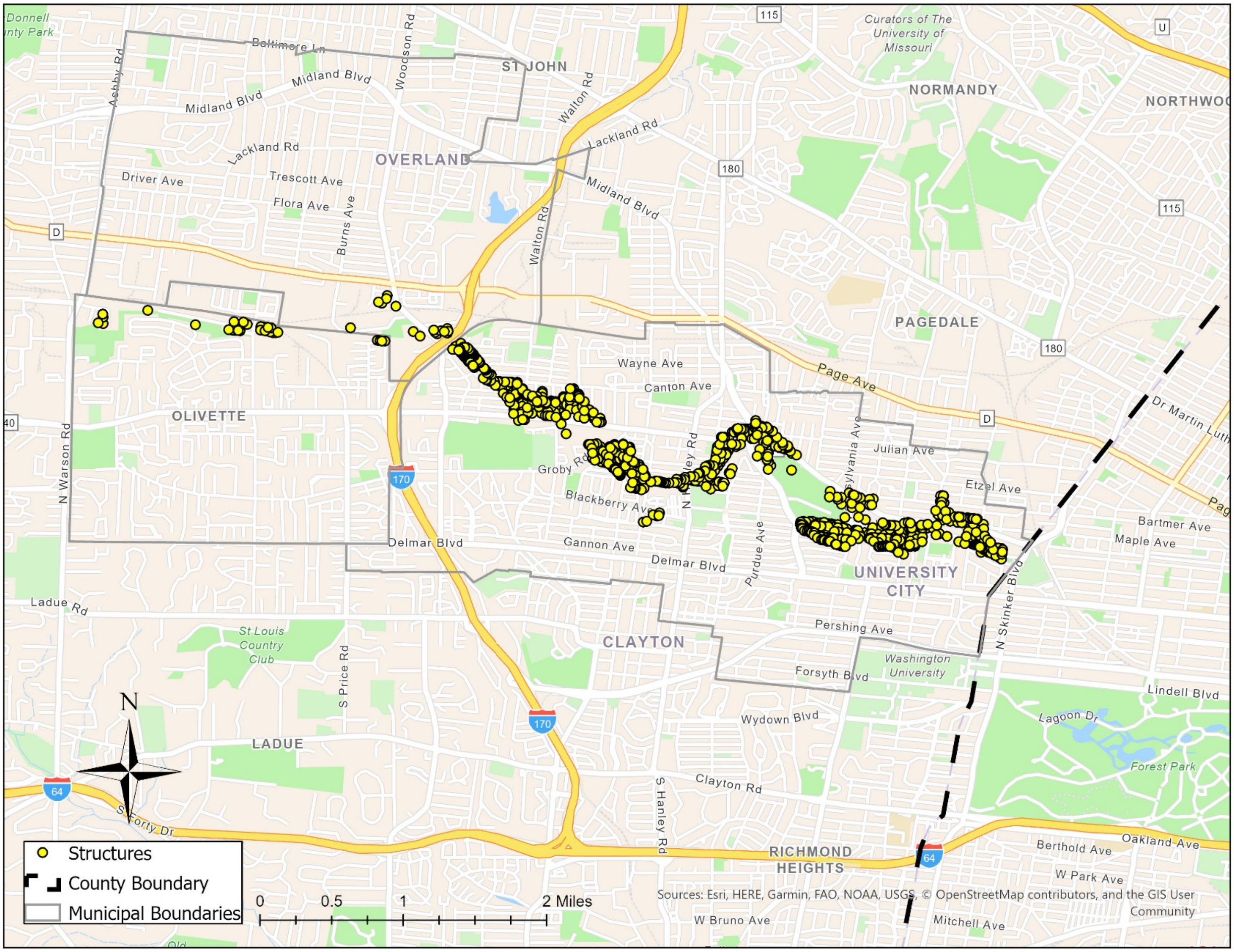

Figure 1. County and Municipal Boundaries, and Structure Inventory

The study area was divided into reaches, which were designed by the economist in coordination with the hydraulics and hydrology (H&H) engineer to contain areas that experienced similar hydraulic conditions and for measuring localized impacts of the focused array of alternatives. The reaches begin with Reach 1, which is the furthest downstream, and increase while moving upstream and ending with reach 11. Table 1 shows the structure count by reach and structure type (residential and non-residential). Non-residential structures include commercial, industrial, and public structures. The study area has a total of 1,156 structures. Figure 1 shows the study area reach boundaries.

Table 1. Structure Count by Structure Type and Reach

Reach	Residential Count	Non-Residential Count	Total
1	223	88	311
2	162	0	162
3	249	22	271
4	22	1	23
5	63	0	63
6	112	3	115
7	5	2	7
8	5	9	14
9	90	7	97
10	48	0	48
11	17	28	45
Total	996	160	1,156

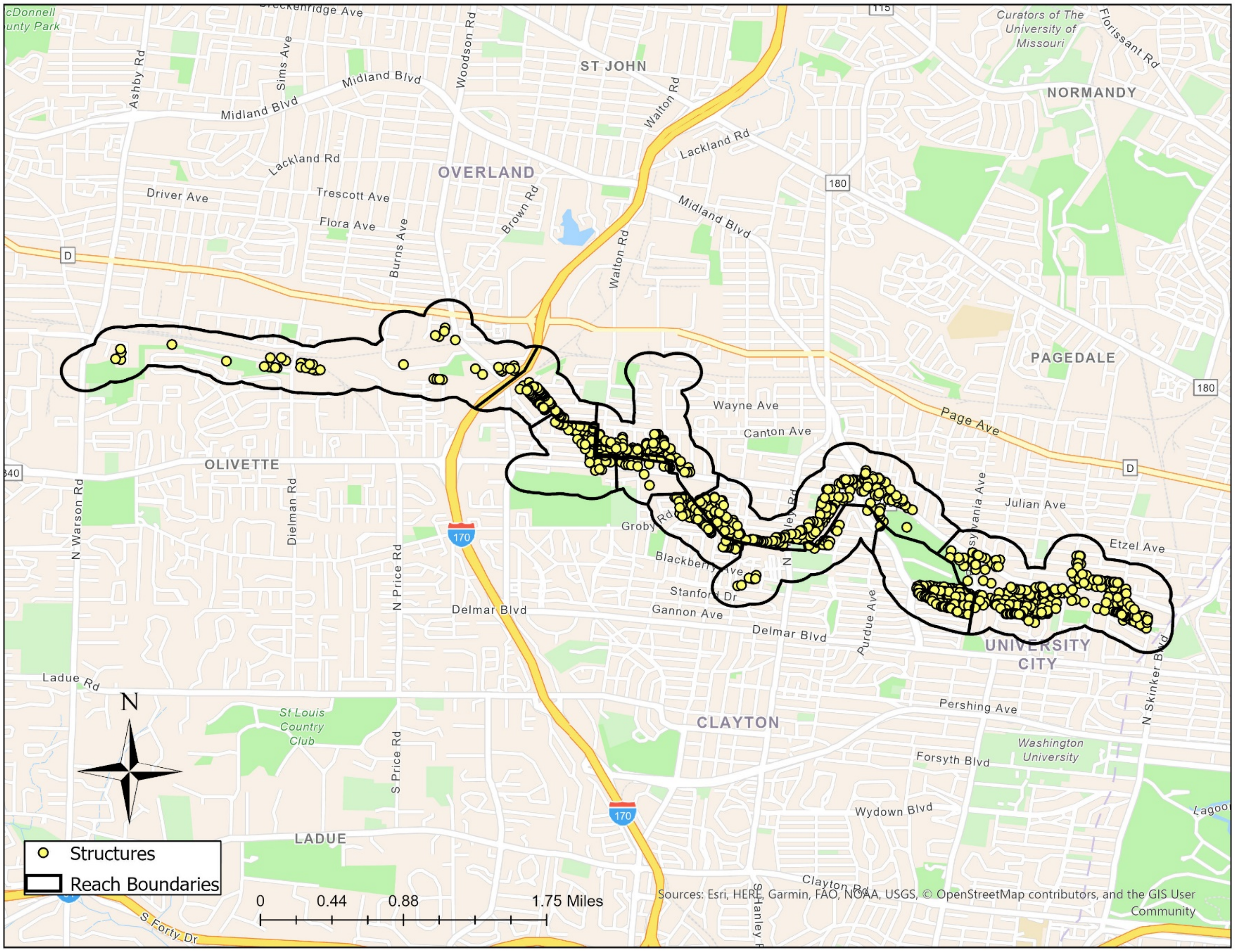

Figure 2. Study Area Reaches

1.3 SOCIOECONOMIC SETTING

Population, Number of Households, and Employment. Table 2 shows the population trend in St. Louis County from 1970 to 2010 and projections through 2040. The population total has been largely stagnant for the past fifty years and is expected to remain so in the future. Table 3 shows the number of households over the same period. The total number of households has shown a steady increasing trend from 1970 to 2010 and projections through 2040.

Table 2. Historical and Projected Population

Total Population (Thousands)							
U.S. Census Bureau (BOC); Moody's Analytics (ECCA) Forecast							
1970	1980	1990	2000	2010	2020	2030	2040
953.131	975.090	995.198	1,016.178	998.803	1,002.861	1,004.924	999.196

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

Table 3. Historical and Projected Households

Households (Thousands)							
U.S. Census Bureau (BOC); Moody's Analytics (ECCA) Forecast							
1970	1980	1990	2000	2010	2020	2030	2040
283.691	344.986	380.785	405.177	405.139	429.378	452.144	466.605

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

Table 4 shows the growth of non-farm payrolls since 1970 and projections through 2040. Nonfarm payroll employment is the number of paid US workers in all businesses, excluding those who work for farms, serve in the military, volunteer for nonprofit organizations, and perform unpaid work in their own household. Self-employed, unincorporated individuals are excluded as well. The leading employment sectors for St. Louis County are Office Using Industries, Trade; Transportation; and Utilities, Professional and Business Services, and Education and Health Services. Table 5 shows the Labor Force, Employment, Unemployment, and Unemployment Rate for St. Louis County. Save for shortly after the 2008 recession, employment has been largely flat. Table 6 shows the actual and projected per capita personal income levels for St. Louis County from 1970 through 2040. Income per capita has steadily increased since 1970 and is expected to continue to do so into 2040.

Table 4. Non-farm Payrolls

Employment: Non-Farm Payroll (Thousands)								
U.S. Bureau of Labor Statistics: Census of Employment & Wages (QCEW - ES202); Moody's Analytics (ECCA) Forecast								
	1970	1980	1990	2000	2010	2020	2030	2040
Natural Resources and Mining	0.42	0.38	0.29	0.37	0.21	0.21	0.21	0.21
Construction	11.87	17.57	23.32	35.93	23.89	30.97	31.74	33.66
Manufacturing	76.10	85.56	103.23	78.38	42.86	43.52	39.66	37.90
Food; Beverage; and Tobacco Manufacturing	4.89	5.49	8.29	7.92	3.68	4.48	4.01	3.53
Textile; Fiber; and Printing Manufacturing	10.48	11.98	14.38	10.20	4.78	4.88	4.50	4.29
Chemical; Energy; Plastic; and Rubber Manufacturing	6.07	7.38	8.35	9.56	6.05	7.01	6.62	6.35
Metals and Mining Based Manufacturing	8.11	8.23	7.09	6.70	3.32	3.73	3.14	2.91
Machinery Manufacturing	8.42	8.80	10.73	11.53	4.64	4.66	3.72	3.31
Electronic and Electrical Manufacturing	8.45	9.94	8.31	5.93	2.49	2.83	2.54	2.29
Transportation Equipment Manufacturing	27.75	31.19	43.25	23.84	15.71	13.75	13.17	13.39
Furniture and Misc. Manufacturing	1.92	2.55	2.83	2.69	2.18	2.18	1.97	1.84
Trade; Transportation; and Utilities	74.35	95.57	132.47	137.83	119.32	128.87	129.98	132.39
Wholesale Trade	15.98	24.21	34.97	34.80	33.57	37.13	37.78	38.30
Retail Trade	50.59	58.94	75.48	76.34	66.70	70.03	70.67	72.65
Transportation; Warehousing; and Utilities	7.78	12.41	22.01	26.69	19.05	21.71	21.53	21.43
Transportation and Warehousing	7.38	11.56	21.00	25.99	17.93	20.68	20.62	20.62
Utilities	0.40	0.85	1.01	0.70	1.12	1.02	0.91	0.81
Information	4.88	7.25	11.66	17.46	16.39	14.95	14.87	14.98
Financial Activities	14.66	18.94	35.88	41.94	41.12	48.50	49.71	52.02
Professional and Business Services	25.69	43.24	82.88	111.38	108.05	132.71	144.63	160.60
Education & Health Services	27.55	44.52	62.52	86.64	101.13	115.62	123.35	130.80
Leisure and Hospitality	19.81	34.04	51.77	60.83	57.94	66.63	72.62	80.44
Other Services (except Public Administration)	9.76	13.13	24.16	27.56	20.02	21.17	21.38	21.71
Government	30.91	34.55	44.09	55.97	58.45	52.48	54.57	55.72
Federal Government	3.00	3.41	4.59	5.95	7.23	6.20	6.28	6.35
Local Government	23.77	26.49	33.49	42.17	44.53	41.87	43.84	44.90
State Government	4.15	4.65	6.01	7.84	6.69	4.41	4.45	4.46
Office-using Industries	50.26	76.00	136.76	178.94	172.09	196.19	204.95	217.34
High Technology Industries	14.97	20.59	28.69	38.99	33.07	37.94	40.43	42.46

Table 5. Employment

Labor Force, Employment, Unemployment, and Unemployment Rate						
BLS; Moody's Analytics (ECCA) Forecast						
	1990	2000	2010	2020	2030	2040
Labor Force, (Ths.)	548.297	554.013	535.129	559.041	573.375	593.772
Employment, (Ths.)	524.237	536.744	487.371	538.789	549.765	569.178
Unemployment, (Ths.)	24.061	17.269	47.758	20.252	23.609	24.595
Unemployment Rate, (%)	4.4	3.1	8.9	3.6	4.1	4.1

Table 6. St. Louis County per Capita Income ($)

Income: Per Capita (Dollars)							
U.S. Census Bureau (BOC); Moody's Analytics (ECCA) Forecast							
1970	1980	1990	2000	2010	2020	2030	2040
$5,233	$12,132	$26,074	$41,247	$53,782	$81,596	$118,113	$175,756

Compliance with Policy Guidance Letter (PGL) 25 and Executive Order 11988. Based on the socioeconomic data, St. Louis County has experienced little population and employment growth. Given stagnation, it is expected that little development will occur in the study area with or without riverine flood risk reduction measures, and will not conflict with PGL 25 and EO 11988, which states 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.

1.4 CRITICAL INFRASTRUCTURE

The University City Fire Station is the only identified critical infrastructure that may have flood risk, though flood depths are expected to remain at or just below the foundation at the 0.2% AEP event. University City Senior High School is near, but not within, the 0.2% AEP extent. Figure 3 shows the Fire Station and High School as well as the extent of the 0.2% AEP event.

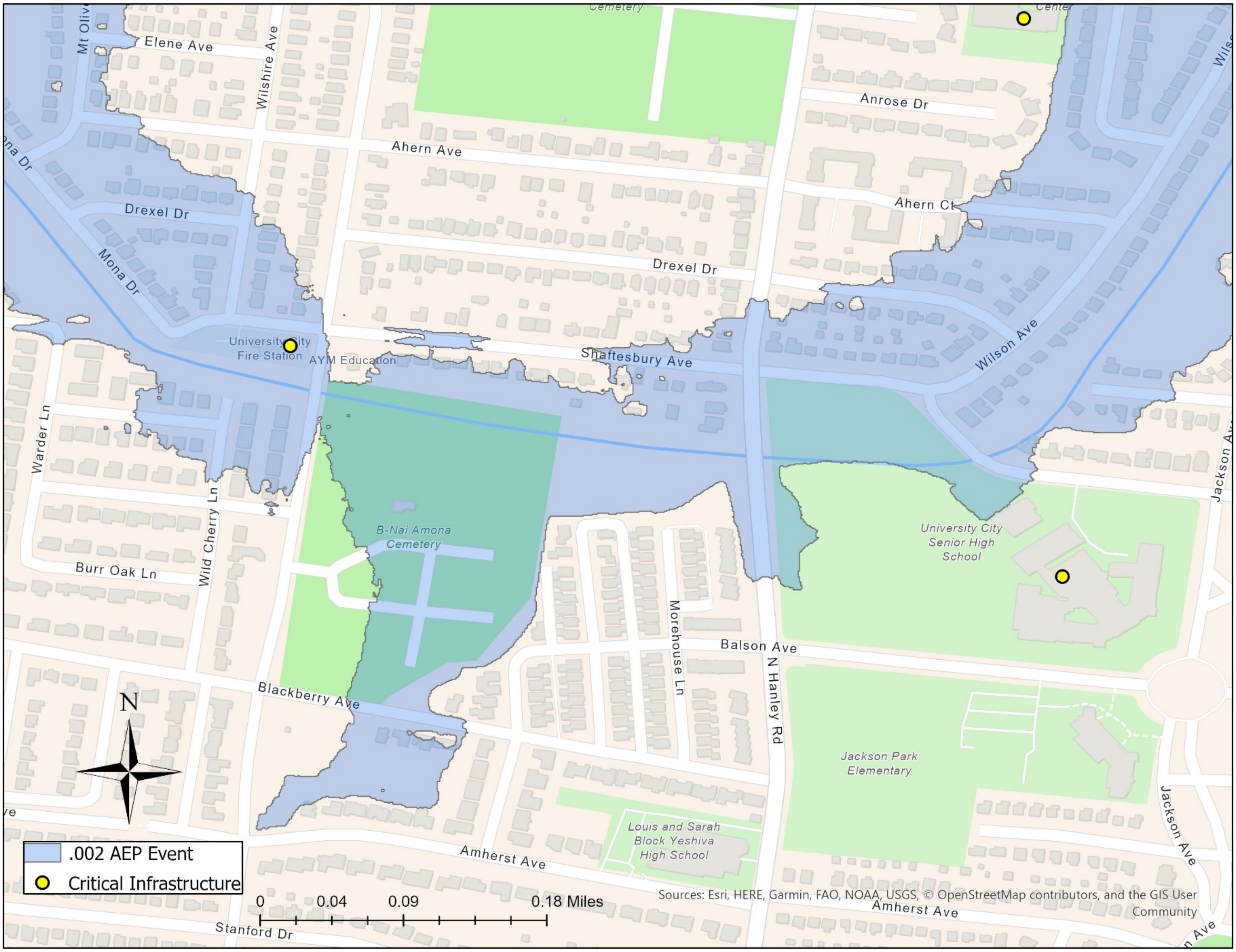

Figure 3. Critical Infrastructure

1.5 SCOPE OF THE STUDY

Problem Description. The study area is mostly an urban setting that is encroaching floodplain boundaries. Flood risk management is the only authorized purpose for the study. Recreation features may be added, if economically justified, within the limits specified by ER 1105-2-100. A total of 9 plans were considered. Table 7 shows the plans and their descriptions.

Table 7. Array of Alternatives

Alternative	**Plan**
No Action	1
Modified 1988 Authorized Plan	2
Detention Basins 3 and 4	3a
Detention Basin 4	3b
Levee/Floodwall	4
4% AEP Acquisitions	5
4% AEP Nonstructural - Floodproofing and Elevations	6
4% AEP Residential Elevations	7
Detention Basin 4 and 4% AEP Residential Elevations	8

Nonstructural TSP. The TSP includes a mix of nonstructural measures. All structures receiving damages at the 4% AEP event are included in the plan. Residential structures with greater than 3 feet of inundation are elevated to the 1% AEP event, not to exceed 13 feet. All other structures receive dry or wet floodproofing. The floodplain aggregation methodology groups structures together based on their flood depth relative to first floor elevation during various riverine events (4%, 2%, and 1% AEP). For example, all structures with damages during the 4% AEP event were grouped together. Evaluating a group of structures together instead of individually helps remove bias related to structure values, building type, social status, or any other contributing factor besides the combination of flood frequency and magnitude. The final array includes the 4% AEP area, which was optimized by comparing net benefits of each of the three floodplains analyzed.

While the floodproofing is limited to 3 feet, the height of elevating structures can be variable up to 13 feet. There are several factors that were utilized to come up with the assumption of elevating to the future year 1% AEP stage. The first factor deals with the long-term performance that any nonstructural alternative selected will be effective for at least 50 years. A significant portion of the cost to elevate residential structures is based on mobilization, and therefore to the extent possible, the elevation recommendations should be high enough to limit the likelihood that a structure would have to be re-elevated prior to the 50 year project life being concluded. The second factor deals with feedback from the public about the ability to afford to live in the study area given high flood insurance premiums. By ensuring that structures are raised to an elevation that exceeds the base flood elevation, the study is assisting locals with the ability to maintain affordable housing and neighborhood cohesion. The study will optimize heights associated with elevating residential to ensure they reasonably maximize net benefits by the final report.

Other Plans in the Final Array. The detention basins will be carried forward along with nonstructural. A combination of detention basin(s) and nonstructural, as well as other nonstructural formulations, will be considered.

2 ECONOMIC AND ENGINEERING INPUTS TO THE HEC-FDA MODEL

2.1 HEC-FDA MODEL

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

The uncertainty surrounding each of the economic and engineering variables was also entered into the model. Either a normal probability distribution, with a mean value and a standard deviation, or a triangular probability distribution, with a most likely, a maximum and a minimum value, was entered into the model to quantify the uncertainty associated with the key economic variables. A normal probability distribution was entered into the model to quantify the uncertainty surrounding the ground elevations. A 50-year period of record was used to quantify the hydrologic uncertainty or error surrounding the stage-probability relationships.

The following economic inputs section is divided into four primary components:

1) **Structure Inventory** – discusses methodology, structural value estimation, content-to-structure value ratios, and flood related damages and costs

2) **Elevation Data & Sampling** – discusses ground surface elevation, foundation heights, first floor elevations, and sampling structural attributes

3) **Structure Inventory Uncertainty** – discusses the uncertainty distributions surrounding structure values, content-to- structure value ratios, and flood related damages and costs, and how the distributions were generated

4) **Depth Damage Relationships** – discusses the depth damage relationships, uncertainty and how the distributions were generated

2.2 ECONOMIC INPUTS TO THE HEC-FDA MODEL

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

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

Occupancy Types. The NSI 2.0 database comes with its own list of occupancy types, which describes the type of structure more than simply residential or non-residential. Occupancy types are important because they are used to assign depth-damage relationships to determine the rate at which a structure is damaged given a depth of water. This study utilized these three different occupancy types:

1. **NSI 2.0** – Occupancy type descriptions come with the original NSI 2.0 data and were the starting point for the study. NSI 2.0 occupancy types were verified during sampling.

2. **RS Means** – To estimate costs per square foot for structures, the NSI 2.0 occupancy types were converted to RS Means occupancy types. In general, there was a unique RS Means occupancy type to match to each NSI 2.0 occupancy type, but certain structures were generalized, such as multi-occupancy apartment buildings. Professional judgment was used when combining occupancy types based on how the structure would be damaged.

3. **Depth-Damage Relationships** – Neither the NSI 2.0 nor RS Means occupancy types matched the occupancy types required to use for the depth-damage relationships that were selected for the local flooding conditions. Professional judgment was used again to sort each structure type into the most representative occupancy type that the depth damage relationships offered.

Table 8 shows the conversion process of moving structures through the three different occupancy types. Further descriptions of each occupancy type can be found in subsequent sections of the report.

Table 8. Structure Types

RS Means OccType	NSI 2.0 OccType	Depth-Damage OccType
Store, Retail	COM1	Retail
Warehouse	COM2	StorageCom/StorageInd
Garage, Service Station	COM3	StorageCom
Office, 1 Story	COM4	OfficeCom
Bank	COM5	OfficeCom
Medical Office, 1 Story	COM7	OfficeCom
Restaurant	COM8	Restaurant
School, Elementary	EDU1	Pub2
Office, 1 Story	GOV1	Pub2
Factory, 1 Story	IND1	StorageInd
Factory, 1 Story	IND2	StorageInd
Factory, 1 Story	IND3	StorageInd
Factory, 1 Story	IND4	StorageInd
Office, 1 Story	IND6	OfficeInd
Church	REL1	Pub1
1 Story Residential No Basement	RES1-1SNB	Oreswoutbsmt
2+ Story Residential No Basement	RES1-2SNB	Treswoutbsmt
1 Story Residential With Basement	RES1-1SWB	Oreswbsmt
2+ Story Residential With Basement	RES1-2SWB	Treswbsmt
Mobile Home	RES2	MobHome
Apartment, 1-3 Story	RES3B	Apt1
Apartment, 1-3 Story	RES3C	Apt1
Apartment, 1-3 Story	RES3D	Apt1
Apartment, 1-3 Story	RES3E	Apt1
Motel, 1 Story	RES4	Apt1

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

Application of RS Means – Residential Structures

The 2021 RS Means Square Foot Costs Data catalog was used to assign a depreciated replacement cost per square foot value to residential structures. The RS Means system of valuation allows the user to customize the following primary items: exterior wall type, build quality, additions, depreciation, and regional factors.

- Exterior Wall Type - Replacement costs per square foot were provided for four exterior walls types (wood frame, brick veneer, stucco, or masonry) and an **average** cost per square foot for the **four exterior wall types** was computed since there was not enough information to determine the exact wall types per structure.

- Build Quality – Build quality of a structure helps determine how high the starting cost per square foot should be for structures. Based on windshield surveys (using Google Street View), it was determined that the characteristics of the structures in the area were consistent with those of the **average build quality** (economy and luxury/custom homes existed, but were in the minority).

- Depreciation – Depreciation of a structure is based on the observed condition (effective age) of the structure and can be described as the structure's wear and tear since it was constructed or last rehabilitated. Based on windshield surveys (using Google Street View), it was determined that the average condition of residential structures in the area was **30 years old**, and therefore structure values were **depreciated on average 30 percent** based on RS Means depreciation schedule. See the "Structure Value Uncertainty" on how uncertainty in observed condition impacts the uncertainty surrounding structure values.

- Region - A regional adjustment factor was applied to the cost per square foot to account for construction costs (**1.0 for residential**) consistent with the **St. Louis, Missouri area**.

- Additions – RS Means allows for users to enter additional structural features that may be present beyond the default features. No additional features were added to residential structures.

Application of RS Means – Non-residential Structures

The 2020 RS Means Square Foot Costs Data catalog was used to assign a depreciated replacement cost per square foot value to non-residential structures. The RS Means system of valuation allows the user to customize the following primary items: exterior wall type, build quality, additions, depreciation, and regional factors.

- Exterior Wall Type - Replacement costs per square foot were provided for six exterior wall types (decorative concrete with steel frame and with bearing walls frame, face brick with concrete block back-up with steel frame and with bearing walls frame, metal sandwich panel with steel frame, and precast concrete panel with bearing walls frame), and an **average** cost per square foot for the **six exterior wall types** was computed since there was not enough information to determine the exact wall types per structure.

- Build Quality – Build quality of a structure helps determine how high the starting cost per square foot should be for structures. Based on windshield surveys (using Google Street View), it was determined that the characteristics of the structures in the area were consistent with those of the **average build quality**, which is the only option for non-residential structures.

- Depreciation – Depreciation of a structure is based on the observed condition (effective age) of the structure and can be described as the structures wear and tear since it was constructed or last rehabilitated. Based on windshield surveys (using Google Street View), it was determined that the average condition of non-residential structures in the area was **30 years old**, and therefore structure values were **depreciated on average 35 percent** based on RS Means depreciation schedule. See the "Structure Value Uncertainty" on how uncertainty in observed condition impacts the uncertainty surrounding structure values.

- Region - A regional adjustment factor was applied to the cost per square foot to account for construction costs (**1.01 for non-residential**) consistent with the **St. Louis, Missouri area**.

- Additions – RS Means allows for users to enter additional structural features that may be present beyond the default features. No additional features were added to non-residential structures.

The formula to determine depreciated replacement value for structures is simplified as follows:

$$Avg.\, Cost\ per\ sq\ ft * Avg.\ depreciation\ factor * \ Regional\ adjustment\ factor$$

The mean final cost per square foot by occupancy type was then applied to every structure in the inventory to determine depreciated replacement values. The square footage for each of the individual residential structures was multiplied by the size-specific depreciated cost per square for the average construction class to obtain a total depreciated cost.

Square Foot Estimation. Square foot estimates were sampled using structures within the 0.2% AEP aggregation. Microsoft Building Footprints were utilized to improve the data source of the square foot estimate.

Microsoft Building Footprints is a GIS outline of each structure generated from an algorithm that recognizes building pixels on aerial imagery and converts the building pixels into polygons. Final square footage estimates per building footprint were spatially joined to the underlying structure points in GIS. Each occupancy type received an average square footage estimate based on the individual structures included within that occupancy type. The square footages sampled for each occupancy type have not been compared to other square footage estimates within the region or country, but will be by the final report.

Table 9 shows the distribution of square foot estimates for each of the RS Means and NSI 2.0 occupancy types. The table shows the results of the RS Means valuation analysis, which is the triangular distribution of cost per square foot by occupancy type. More information on RS Means triangular distribution is provided in subsequent sections.

Table 9. RS Means Structure Inventory Statistics

		RS Means Cost per Sq Ft			
NSI 2.0 OccType	**RS Means OccType**	**Avg Sq Ft**	**Minimum**	**Most Likely**	**Maximum**
RES3C	Apartment, 1-3 Story	2,373	86	140	183
COM5	Bank	6,357	106	172	225
REL1	Church	3,280	135	220	287
EDU2	College, Classroom, 2-3 Story	32,884	82	133	173
IND3	College, Laboratory	2,071	109	177	231
IND1	Factory, 1 Story	5,137	66	107	140
COM3	Garage, Repair	7,352	66	107	140
COM6	Hospital, 2-3 Story	2,140	159	259	339
COM4	Office	10,673	107	174	228
RES1-1SWB	Res 1 Story FB ONLY Avg	1,391	92	143	184
RES1-1SNB	Res 1 Story NB ONLY Avg	1,353	74	115	147
RES1-2SWB	Res 2 Story FB ONLY Avg	1,426	83	130	167
RES1-2SNB	Res 2 Story NB ONLY Avg	1,850	62	96	123
RES1-SLWB	Res Bi Story FB ONLY Avg	1,418	79	122	157
RES1-SLNB	Res Bi Story NB ONLY Avg	1,147	79	123	158
COM8	Restaurant	13,154	94	153	200
EDU1	School, High, 2-3 Story	32,884	94	153	200
COM1	Store, Retail	6,119	66	107	139
GOV1	Town Hall, 1 Story	18,665	61	99	130
COM2	Warehouse	6,835	66	107	140

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

- Minimum Depreciation – Effective Age: 15 Years & Good Condition
- Most Likely Depreciation – Effective Age: 30 Years & Average Condition
- Maximum Depreciation – Effective Age: 50 Years & Poor Condition

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

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

- Minimum Depreciation – Effective Age: 15 Years & Masonry on Masonry/Steel
- Most Likely Depreciation – Effective Age: 30 Years & Masonry on Wood
- Maximum Depreciation – Effective Age: 40 Years & Frame

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

Residential and Non-Residential Content-to-Structure Value Ratios. Based on Economic Guidance Memorandum (EGM), 04-01 and EGM 01-03, a content-to-structure value ratio (CSVR) of 100 percent was applied to all of the residential structures in the structure inventory and the error associated with CSVR was set to zero. The EGMs state that the 100 percent CSVR is to be used with the generic depth-damage relationships developed for residential structures, which were also used for this study.

The content-to-structure value ratios (CSVRs) and uncertainty applied to the non-residential structure occupancies were taken from the 2011 Fargo-Moorhead Feasibility Study, which conducted 33 field interviews with commercial, industrial, and public properties. The interviews were used to develop unique CSVR's for non-residential structures.

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.

Other Flood Related Damage Costs.
This study utilized the 2011 Fargo-Moorhead Feasibility Study post-flood survey data for the other damages category, which applied regression-based statistical analysis to determine the expected damage a landowner would experience based on a depth of flooding. This custom depth-damage function relied on the "other value" within the HEC-FDA model being set at $100,000, and the depth damage function assigned damages ranging from $900 to $17,300 based on the depth of flooding, and is assumed to be normally distributed with a standard deviation of 10%. These damages include damages to vehicles, travel costs, meals, cleanup, medical, and other damages.

Elevation Data & Sampling. Elevation data associated with the ground surface, foundation heights, and first floors of structures are critical to the economic analysis and feasibility of studies. Given the low-resolution of foundation height data provided with the NSI 2.0 database, a statistically significant sample was calculated to inform a windshield survey to improve the estimates associated with foundation and subsequent first floor elevations. The sample was also utilized to measure a handful of other structural attributes, detailed later in this section.

Two Google Street View windshield surveys were conducted:

1. The first was a preliminarily survey completed prior to calculating the formula in Figure 4 to determine the standard deviation of the average residential and commercial structures foundation height (S).

2. Once the standard deviation was estimated, it was entered into the formula in Figure 4 to determine how many structures to sample based on the designated stratification. The second windshield survey was the final survey performed.

The first (preliminary) survey in Google Street view included the maximum and minimum foundation height expected by occupancy type in this study area. 60 residential and 15 non-residential structures were included in the initial sample. The information gathered from the preliminary survey, such as the range (max – min) of foundation heights informed how many additional structures would need to be sampled to meet the statistically significant threshold based on the Z-Value and allowable error used in the formula (See Figure 4).

The second survey included an additional 35 residential and 20 non-residential structures to the sample count based on the results of the first sample. The structures selected were distributed evenly throughout the study area. See Figure 5 for the statistically significant sample size formula utilized for this study. A third sample will be completed post-TSP to better refine structural attributes prior to the final report.

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

n = Sample size

Z = Z-Value (1.96)

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

E = Allowable error (0.20 feet)

Figure 4. Statistically Significant Sample Size Formula

The standard deviation of the final survey was compared to the preliminary survey and verified that the amount of structures sampled exceeded the minimum calculated in the formula. The variables sampled included:

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

Ground Surface Elevations*.* Topographical data was provided by the St. Louis District H&H Engineer. The LiDAR data was used to assign ground elevations to structures.

First Floor Elevations*.* The ground elevation was added to the height of the foundation of the structure above the ground to obtain the first floor elevation of each structure in the study area.

First Floor Elevation Uncertainty. The uncertainty surrounding the foundation heights was determined by referencing the HEC-FDA user manual. A Google Street View survey was assumed to be less accurate than use of stadia, but more accurate than an aerial survey with a 5 ft contour interval. This resulted in the uncertainty around foundation height being determined as distributed normally with a .5 ft standard deviation. This estimate will be further refined post-TSP when a new field survey will be conducted.

Depth-Damage Relationships. Each occupancy type has its own depth-percent of value damaged curves for structure and contents. The USACE generic depth-damage relationships for one-story and two-story residential structures with and without basement from EGM 04-01, and EGM 01-03 were used in the analysis.

Site-specific non-residential depth-damage relationships were not available for this study area. The depth-damage functions for non-residential structures were based on the data presented from the draft report Solicitation of Expert Opinion Depth-Damage Function Calculations for the Benefit-Cost Analysis Tool (URS Group, 2008). Twenty-one core non-residential structures were evaluated by a panel of experts recruited from across the United States. The resulting data from the panel included nationally relevant depth-damage relationships for use in estimating the value of damages expected to occur from a flood event. Each DDF is applicable to businesses across the Nation. These FEMA/USACE expert engineered depth-damage relationships were used for non-residential structures in the study area.

Uncertainty Surrounding Depth-Damage Relationships. For residential structures, a normal distribution with a standard deviation for each damage percentage provided at the various increments of flooding was used to determine the uncertainty surrounding the generic depth-damage relationships used for residential structures and vehicles. This information for residential structures was also sourced from EGM 04-01 and EGM 01-03.

For non-residential structures, the Solicitation of Expert Opinion Depth-Damage Function Calculations for the Benefit-Cost Analysis Tool (URS Group, 2008) reference was utilized to source a normal distribution for non-residential structures.

2.3 ENGINEERING INPUTS TO THE HEC-FDA MODEL

Stage-Probability Relationships. Stage-probability relationships were provided for the existing without-project condition (2025) and future without-project condition (2075). Future condition hydraulics are equal to existing condition hydraulics, as no change is expected.

The H&H engineer provided water surface profiles from HEC-RAS for eight AEP events including the 50% (2-year), 20% (5-year), 10% (10-year), 4% (25-year), 2% (50-year), 1% (100-year), 0.5% (200-year), and 0.2% (500-year). The without-project water surface profiles were based on riverine flood events. Hydraulic data was provided in geo-referenced 2D format.

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

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 for each of the 11 study area reaches. A range of possible values, defined by the probability distributions for each economic variable (first floor elevation, structure and content values, and depth-damage relationships), were entered into the HEC-FDA model to calculate the uncertainty surrounding the elevation-damage, or stage-damage, relationships for structures and contents. The model also used the number of years that stages were recorded to determine the hydrologic uncertainty surrounding the stage-probability relationships.

The possible occurrences of each variable are determined through a Monte Carlo process, which samples random values from each defined probability distribution. 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 represent an estimate of the full set of possible outcomes.

3.2 STAGE-DAMAGE RELATIONSHIPS WITH UNCERTAINTY

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

3.3 STAGE-PROBABILITY RELATIONSHIPS WITH UNCERTAINTY

The HEC-FDA model used an equivalent record length of 50 years for this study area to generate a stage-probability relationship with uncertainty for the without-project condition under base year (2025) conditions by graphical analysis. 50 years was selected by the hydraulic engineer to represent the length of records analyzed during the calibration process that the hydraulic model underwent. The model used the eight stage-probability events together with the equivalent record length to define the full range of the stage-probability functions by interpolating between the data points. Confidence bands surrounding the stages for each of the probability events were also provided.

3.4 WITHOUT-PROJECT EXPECTED ANNUAL DAMAGES

The model used Monte Carlo simulation to sample from the stage-probability curve with uncertainty. For each of the iterations within the simulation, stages were simultaneously selected for the entire range of probability events. The sum of all damage values divided by the number of iterations run by the model yielded the expected value, or mean damage value, with confidence bands for each probability event. The probability-damage relationships are integrated by weighting the damages corresponding to each magnitude of flooding (stage) by the percentage chance of exceedance (probability). From these weighted damages, the model determined the expected annual damages (EAD) with confidence bands (uncertainty). For the without-project alternative, the expected annual damages (EAD) were totaled for the study area to obtain the total without-project EAD under base year (2025) conditions. Table 10 displays the damages by reach and type of structures that are damaged for the year 2025 under without-project conditions.

Table 10. Existing Condition Total Economic Damage by Reach and Structure Type for 2025 ($1,000s)

Reach	Non-Residential	Residential	Total
1	$774	$735	$1,509
2	$0	$870	$870
3	$332	$515	$847
4	$4	$41	$45
5	$0	$79	$79
6	$0	$637	$637
7	$21	$424	$444
8	$330	$18	$348
9	$11	$199	$210
10	$0	$49	$49
11	$846	$1	$847
Total	$2,318	$3,569	$5,886

3.5 STRUCTURE INVENTORY ADJUSTMENTS FOR HIGH FREQUENCY INUNDATION

Adjustments were made to the structure inventory to more accurately reflect the most-likely future without-project and with-project conditions. Under without-project and with-project conditions, residential and non-residential structures that were identified as being inundated above the first floor elevation from the 50% (2-year) and 20% (5-year) AEP events were modified to have the 2-year and 5-year stages below the ground surface elevation by at least nine feet to ensure high frequency damages were mitigated in the existing and future without-project conditions. This adjustment is consistent with the FEMA floodplain regulations that require residents to rebuild above the base flood elevation after a structure receives greater than 50 percent damage to the structural components as a result of a flood.

3.6 WITH-PROJECTD EXPECTED ANNUAL DAMAGES

Each of the focused array's plans were run through HEC-FDA, which allows for determining damages reduced by damage category. Table 11 show the damages reduced and residual damages for each plan. The .04 AEP Acquisitions and Nonstructural alternatives are most effective at reducing damages, while Detention Basin 4 and the .04 AEP Residential Elevations show the greatest remaining residual risk.

Figures 5, 6, and 7 show the existing condition damages for the 4%, 2%, and 1% AEP flood frequencies respectively.

Table 11. Focused Array With-Project Expected Annual Damages (Residual Risk) by Damage Category ($1,000's)

Plan Description	Residential	Non-Residential	With-Project Damages	Damages Reduced
No Action	$3,569	$2,318	$5,886	$0
Modified 1988 Authorized Plan	$1,571	$1,253	$2,824	$3,063
Detention Basins 3 and 4	$1,753	$1,223	$2,977	$2,910
Detention Basin 4	$2,664	$1,416	$4,080	$1,807
Levee/Floodwall	$1,727	$1,221	$2,948	$2,939
4% AEP Acquisitions	$379	$216	$596	$5,291
4% AEP Nonstructural - Floodproofing and Elevations	$826	$897	$1,723	$4,163
4% AEP Residential Elevations	$2,815	$2,318	$5,133	$754
Detention Basin 4 and 4% AEP Residential Elevations	$2,214	$1,416	$3,630	$2,257

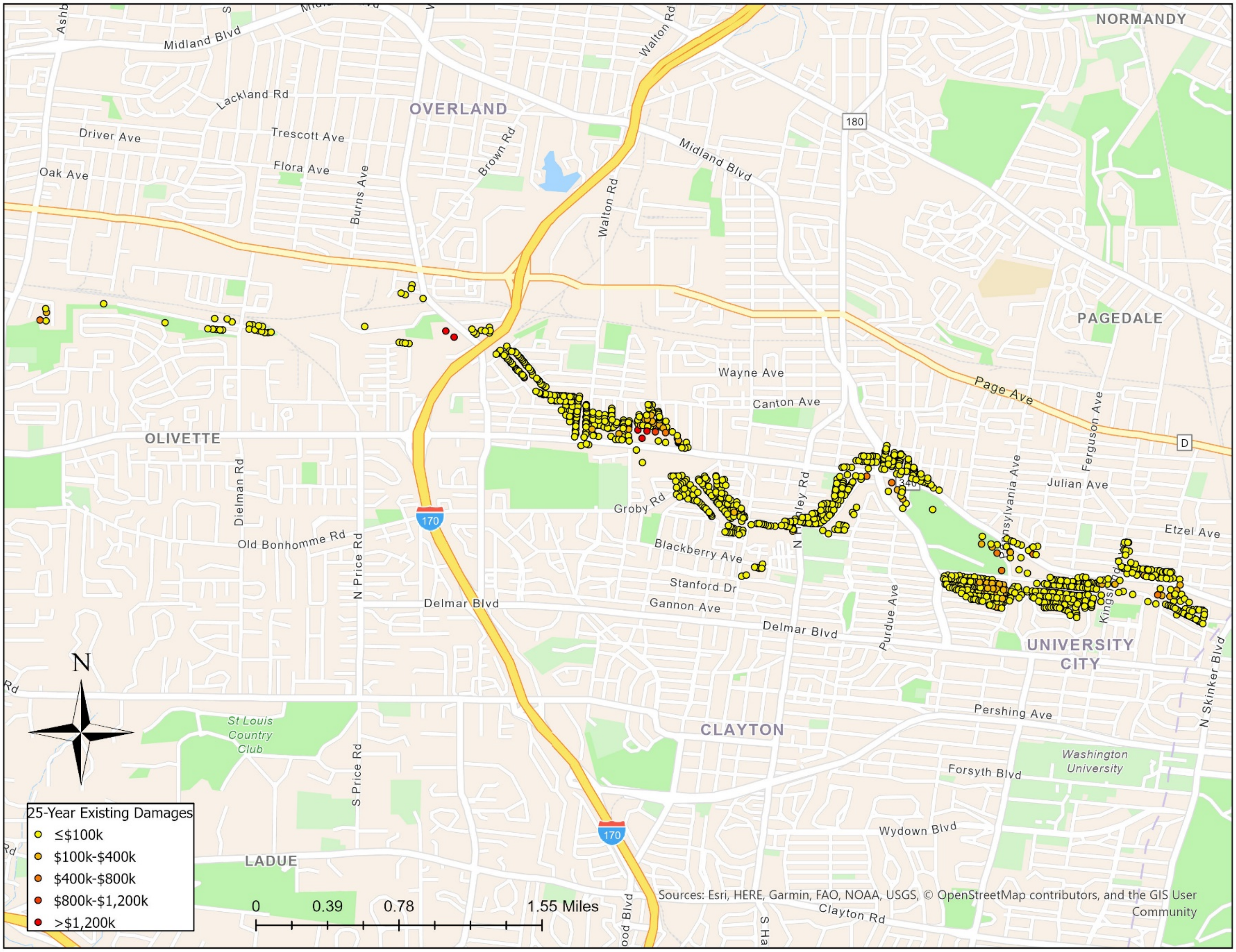

Figure 5. Existing Condition 4% AEP Damages

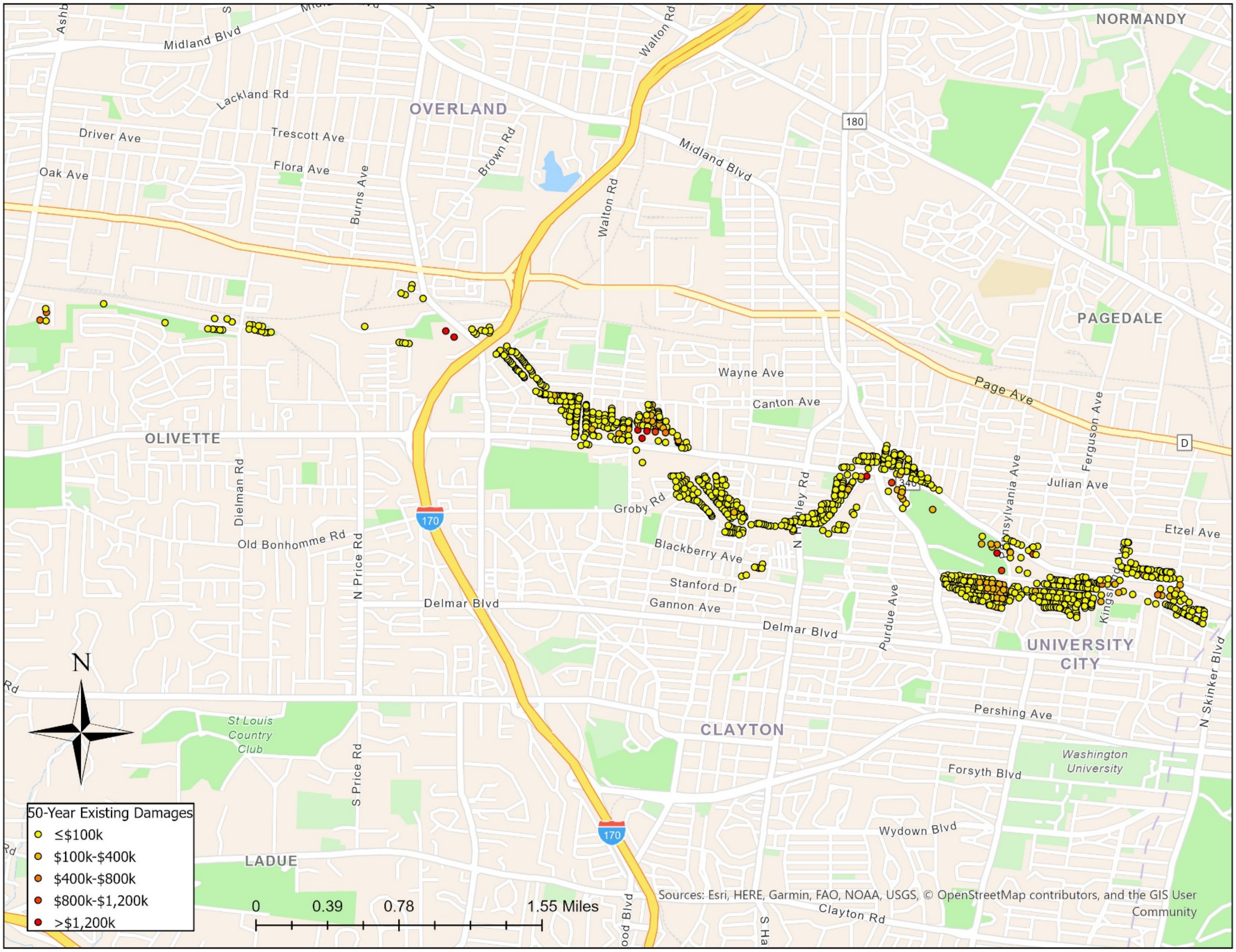

Figure 6. Existing Condition 2% AEP Damages

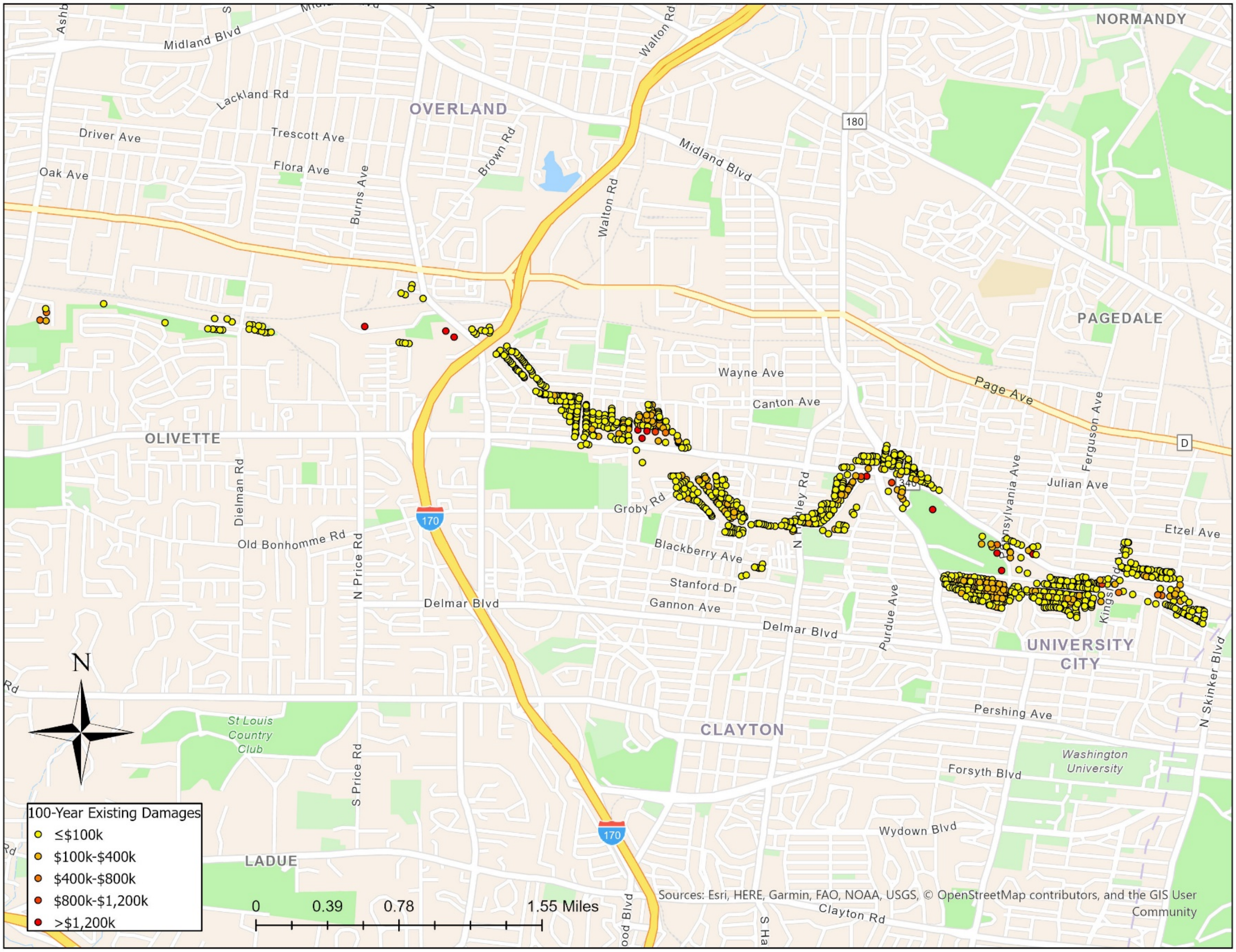

Figure 7. Existing Condition 1% AEP Damages

4 PROJECT COSTS

Construction Schedule. For the purposes of computing interest during construction (IDC), construction of the nonstructural components of the plans is expected to begin in the year 2025 and will continue for a period of twelve months. Construction of Detention Basin 4 is expected to last one years. Construction of the Detention Basins 3 and 4 alternative is expected to last 18 months. The levee/floodwall construction is estimated to last two years. Construction of the Modified 1988 Authorized Plan is expected to last 18 months.

Interest during constructed was calculated for each of the alternatives. Interest during construction was calculated using a mid-year payment schedule and 2.5% discount rate.

Structural Costs. Structural cost estimates for the final array were developed by the St. Louis District Cost Engineering Branch. An abbreviated cost risk analysis was completed to determine the contingencies used for all structural and nonstructural measures.

Nonstructural Costs – Elevation & Floodproofing. Nonstructural cost estimates were developed from cost estimates utilized in the 2021 North DeSoto Feasibility Study and the 2019 Lower Meramec Floodplain Management Plan. A 60% contingency was applied to all nonstructural cost estimates to represent the uncertainty regarding the cost and schedule risk of these measures. Revised nonstructural cost estimates in coordination with cost engineering will be obtained post-TSP.

Interest during constructed was calculated for each of the nonstructural alternatives and assumed the construction period lasted twelve months. Interest during construction was calculated on a mid-period basis payment schedule and 2.5% discount rate.

For acquisitions, costs were assumed to be equal to the structure value used to estimate damages. This represents an underestimate, as real estate costs are excluded from that value, and the BCR resulted in a .66.

Elevations. The estimate of the cost to elevate 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 1% AEP stage) for each structure in the HEC-FDA module. The number of feet that each structure was raised was rounded to the next highest one-foot increment. 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 the 2021 North DeSoto Feasibility Study. Table 12 displays the costs for one and two-or-more story structures, and by the number of feet elevated.

Table 12. Nonstructural Elevation Costs for Residential Structures ($/Sq ft.)

Height	One-Story	Two+-Story
[ft.]	[$/sq ft]	[$/sq ft]
N/A	$0	$0
1	$118	$130
2	$118	$130
3	$121	$133
4	$125	$143
5	$125	$143
6	$128	$144
7	$128	$144
8	$132	$149
9	$132	$149
10	$132	$149
11	$132	$149
12	$132	$149
13	$136	$157
14	$136	$157
15	$136	$157
16	$136	$157

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. The cost to fill the subfloor (crawlspaces or basements) and relocate utilities (basements) if necessary was then applied, which were obtained from the 2019 Lower Meramec Floodplain Management Plan. Filling the subfloor is estimated to cost $30 per cubic yard and relocation of utilities is estimated to cost $14 per square foot.

Floodproofing. The floodproofing measures were applied to all non-residential structures with damages, and residential structures with damages but less than 3 feet of inundation. Non-residential floodproofing is estimated to cost $153,000 and this estimate was obtained from the 2021 North DeSoto Feasibility study.

Residential floodproofing includes installation of a sewer check valve, which is estimated to cost $1,600. This also includes filling the subfloor and relocating utilities as described in the previous section, as well as the installation of a waterproof veneer and watertight doors at $25 per square foot. These estimates were derived from the 2019 Lower Meramec Floodplain Management Plan. Floodproofing cost estimates for residential and non-residential structures will be revised prior to ADM in coordination with the St. Louis District Office Cost Engineering section.

Annual Project Costs. Life cycle cost estimates were provided for the nonstructural measures in FY21 price levels. The initial construction costs (first costs) and the schedule of expenditures were used to determine the interest during construction and gross investment cost at the end of the installation period (2025). The FY 2021 Federal interest rate of 2.5 percent was used to discount the costs to the base year and then amortize the costs over the 50-year period of analysis.

Operations, maintenance, relocations, rehabilitation, and repair (OMRR&R) costs associated with each of the structural measures was estimated by the cost engineering branch. There is no OMRR&R assumed to be associated with the nonstructural measures. Residential structures are recommended to be elevated to the future year (2075) 1% AEP stage, and therefore it is assumed that future increases in water surface elevation will not require future elevations.

Table 13 summarizes costs for each of the alternatives in the final array:

1 - No Action
2 - Authorized Plan with Modifications (DB3 & DB4)
3a - Detention Basins (DB3 and DB4)
3b - Detention Basin 4 (DB4)
4 - Levee/Floodwall (with DB3 & DB4)
5 - Nonstructural – Acquisition
6 - Nonstructural – FP & elevation
7 - Nonstructural (elevation only)
8 - DB4 + Nonstructural (elevation only) (25yr)

Table 13. Summary of Costs

	Alternative							
	2	**3a**	**3b**	**4**	**5**	**6**	**7**	**8**
Total Project Costs								
First Cost	$58,547,000	$43,330,000	$8,746,000	$84,589,000	$222,591,000	$68,837,000	$26,498,000	$25,650,000
Interest During Construction	$2,222,000	$1,644,000	$213,000	$4,316,000	$5,582,000	$1,726,000	$664,520	$643,000
Total Investment Cost	$60,769,000	$44,974,000	$8,689,000	$88,905,000	$228,173,000	$70,563,000	$27,163,000	$26,293,000
Estimated Annual Costs								
Annualized Project Costs	$2,143,000	$1,586,000	$306,000	$3,135,000	$8,045,000	$2,488,000	$958,000	$927,000
Annual OMRR&R	$900,000	$600,000	$300,000	$900,000	-	-	-	$300,000
Total Annual Costs	$3,043,000	$2,186,000	$606,000	$4,035,000	$8,045,000	$2,488,000	$958,000	$1,227,000

5 RESULTS OF THE ECONOMIC ANALYSIS

5.1 NET BENEFIT ANALYSIS

Calculation of Net Benefits. The expected annual benefits attributable to the final array of measures were compared to the annual costs to develop a benefit-to-cost ratio for the measures. The net benefits for the measures were calculated by subtracting the annual costs from the expected annual benefits. The net benefits were used to determine the economic justification of the project measures. Net benefit calculations for the with-project condition were computed using the HEC-FDA that contained the stage frequency-damage relationships for the study. Table 14 shows the net benefits and benefit-cost ratio for the final array.

Table 14. Final Array Economic Net Benefits and BCR

Alternative	Average Annual Costs	Average Annual Benefits	Net Annual Benefits	Benefit to Cost Ratio
2 -Modified 1988 Authorized Plan	$3,043,000	$3,063,000	$20,000	1.01
3a - Detention Basins 3 and 4	$2,186,000	$2,910,000	$724,000	1.33
3b - Detention Basin 4	$606,000	$1,807,000	$1,201,000	2.98
4 - Levee/Floodwall	$4,035,000	$2,939,000	($1,096,000)	0.73
5 - 4% AEP Acquisitions	$8,045,000	$5,291,000	($2,754,000)	0.66
6 – 4% AEP Nonstructural – Floodproofing and Elevations	$2,488,000	$4,163,000	$1,675,000	1.67
7 – 4% AEP Residential Elevations	$958,000	$753,670	($204,330)	0.79
8 - Detention Basin 4 and 4% AEP Residential Elevations	$1,227,000	$2,256,510	$1,029,510	1.84

The plan that reasonably maximizes net benefits and is therefore the NED plan is Alternative 6, the 4% AEP Nonstructural – Floodproofing and Elevations alternative. Table 15 shows the cost and benefit summary of the NED plan. Table 16 breaks down the nonstructural features of the NED plan by floodproofing and elevation components.

Table 15. Summary of Costs and Benefits for the Tentatively Selected Plan (TSP)

25-Year Nonstructural – Floodproofing and Elevation	
Total Project Costs	
First Cost	$68,837,000
Interest During Construction	$1,726,000
Total Investment Cost	$70,563,000
Estimated Annual Costs	
Annualized Project Costs	$2,488,000
Annual OMRR&R	$-
Total Annual Costs	$2,488,000
Average Annual Benefits	
Total Annual Benefits	$4,163,000
Net Annual Benefits	$1,675,000
Benefit to Cost Ratio	1.67
Residual Risk	$1,723,000

Table 16. Summary of the Nonstructural Features of the Tentatively Selected Plan (TSP)

Nonstructural Measure	**TSP**
Floodproofing (Commercial)	64
Floodproofing (Residential)	449
Elevation (Residential)	7
Total	520

5.2 RISK ANALYSIS

The risk analysis is a section of the report that discusses the risk and uncertainty associated with the HEC-FDA model and the economic benefits. The HEC-FDA model was utilized for the existing condition and with project alternatives. The risk analysis uses expected annual damages instead of equivalent annual damages since future conditions are the same as existing conditions.

5.3 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 project alternatives. Table 17 shows the mean expected annual benefits and the benefits at the 75, 50, and 25 percentiles for the NED and LPP plans. These percentiles reflect the percentage chance that the benefits will be greater than or equal to the indicated values. The table indicates the percent chance that the expected annual benefits will exceed the expected annual costs therefore the benefit cost ratio is greater than one and the net benefits are positive.

Table 17 can be interpreted as there is a 75% chance that the expected annual damages reduced (annual benefits) of the NED plan will exceed $34,190, and therefore a 75% chance that the BCR will exceed 1.01.

Table 17. Probability Benefits Exceed Costs

NED Plan	0.75	0.5 (Median)	Mean	0.25
Total Average Annual Cost	$2,488,000	$2,488,000	$2,488,000	$2,488,000
Total Average Annual Benefits	$2,522,190	$3,758,460	$4,163,330	$5,444,310
Net Benefits	$34,190	$1,270,460	$1,675,330	$2,956,310
BCR	1.01	1.51	1.67	2.19

There are various assumptions that inform the HEC-FDA model that are subject to continued uncertainty and have a chance to impact the estimated net benefits. The primary changing variable are the hydraulic inputs. The H&H engineering branch has provided revised hydraulics that were not available in time to incorporate into this draft report. This will be incorporated prior to the Agency Decision Milestone (ADM).

The cost estimates for each plan have not been certified by the cost center of expertise and therefore the cost data utilized in this study is also subject to change. A field survey of the structure inventory will be conducted prior to ADM, which will likely result in some structure attributes being revised. Finally, the nonstructural aggregation will be re-formulated to include considerations other than just depth of flooding relative to first floor.

5.4 RESIDUAL RISK

The flood risk that remains in the floodplain after the proposed alternatives are implemented is known as the residual flood risk. For this study, the residual risk is best illustrated in Table 11 in section 3.6 of this appendix. While the NED plan reasonably maximized net benefits, it does not provide the most damages reduced (minimizing residual damages). The plan that reduces the most amount of damages is the 4% AEP Acquisitions, which is prohibitively costly despite underestimated costs as described in section 4.0 of this appendix.

5.5 LIFE SAFETY

To estimate the risk of life loss on roads, depth times velocity (DxV) grids were georeferenced to roadways. Referencing the HEC-LifeSim user manual, a depth times velocity relationship was obtained to show when vehicles will begin to lose traction and potentially be swept off the road (Table 18). Figures 8 and 9 show dots with graduated colors that indicate road segments with varying potential for life loss for the 1% AEP (100-year) event in the existing condition. Those include portions of Groby Rd, Glenside Pl, Mona Dr, Shaftesbury Ave, Wilson Ave, N Hanley Rd, Midland-Olive intersection, Vernon Ave, Pennsylvania Ave, and Cabanne Ave. Figure 10 shows the depth times velocity relationship with uncertainty bands.

Each of the structural alternatives are expected to reduce the risk of life loss on roads by reducing the probability of flooding. The TSP nonstructural plan does not reduce the probability of flooding, so the risk of direct life loss on roads or the risk of indirect life loss due to emergency services being unable to reach residents is unmitigated. Further analysis of life safety will be conducted prior to ADM.

Table 18. Hydraulic Threshold for Vehicle Stability

	Low Clearance Vehicles			**High Clearance Vehicles**		
Hydraulic Threshold	Low	Best Estimate	High	Low	Best Estimate	High
Depth (ft)	0.98	3.94	4.92	1.64	4.92	6.56
Velocity (ft/s)	9.84	14.76	19.69	9.84	19.69	19.69
DxV (ft^2/s)	0.98	2.62	4.27	1.97	3.94	7.87

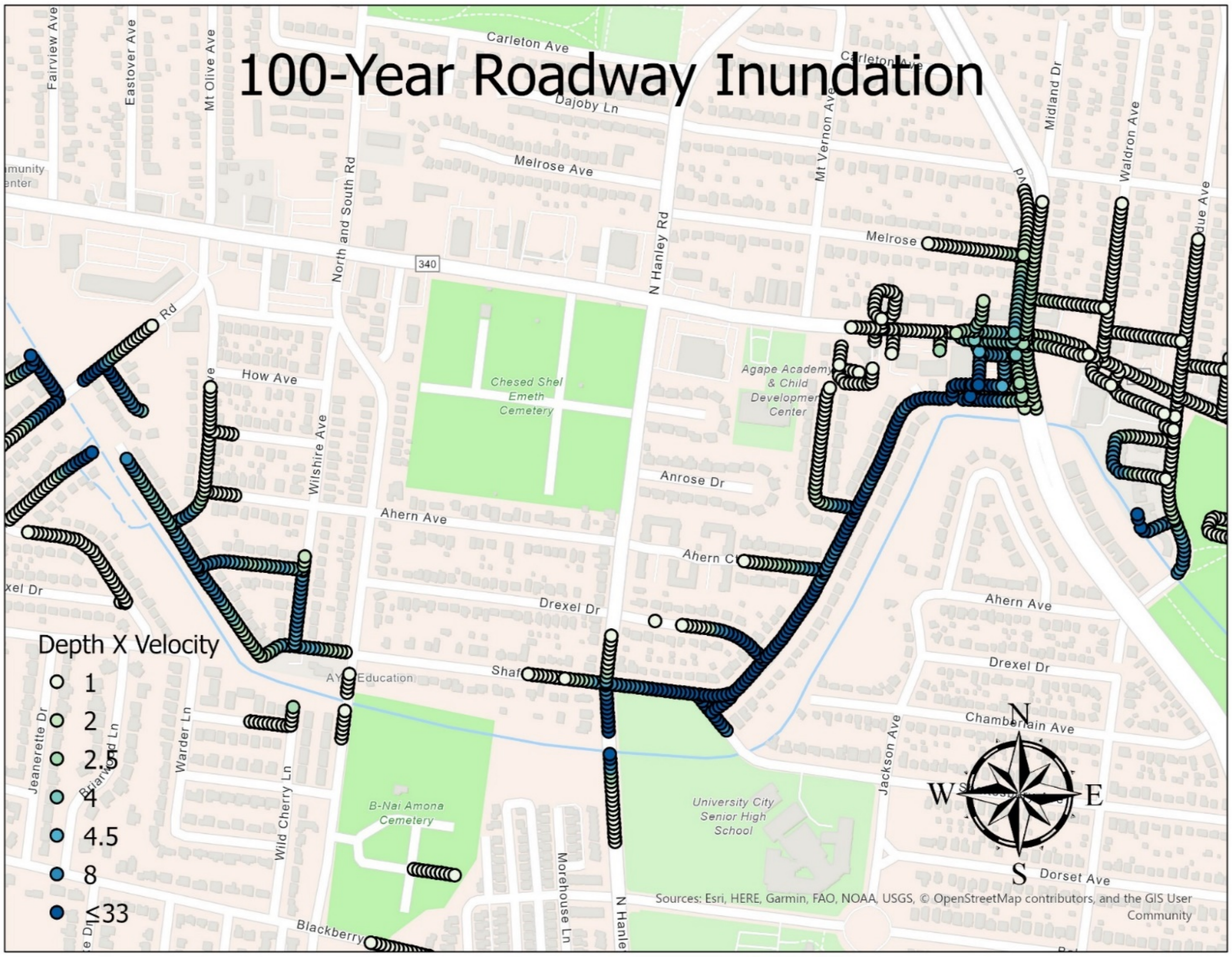

Figure 8. Depth Times Velocity on Roadways (Wilson Ave, Shaftesbury Ave)

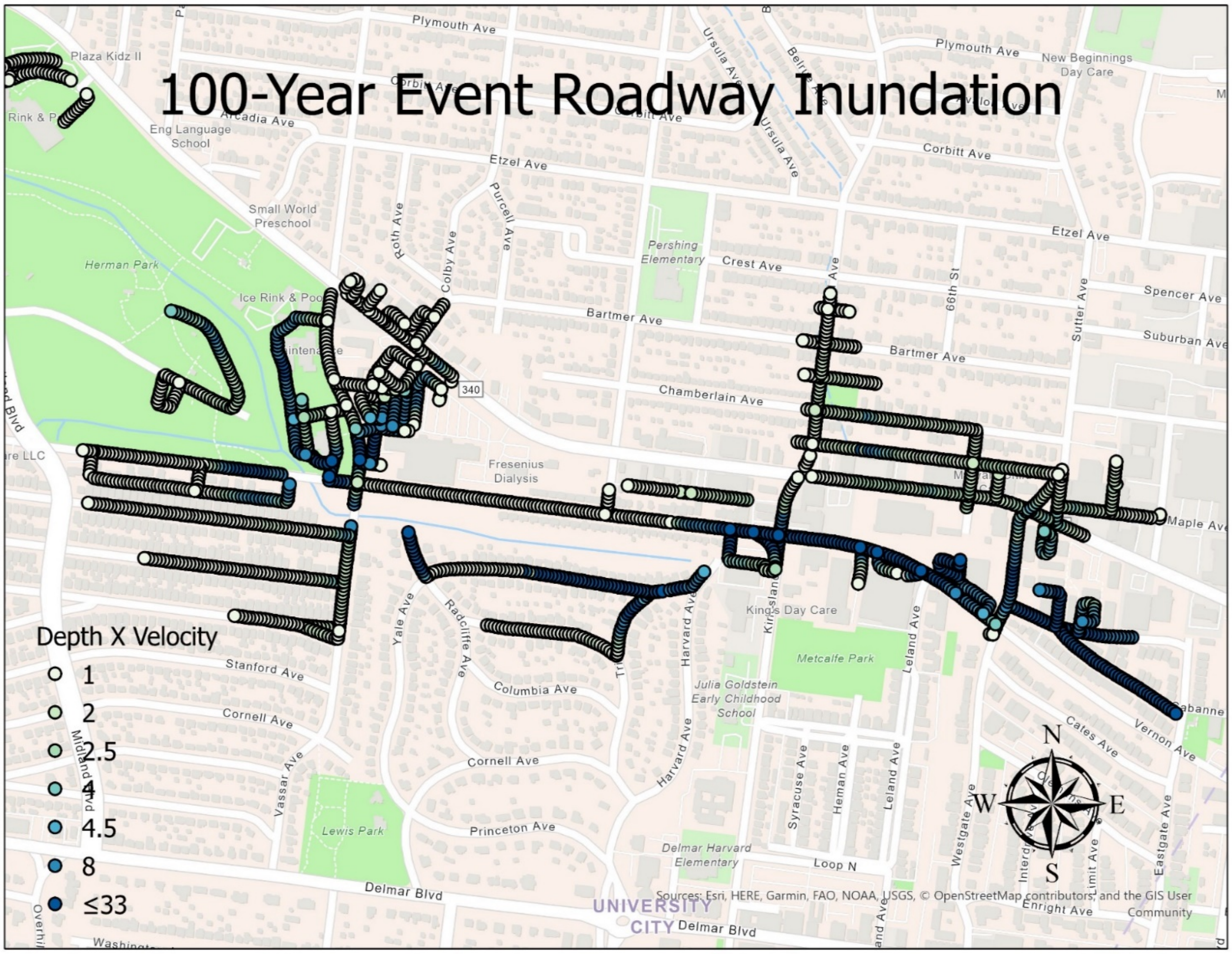

Figure 9. Depth Times Velocity on Roadways (Vernon Ave, Pennsylvania Ave)

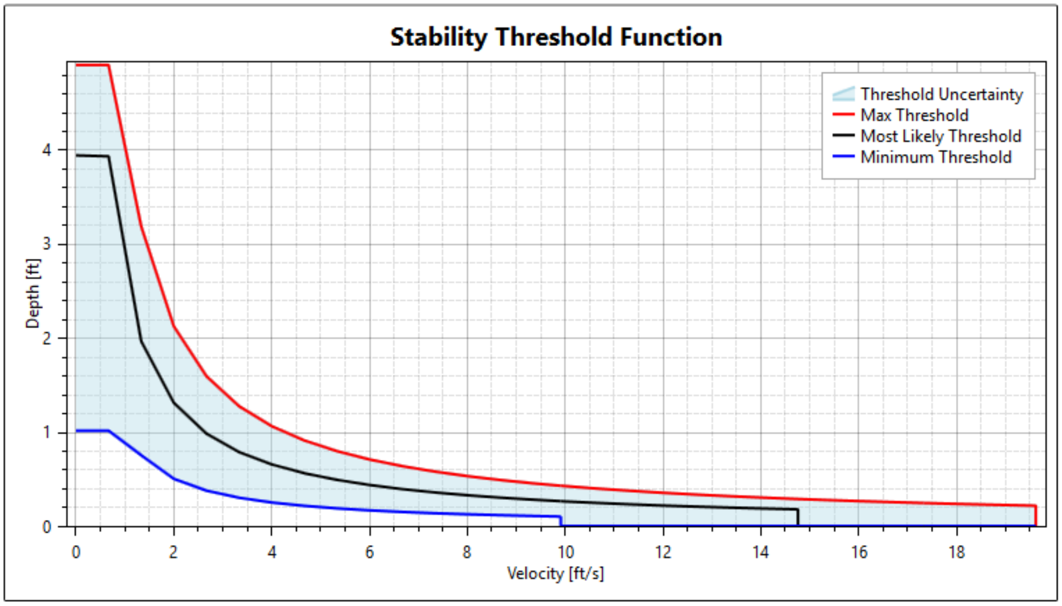

Figure 10. HEC-LifeSim Vehicular Stability Function

5.6 COMPLIANCE WITH SECTION 308 OF WRDA 1990

Section 308 of the Water Resource Development Act (WRDA) 1990 limits structures built or substantially improved after July 1, 1991 in designated floodplains not elevated to the 1% AEP flood elevation from being included in the benefit base of the economic analysis.

To ensure compliance with the act, the economist will review prior to ADM the structures being damaged at the 1% AEP event that county parcel data indicate were built post-1991. If any structures are found to be in violation of section 308, they will be removed from benefit analysis.

6 RESULTS OF THE REGIONAL ECONOMIC DEVELOPMENT ANLYSIS (RED)

When the economic activity lost in a flooded region can be transferred to another area or region in the national economy, these losses cannot be included in the NED account. However, the impacts on the employment, income, and output of the regional economy are considered part of the RED account. The input-output macroeconomic model RECONS can be used to address the impacts of the construction spending associated with the project alternatives. The RECONS model utilizes a total construction cost of a project that is attributable to contracts being awarded to complete the construction of the project. This cost excludes USACE labor associated with planning, engineering, and design, as well as economic costs like interest during construction. The RECONS model was utilized for the NED Plan and the results are below. Results will be obtained from the Economic Consequence Assessment Model (ECAM) prior to ADM.

The total cost input into the RECONS model for the recommended NED plan was $68,837,000. Of this total expenditure, $54,795,575 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 $68,836,327 support a total of 644.4 full-time equivalent jobs, $51,590,442 in labor income, $64,973,069 in the gross regional product, and $101,016,420 in economic output in the local impact area. More broadly, these expenditures support 1,023.4 full-time equivalent jobs, $75,048,233 in labor income, $104,317,129 in the gross regional product, and $173,952,455 in economic output in the nation.

Table 19 summarizes the local, state, and nationwide impact of the NED Plan. Table 20 breaks the local impacts down by industry.

Table 19. NED RECONS Impacts to Local, State, and National Economy's ($1,000)

Area	Local Capture	Output	Jobs*	Labor Income	Value Added
Local					
Direct Impact		$ 54,795,575	397.30	$ 34,669,364	$ 37,693,819
Secondary Impact		$ 46,220,845	247.10	$ 16,921,078	$ 27,279,250
Total Impact	$ 54,795,575	$ 101,016,420	644.40	$ 51,590,442	$ 64,973,069
State					
Direct Impact		$ 49,491,041	287.30	$ 27,647,421	$ 31,518,491
Secondary Impact		$ 48,065,075	263.30	$ 16,283,097	$ 26,693,619
Total Impact	$ 58,267,758	$ 97,556,116	550.60	$ 43,930,518	$ 58,212,110
US					
Direct Impact		$ 65,687,191	529.50	$ 40,417,649	$ 45,150,608
Secondary Impact		$ 108,265,264	493.90	$ 34,630,584	$ 59,166,521
Total Impact	$ 65,687,191	$ 173,952,455	1,023.40	$ 75,048,233	$ 104,317,129
* Jobs are presented in full-time equivalence (FTE)					

Table 20. NED RECONS Impacts to Specific Industries ($1,000)

Industries	Output	Jobs*	Labor Income	Value Added
Direct Impacts				
Sand and gravel mining	$ 63,494	0.50	$ -	$ 15,153
Construction of new highways and streets	$ 688,370	3.00	$ 253,937	$ 354,404
Construction of new commercial structures, including farm structures	$ 7,572,070	47.70	$ 3,984,730	$ 4,413,536
Construction of other new nonresidential structures	$ 688,370	9.10	$ 780,051	$ 198,588
Construction of new single-family residential structures	$ 10,325,550	57.30	$ 4,889,687	$ 6,327,205
Cement manufacturing	$ 1,143,310	1.70	$ 135,603	$ 335,185
Iron and steel mills and ferroalloy manufacturing	$ 30,649	-	$ 3,101	$ 5,102
All other industrial machinery manufacturing	$ 3,031	-	$ 824	$ 1,074
Switchgear and switchboard apparatus manufacturing	$ 21,627	-	$ 5,037	$ 9,816
Wholesale - Machinery, equipment, and supplies	$ 48,153	0.10	$ 17,518	$ 31,309
Wholesale - Other nondurable goods merchant wholesalers	$ 988,684	2.50	$ 315,385	$ 604,088
Wholesale - Wholesale electronic markets and agents and brokers	$ 184,471	1.60	$ 268,881	$ 169,760
Air transportation	$ 9,051	-	$ 1,931	$ 6,195
Rail transportation	$ 72,712	0.10	$ 14,844	$ 34,857
Water transportation	$ 1,206	-	$ 303	$ 426
Truck transportation	$ 661,501	3.70	$ 233,552	$ 286,911
Insurance carriers, except direct life	$ 622,002	0.80	$ 98,030	$ 276,905
Commercial and industrial machinery and equipment rental and leasing	$ 2,753,292	5.80	$ 957,934	$ 1,954,549
Architectural, engineering, and related services	$ 10,655,039	46.60	$ 5,371,628	$ 6,126,179
Environmental and other technical consulting services	$ 394,074	2.90	$ 337,330	$ 281,044
Office administrative services	$ 3,413,151	34.40	$ 4,117,159	$ 1,805,762
* Employment and payroll of federal govt, non-military	$ 5,679,052	31.60	$ 4,105,182	$ 5,679,052
Private Labor	$ 8,776,718	147.90	$ 8,776,718	$ 8,776,718
Direct Impact	$ 54,795,575	397.30	$ 34,669,364	$ 37,693,819
Secondary Impact	$ 46,220,845	247.10	$ 16,921,078	$ 27,279,250
Total Impact	$ 101,016,420	644.40	$ 51,590,442	$ 64,973,069

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