

ROCKAWAY RIVER AND DEN BROOK  
DENVILLE TOWNSHIP  
MORRIS COUNTY, NEW JERSEY  
CAP SECTION 205  
FLOOD RISK MANAGEMENT STUDY

APPENDIX D  
ECONOMICS

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In partnership with the New Jersey Department of Environmental Protection

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# 1 Introduction

The Township of Denville New Jersey Flood Risk Management (FRM) economic analysis was conducted to assess whether changes in without conditions compared to the recommended plan are economically justified. The analysis measured the flood damage reduction benefits and costs of several alternatives, including various floodwall configurations, the combination of floodwalls and selective road raising, bypass culvert, and nonstructural treatments adjacent to the Upper Rockaway River and its tributary, Den Brook.

# 2 Summary of Study Area

Rockaway River is in the Township of Denville, Morris County, New Jersey. The village is mostly developed, with a mix of residential and commercial structures. There are numerous small lakes within the basin and several important tributaries, including Den Brook that originates in Randolph Township, and enters the Upper Rockaway River in Denville. Note that the Lower Rockaway River is not part of the study area. Figure 1 shows the study area with Rockaway River and Den Brook.

Figure 1: Study Area



The Township of Denville had a population of 15,824 as of the 2000 Census Bureau data. In 2021 the population was 17,100, reflecting an increase of 1,276 people with a rate of 8.1 percent from 2000 to 2021.

Many people left the Denville, NJ area following the aftermath of Hurricane Irene that hit the region and caused severe damage in 2011. Since that time the Township has been rebuilt and the population reached 16,642 in 2015. The population has continued to increase and reached 17,100 in 2021, with 50.4 percent males and 49.6 percent females.

The median household income and housing values were \$125,655 and \$419,500, respectively, as of 2019.

Several flood events have impacted the Township of Denville, Morris County. In September 1971, most of the houses were surrounded by three feet of water. The storm damages were estimated to be \$621,000. During a storm event in January 1979, many families evacuated from their homes. In April 1984, Riverside Drive East was inundated, and as a result, 110 people temporarily evacuated the township. In September 1999, Tropical Storm Floyd hit the township with approximate total damages of \$250 million statewide. The latest and the most severe storm damage that has impacted Denville occurred during Hurricane Irene on August 27-28, 2011, when 13.29 inches of rain fell in Morris County. Hundreds of people left the township. Figure 2 shows some images associated with storm events.

Figure 2: Inundations in the Township of Denville, NJ



### 3 Methodology

#### 3.1 HEC-FDA

This analysis follows USACE guidance for conducting flood damage analyses as contained in Engineering Regulation (ER) 1105-2-100, Appendix E, Section III, "Flood Damage Reduction", 22 April 2000. The U.S. Army Corps of Engineers (USACE) Hydraulic Engineering Center Flood Damage Analysis (HEC-FDA) version 1.4.2 tool was used to compute damages for properties in the Township of Denville during FY 2021 economic analysis. HEC-FDA provides the capability to perform an integrated hydrologic engineering and economic analysis during the formulation and evaluation of FRM plans. Generic depth-damage functions

developed by the USACE Institute for Water Resources (IWR) were used within the tool to show the percentage of structure value damaged by varying water levels. Characteristics such as low opening, main floor elevation and building material were recorded to determine the percent damage to the structures resulting from inundation levels.

The project benefit is defined as the difference between the without and with-project equivalent annual damage from structure and content values of buildings. Benefits and costs are calculated for a 50-year period of analysis using the October-2020 price level (FY 2021) and discount rate of 2.5 percent with the Capital Recovery Factor of 0.035 to annualize benefits and costs.

For each plan, the average annual benefit amount is divided by the average annual cost to determine a benefit-to-cost ratio (BCR). This ratio must be equal to or greater than 1.0 for federal participation in water resource improvement projects. The plan with the greatest difference between the average annual benefit and average annual cost will be identified. This plan usually defines the extent of federal interest in a project and is considered the National Economic Development (NED) Plan.

### 3.2 Hydrology and Hydraulics Inputs

The study area is impacted by two overlapping flood threats, Rockaway River and its tributary Den Brook. Eight water surface profiles and their associated Annual Exceedance Probabilities (AEP) 50%, 20%, 10%, 4%, 2%, 1%, 0.4%, and 0.2% were entered into the model for without-project conditions and future with-project conditions. The downstream station, the upstream station, and the index location for Rockaway River reach are respectively 28164, 33071, and 31440. For Den Brook reach they are 2240, 2803, and 2644 respectively. Attached files show Rockaway River reach and Den Brook reach water surface profile. Figures 3 and 4 show Rockaway River reach and Den Brook water surface profiles.

Figure 3: Rockaway River Reach Water Surface Profile

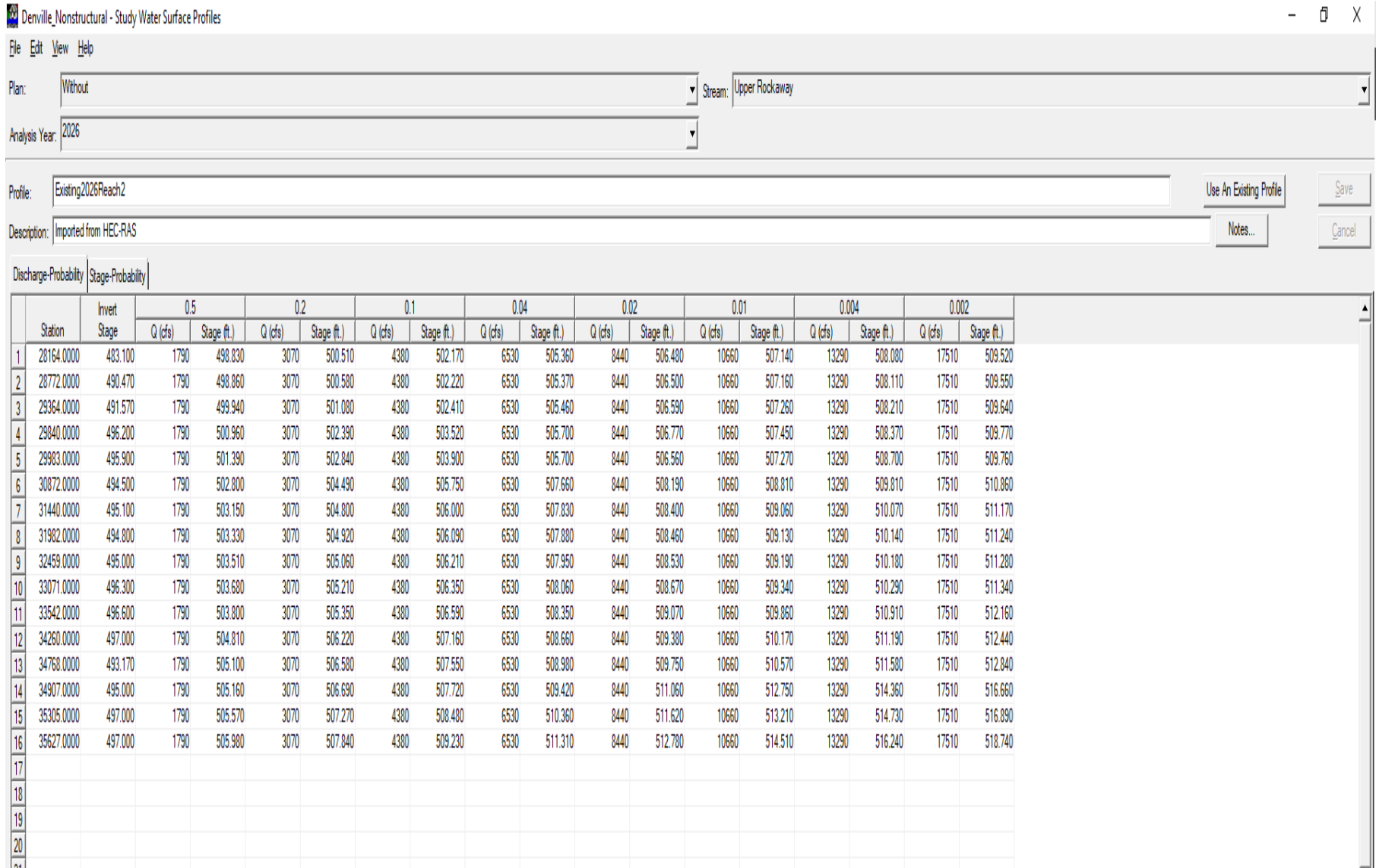
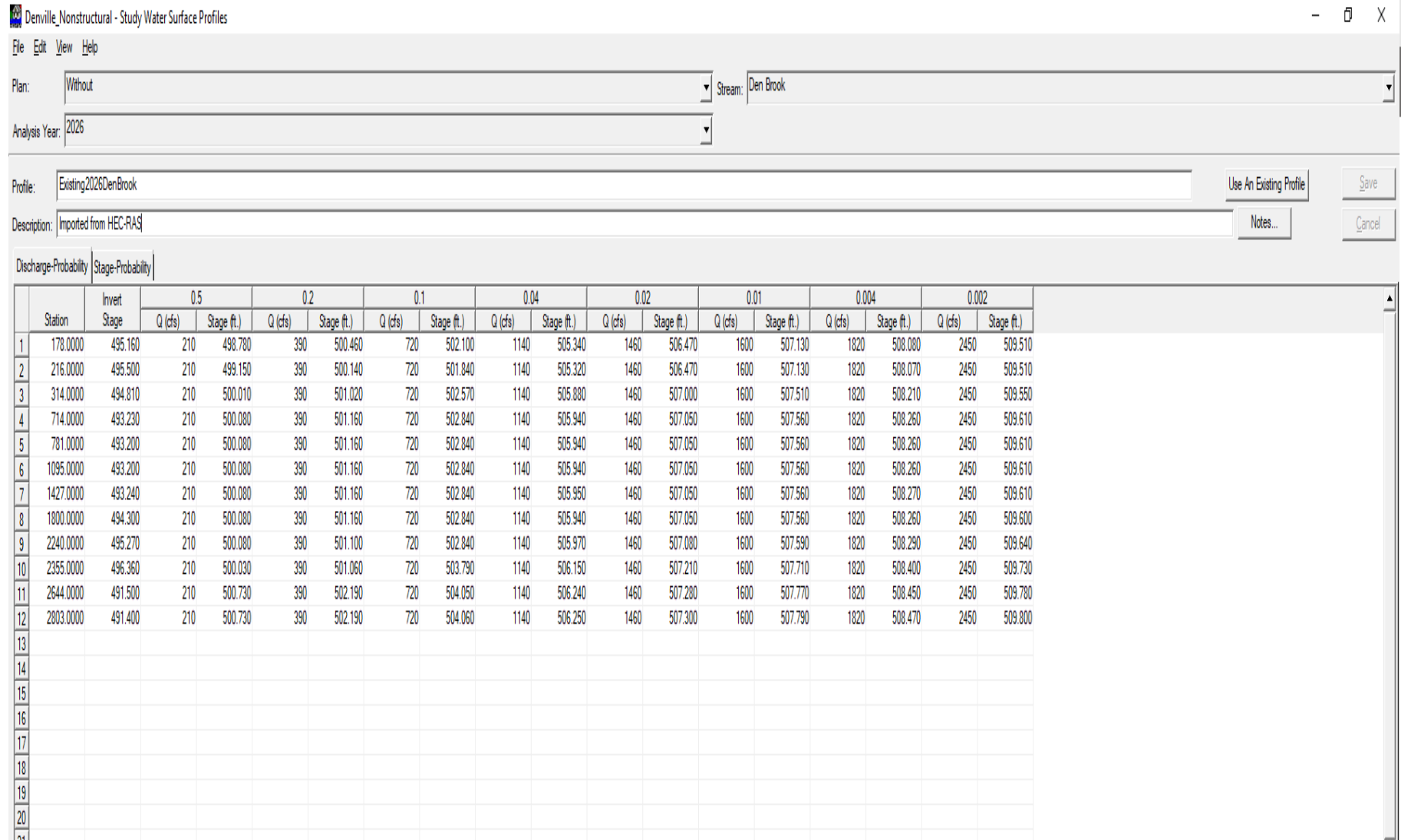


Figure 4: Den Brook Reach Water Surface Profile



As part of this study, an economic analysis was conducted using depth-damage data from models. Actual damage data from previous flooding events mentioned in the previous section were not collected or used.

### 3.3 Assumptions

The following assumptions are made for this analysis:

- a. Inflation is not factored into the analysis.
- b. Land use zoning and construction codes will not change during the period of analysis.
- c. Real property will continue to be repaired to pre-flood conditions after each flood event. Structures are not removed or acquired even they exceeded the 50 percent substantial damage since there is no USACE guidelines that require the removal or acquisition of structures once damage has exceeded its present value threshold. The homeowners have cultural norms to stay in their community. Hence, it is more likely that property owners would continuously to repair their properties due to flood damages since this often has occurred in the study area. The reconstruction of substantial damaged buildings to levels above the regulated Base Flood Elevation (BFE) in accordance with floodplain management will provide them resiliencies against future storms. All new buildings and additions to post-FIRM buildings after July 1, 1991, must be elevated at least as high as FEMA Base Flood Elevation (BFE) and are not included in the benefit base.
- d. Damaged or destroyed properties will be restored to pre-storm conditions and remain in the structure inventory for the 50-year period of analysis.
- e. Empirical storm frequencies are based on historical records and indicate the probability of future events.
- f. Damages are related to the first-floor elevation of the residential and nonresidential structures and to their low opening.

### 3.4 Flood Damage Computation

One of the chief inputs in developing a model using the HEC-FDA program is the structure inventory. The structure inventory was created considering the 1% AEP floodplain developed by USACE Hydrology and Hydraulic (H&H) group.

The structure inventory was developed using ArcGIS Pro software version 2.3.0. A shapefile was paired with digital elevation data presented in the North American Vertical Datum (NAVD88) elevation to obtain ground elevations of structures within the flood zone. The shapefiles were then joined with one another and clipped in the study area. Then the flood zone shapefile was used to select all of the structures within the floodplain. The residential structure values were calculated using Marshall & Swift Residential Estimator 7 version 7.7.7. The commercial structure values were calculated using Marshall & Swift Commercial Estimator 7 / Agricultural Estimator version 7.2.10. Marshall & Swift provides accurate costs for structures found throughout the United States and Canada by assessing their cost primarily through the building material, the type of roof, the square footage, the effective age, the number of stories, and their location factor. Table 1 shows a random sample of 30 structures in the Township of Denville, NJ.

Table 1: Random Sample of Structures

Struct Name	Category Name	Occupancy Type	CSVR <sup>1</sup>	IMPRVT_VAL <sup>2</sup> (\$)	YR	Sq Feet	DRV <sup>3</sup> (\$)	Story Number
1	Nonresidential	N13	1.88	253400	1949	3774.59	294442	1
13	Nonresidential	N13	0.73	138400	1957	3512.06	227556	1
25	Nonresidential	N13	0.21	1020200	1974	4225.11	1070908	1
37	Nonresidential	N13	0.21	93100		1577.86	245513	1
49	Nonresidential	N13	0.21	1100800		10764	1453147	2
61	Nonresidential	N14	0.21	524000	1966	3240.85	829479	2
73	Residential	IWR5	1	260200	1934	2875.35	567928	2
85	Residential	IWR5	1	150200	1952	1341.05	300423	2
97	Nonresidential	N14	0.21	135400	1959	2406.52	261868	2
109	Residential	IWR4	1	95600	1946	1165.77	298511	1
123	Residential	IWR5	1	117900	1925	1088.08	258462	2
133	Nonresidential	N14	1.28	351400	1945	4374.59	443927	2
144	Residential	IWR6	1	149900	1937	1139.06	267481	2
157	Residential	IWR4	1	200500	1963	1455.91	271904	1
169	Residential	IWR4	1	153300	1980	1358.77	393833	1
181	Residential	IWR5	1	126400	1928	955.88	289753	2
193	Residential	IWR5	1	209900	1950	1751.42	439146	2
205	Residential	IWR4	1	147800	1968	1380.62	318830	1
217	Residential	IWR4	1	104800	1960	1059.68	252448	1
229	Residential	IWR5	1	229500	1940	2064	240134	2
241	Residential	IWR5	1	269800	2001	2076.12	838017	2
253	Residential	IWR6	1	112600	1924	1700	210303	2
265	Residential	IWR4	1	130600	1955	1431	198790	1
277	Residential	IWR6	1	250600	1951	2206.55	319305	2
289	Residential	IWR6	1	140600	1930	1234.38	208425	2
301	Residential	IWR6	1	191800	1948	1871	282274	2
313	Residential	IWR5	1	161100	1948	1133.78	223688	2
325	Residential	N14	0.21	119500	1950	1299.75	216305	2
349	Residential	IWR5	1	111700	1958	1083.68	196673	2
361	Residential	IWR6	1	179000	1930	1229.08	207828	2
<b>Total IMPRVT_VAL =</b>				<b>7230000</b>	<b>Total DRV = 11627301</b>			
<b>DRV to IMPRVT RATIO =</b>					<b>1.608</b>			

<sup>1</sup> Content-to-Structure Value Ratio

<sup>2</sup> Structure Improvement Value

<sup>3</sup> Depreciated Replacement Value

N13 – Nonresidential Structure without Basement

N14 – Nonresidential Structure with Basement

IWR4 – One Story Residential Structure with Basement

IWR5 – Two Stories Residential Structure with Basement

IWR6 – Split-Level Residential Structure with Basement

Reasonable coefficients of the sample structure values by their square footages were derived for residential and nonresidential structures. These coefficients were used to multiply each structure’s square footage to obtain the DRV of all structures in the inventory.

Table 2 shows a sample of structures in the study area. The depreciated replacement costs of the buildings were used as the structure values in the structure inventory.

Table 2: Sample of Structures in the Study Area

Structure Name	Structure Address	DRV (\$000s)	Number of Stories	Structure Value in the Inventory (\$000s)
25	6 BLOOMFIELD AVE	1,071	1	1,071
49	1 BROADWAY	1,453	2	1,453
61	18 BROADWAY	829	2	829
73	4 THIRD AVE	568	2	568
85	9 THIRD AVE	300	2	300
109	5 HINCHMAN AVE	299	1	299
123	18 HINCHMAN AVE	258	2	258
144	6 HEWETSON RD	267	2	267

The value of contents for each structure was determined according to pre-defined content-structure value ratios for each damage function.

The Analysis of Nonresidential Content Value and Depth-Damage for Flood Damage Reduction Studies (IWR Report 96-R-12 May 1996) was used to determine the content values of the nonresidential structures. These depth damage functions are appropriate for this study because they were developed during the expert solicitation process for similar occupancies in a location relatively close to the Township of Denville, New Jersey.

Based on the Economic Guidance Memorandum (EGM) 01-03 and (EGM) 04-01, the residential content value was assumed to be equal to 100% of the structure value, since the depth-damage functions model content damage as a percentage of the structure value. Table 3 is a condensed structure inventory that contains Structure Occupancy Types, Structure Values, and Content Values.

A Digital Elevation Model was used in conjunction with parcel data to determine the ground elevation in NAVD88 of each structure. The first floor, which was determined by a combination of the first-floor survey provided by the sponsor on most structures, by GIS capability, and by desk top survey, was also used as a reference point for beginning damage when the structure contains a basement or other low opening point. A random sample of structures was used in the study area. Street View options from Google Earth, Google Maps and Bing were used to assess the first-floor elevation, which was the height of the ground elevation plus the foundation height. The beginning damage was a reference point at the low opening where water was likely to enter the building from the ground elevation. The final component necessary to complete the structure inventory was the location of the structures with their respective river station.

Table 3: Condensed Structure Inventory

Structure Occupancy Type	Description	# of Structures	Structure Value (\$000)	Content Value (\$000)	Total Value (\$000)	FFE Elevation (ft)
<b>IWR1</b>	One Story/ No Basement	28	6,583	6,583	13,166	510.456
<b>IWR2</b>	Two Story/ No Basement	44	12,025	12,025	24,050	509.008
<b>IWR3</b>	Split-Level/ No Basement	11	2,798	2,798	5,596	509.854
<b>IWR4</b>	One Story/ With Basement	14	3,220	3,220	6,440	510.857
<b>IWR5</b>	Two Story/ With Basement	89	35,052	35,052	70,104	510.232
<b>IWR6</b>	Split-Level/ With Basement	88	22,732	22,732	45,464	511.761
<b>N13</b>	Nonresidential/ No Basement	61	64,355	41,944	106,299	506.185
<b>N14</b>	Nonresidential/ With Basement	36	34,327	10,502	44,829	507.569
<b>T77</b>	Emergency Flood Fighting	1	51	1,544	1,595	505.3
	<b>Total</b>	<b>372</b>	<b>181,143</b>	<b>94,456</b>	<b>317,543</b>	

The river stations were placed over the existing GIS dataset and Geological Coding (geo-coding) was used to assign a location to each structure by determining the structure’s latitude and longitude. Using the latitude and longitude data, each structure was assigned a river station. Once each structure had been assigned a river station, the structure inventory was imported into the HEC-FDA program. The HEC-FDA program utilizes hydrologic data to determine the frequency and elevation, or stage, of water surfaces during a flood event. The stage-frequency data is combined with the structure data to determine the extent of damages based on low opening and first floor elevations of buildings in the study area.

The computation of annual flood damages is based on the application of depth-damage functions to the structures in the study area to compute damage incurred by structures and contents during flood events of different probabilities of occurrence. The depth-damage functions applied for the analysis are representative of post storm surveys of residential damages in multiple areas exposed to flooding. Depth-damage functions used for this study were the generic depth-damage functions for residential structures developed by USACE,

and the damage functions for nonresidential structures that were developed following an expert opinion solicitation exercise carried out by FEMA and USACE/Institute for Water Resources:

- Single-family residential structures (and two- or multi-family structures with similar physical characteristics) without basements: *Economic Guidance Memorandum (EGM) 01-03, "Generic Depth-Damage Relationships", December 4, 2000.*
- Single-family residential structures (and two- or multi-family structures with similar physical characteristics) with basements: *Economic Guidance Memorandum (EGM) 04-01, "Generic Depth-Damage Relationships for Residential Structures with Basements", October 10, 2003.*
- Nonresidential Content Value and Depth-Damage for Flood Damage Reduction Studies (IWR Report 96-R-12 May 1996).

The Generic Depth Damage Relationships within EGM 04-01, dated October 2003, are derived from comparable riverine floodplains. The Generic Depth Damage Relationships are derived by evaluating structure damages in riverine floodplains. The model outputs as well as the occupancies were compared to historic events and confirmed to be appropriate for use. A sample of depth-damage relationships for structures and contents is found in Table 5 below. The percentages damages to structures and their content values in Table 5 are based upon occupancy type and inundation depth.

### 3.5 Risk and Uncertainty

USACE regulations require the use of a risk and uncertainty (R&U) analysis for flood damage reduction studies at the feasibility level of detail and above. R&U analysis provides decision-makers with more information to select the appropriate project. The economic portion of R&U pertains to the extent of damages associated with various levels of flooding. Flooding damages were developed by stage or height of water over the ground. However, estimates of damages are subject to error. The study was conducted in accordance with Engineering Manual EM 1110-2-1619, "Risk-Based Analysis for Flood Damage Reduction Studies" (USACE, August 1, 1996), which requires that primary elements of the damage estimation computations be explicitly subjected to probabilistic analyses. Estimates of annual flood damage were computed for this study using version 1.4.2 of HEC-FDA, which applies Monte Carlo simulation techniques to calculate expected damage values while explicitly accounting for uncertainty in the input data. Uncertainty was incorporated into the following components of the flood damage calculations:

- Stage-frequency and discharge-frequency functions
- Inflow/outflow transform functions
- Stage-discharge functions
- Structure first floor elevation
- Structure Depreciated Replacement Value
- Depth-damage functions

There are two sources of uncertainty surrounding first floor elevations: the use of the LiDAR data for the ground elevations with the vertical accuracy of 18.13 centimeters, and the use of parcel data and Google Street View techniques to determine the structure foundation heights above ground elevation.

The error implicit in the parcel data is normally distributed with a mean of zero and standard deviation of 0.5 feet for both residential and nonresidential structures.

Error in the LiDAR data was further calculated to have a fundamental vertical accuracy of 18.13 cm at a 95% confidence level using  $RMSE(z) \times 1.9600$  (RMSE – Root Mean Square Error) as defined by the National Standards for Spatial Data Accuracy (NSSDA); assessed and reported using National Digital Elevation Program (NDEP)/ASRPS Guidelines. Error in the LiDAR is also normally distributed with a mean of zero and the standard deviation of 0.3035 feet as shown in Table 4.

Table 4: Uncertainties around Ground Elevations

<b>Ground – LiDAR</b>	
(Conversion cm to inches then to feet)	
+/- 18.13 cm @ 95% confidence	18.13cm
x	0.3937
$z = (x - u) / \text{std. dev.}$	7.1378in
÷	12
$1.96 = (0.5948 - 0) / \text{std. dev.}$	0.5948ft
$0.3035 = \text{std. dev.}$	

The combined uncertainty distribution surrounding the foundation height and the ground elevation is:

$$\sqrt{0.5^2 + 0.3035^2} = 0.58 \text{ feet.}$$

Table 5 shows riverine depth-damage functions used in this analysis and their uncertainties.

Table 5: Depth-Damage Relationship of the Structures and Content in Denville, NJ

Occupancy Type	Category Name	Damage Type	Stage												
			-2	-1	0	1	2	3	4	5	6	7	8	9	10
<b>One Story, No Basement</b>															
IWR1	Residential	S	0	2.5	13.4	23.3	32.1	40.1	47.1	53.2	58.6	63.2	67.2	70.5	73.2
		SN	0	2.7	2	1.6	1.6	1.8	1.9	2	2.1	2.2	2.3	2.4	2.7
		C	0	2.4	8.1	13.3	17.9	22	25.7	28.8	31.5	33.8	35.7	37.2	38.4
		CN	0	2.1	1.5	1.2	1.2	1.4	1.5	1.6	1.6	1.7	1.8	1.9	2.1
<b>Two Stories, No Basement</b>															
IWR2	Residential	S	0	3	9.3	15.2	20.9	26.3	31.4	36.2	40.7	44.9	48.8	52.4	55.7
		SN	0	4.1	3.4	3	2.8	2.9	3.2	3.4	3.7	3.9	4	4.1	4.2
		C	0	1	5	8.7	12.2	15.5	18.5	21.3	23.9	26.3	28.4	30.3	32
		CN	0	3.5	2.9	2.6	2.5	2.5	2.7	3	3.2	3.3	3.4	3.5	3.5
<b>Split-Level, No Basement</b>															
IWR3	Residential	S	0	6.4	7.2	9.4	12.9	17.4	22.8	28.9	35.5	42.3	49.2	56.1	62.6
		SN	0	2.9	2.1	1.9	1.9	2	2.2	2.4	2.7	3.2	3.8	4.5	5.3
		C	0	2.2	2.9	4.7	7.5	11.1	15.3	20.1	25.2	30.5	35.7	40.9	45.8
		CN	0	2.2	1.5	1.2	1.3	1.4	1.5	1.6	1.8	2.1	2.5	3	3.5
<b>One Story, With Basement</b>															
IWR4	Residential	S	13.8	19.4	25.5	32	38.7	45.5	52.2	58.6	64.5	69.8	74.2	77.7	80.1
		SN	0.85	0.83	0.85	0.96	1.14	1.37	1.63	1.89	2.14	2.35	2.52	2.66	2.77
		C	10.5	13.2	16	18.9	21.8	24.7	27.4	30	32.4	34.5	36.3	37.7	38.6
		CN	0.74	0.72	0.74	0.83	0.98	1.17	1.39	1.6	1.81	1.99	2.13	2.25	2.35
<b>Two Stories, With Basement</b>															
IWR5	Residential	S	10.2	13.9	17.9	22.3	27	31.9	36.9	41.9	46.9	51.8	56.4	60.8	64.8
		SN	1.47	1.37	1.32	1.35	1.5	1.75	2.04	2.34	2.63	2.89	3.13	3.38	3.71
		C	8.4	10.1	11.9	13.8	15.7	17.7	19.8	22	24.3	26.7	29.1	31.7	34.4
		CN	1.21	1.13	1.09	1.11	1.23	1.43	1.67	1.92	2.15	2.36	2.56	2.76	3.04
<b>Split-Level, With Basement</b>															
IWR6	Residential	S	10.4	14.2	18.5	23.2	28.2	33.4	38.6	43.8	48.8	53.5	57.8	61.6	64.8
		SN	1.6	1.6	1.6	1.7	1.9	2.1	2.4	2.6	2.9	3.2	3.4	3.6	3.9
		C	7.3	9.4	11.6	13.8	16.1	18.2	20.2	22.1	23.6	24.9	25.8	26.3	26.3
		CN	1.03	1.04	1.06	1.12	1.23	1.38	1.57	1.76	1.95	2.13	2.28	2.44	2.44
<b>Nonresidential, No Basement</b>															
N13	Residential	S	0	0	0	9	16.8	23.7	29.7	35	39.6	43.7	47.2	50.3	53
		SN	0	0	0	1.8	3.4	4.7	5.9	7	7.9	8.7	9.4	10.1	10.6
		C	0	0	0	21.6	36.6	47.1	54.4	59.5	63	65.5	67.2	68.4	69.2
		CN	0	0	0	4.3	7.3	9.4	10.9	11.9	12.6	13.1	13.4	13.7	13.8
<b>Nonresidential, With Basement</b>															
N14	Residential	S	0	0	6.7	14.9	22	28.2	33.7	38.5	42.7	46.3	49.5	52.3	54.8
		SN	0	0	1.3	3	4.4	5.6	6.7	7.7	8.5	9.3	9.9	10.5	11
		C	0	0	9.7	28.3	41.3	50.4	56.7	61.1	64.1	66.3	67.7	68.8	69.5
		CN	0	0	1.9	5.7	8.3	10.1	11.3	12.2	12.8	13.3	13.5	13.8	13.9
<b>Emergency Flood Fighting</b>															
T77	Residential	S	0	0	3.7	3.7	3.7	9.3	50	50	50	50	50	50	50
		SN	0	0	0.74	0.74	0.74	1.86	10	10	10	10	10	10	10
		C	0	0	0	0	0	0	0	0	0	0	0	0	0
		CN	0	0	0	0	0	0	0	0	0	0	0	0	0

### 3.6 Future Without-Project Conditions

The future without-project condition was determined by projecting conditions in the study area over a 50-year period of analysis, and the annualized damages were computed with 2.5% discount rate. The period of analysis is determined to be from 2026 to 2075. In the absence of federal action, flooding problems associated with rainfall events in the study area are expected to continue. These problems may be exacerbated by increased damage potential in the floodplain of the Township of Denville, New Jersey within the Upper Rockaway River Basin and its tributary, Den Brook, related to increased precipitation for high intensity, low frequency storm events in the future. It is expected, based on future land use projections in the study area, there will be limited additional development within the basin in the future period of analysis. The existing condition water surface profiles and the future without project condition water surface profiles were similar. In general, no significant changes are expected. A summary of Equivalent Annual Damages (EAD) for the without-project condition is presented in Table 6.

Table 6: Summary of EAD for the Without-Project Conditions (October-2020 price level, 2.5% Discount Rate)

Damage Reach	Annual Damages by Reach	Total Annual Damages
Den Brook	\$343,000	\$2,381,000
Upper Rockaway	\$2,038,000	

### 3.7 Future With-Project Conditions

The study has been conducted in accordance with ER 1105-2-101, "Risk Assessment for Flood Risk Management Studies (USACE, July 15, 2019), which states that the risk assessment will quantify the performance of all alternatives and evaluate the residual risk, including the consequences of the project's capacity exceedance.

The economic performance analysis has been completed on physical infrastructure by using the HEC-FDA model.

#### 3.7.1 Description of Each Alternative

##### *Overview*

Alternatives for the proposed action were formulated in consideration of study area problems and opportunities, as well as study goals, objectives, and constraints with consideration of four criteria: completeness, effectiveness, efficiency, and acceptability.

- Completeness is the extent to which a given alternative plan provides and accounts for all necessary investments or other actions to ensure the realization of the planned effects.
- Effectiveness is the extent to which an alternative plan alleviates the specified problems and achieves the specified opportunities.
- Efficiency is the extent an alternative plan is the most cost-effective means of alleviating the specified problems and realizing the specified opportunities, consistent with protecting the Nation's environment.

- Acceptability is the workability and viability of the alternative plan with respect to acceptance by state and local entities and the public and compatibility with existing laws, regulations, and public policies.

At a minimum, the potential FRM measures examined in this economic analysis included the “no action” alternative, structural measures, and nonstructural measures. This included variations of the recommended plan’s components such as floodwalls, road raising, and bypass culverts. Nonstructural measures such as elevation, flood-proofing, and relocation were also considered in light of changes to existing conditions and changes to environmental policy. The report is constrained by technical, environmental, economic, and social considerations. Once existing conditions were assessed and the *without*-project conditions established, the analysis proceeded to a *with*-project conditions assessment. Plan formulation techniques were employed to guide the development, screening, and selection of opportunities for improvement to the recommended plan, in accordance with local interests’ needs, while meeting planning objectives and within the aforementioned constraints. Formulation sought to maintain the recommended plan’s purposes of FRM, while employing environmentally sound solutions. Refer to Section 4.2 of the main report for maps of the alternatives described below.

### 3.7.2 Alternative 1a

#### 3.7.2.1 Description

Alternative 1a consists of a floodwall around the perimeter of the study area exposed to high floodwaters from the Upper Rockaway River and Den Brook. The alternative is designed to keep floodwaters associated with the 1% AEP storm events from inundating the Township of Denville, NJ. Ten closure structures or stop log structures are proposed within Alternative 1a. The closure structures would be designed to allow the floodwall to pass through a deed restricted area held by FEMA, to cross major roads, or to allow access to the business center. The total length of the floodwall is approximately 7,026 feet. The floodwall has three segments along the Upper Rockaway reach. The first segment of the floodwall has an average height of 12.54 feet above grade. The second segment of the floodwall has an average height of 9.03 feet above grade and the third segment of the floodwall has an average height of 7.82 feet above grade. The floodwall segment along the Den Brook reach, adjacent to Route 46, has an average height of 5.10 feet above grade.

#### 3.7.2.2 Residual Damages and Benefits

Using HEC-FDA, the EAD were calculated for the base year and future years with Alternative 1a in place, and the EAD were calculated for the 50-year period of analysis, using the 2021 fiscal year USACE project evaluation discount rate of 2.5 percent. The future without-project condition water surface profiles were similar to the existing condition water surface profiles. Hence, the Expected Annual Damages and the EAD yielded the same value.

Annual Exceedance Probability (AEP) of the project is the likelihood that a target elevation is exceeded by flood waters in any given year and can be considered as an indication of the risk reduction provided by the alternative. The target elevation in the *with*-project conditions is the stage associated with the 1% AEP storm events. A summary of EAD and benefits for Alternative 1a is presented in Table 7.

Table 7: Summary of Damages and Benefits for Alternative 1a (October-2020 price level, 2.5% Discount Rate)

Plan	Damage Reach	Without-Project Annual Damages	With-Project Annual Damages	Annual Benefits by Reach	Total Annual Benefits
<b>Alt-1a: 1% AEP Risk Reduction With 10 Stop Log Structures</b>	Den Brook	\$343,000	\$138,000	\$205,000	\$937,000
	Upper Rockaway	\$2,038,000	\$1,306,000	\$732,000	

### 3.7.3 Alternative 1b

#### 3.7.3.1 Description

The flood protection systems and the dimensions of Alternative 1b are the same as in Alternative 1a. The only difference is that four closure structures are eliminated. Hence, six closure structures or stop log structures were proposed within Alternative 1b. The elimination of the closure structures would limit access to some businesses along Route 46.

#### 3.7.3.2 Residual Damages and Benefits

Using HEC-FDA, Expected Annual Damages were calculated for the base year and future year with Alternative 1b in place, and EAD were calculated for the 50-year period of analysis, using the 2021 fiscal year USACE project evaluation discount rate of 2.5 percent.

The AEP storm events of the project are the likelihood that a target elevation is exceeded by flood waters in any given year and can be considered as an indication of risk reduction provided by the alternative. The target elevation in the *with*-project conditions is 1% AEP storm events. A summary of EAD and benefits for Alternative 1b is presented in Table 8.

Table 8: Summary of Damages and Benefits for Alternative 1b (October-2020 price level, 2.5% Discount Rate)

Plan	Damage Reach	Without-Project Annual Damages	With-Project Annual Damages	Annual Benefits by Reach	Total Annual Benefits
<b>Alt-1b: 1% AEP Risk Reduction With 6 Stop Log Structures</b>	Den Brook	\$343,000	\$138,000	\$205,000	\$937,000
	Upper Rockaway	\$2,038,000	\$1,306,000	\$732,000	

### 3.7.4 Alternative 1c

#### 3.7.4.1 Description

Alternative 1c was designed to keep floodwaters associated with the 2% AEP storm events from inundating the Township of Denville, NJ. As in Alternative 1a, Alternative 1c contains ten closure structures or stop log structures. The floodwall of Alternative 1c also has three segments along the Upper Rockaway reach, although each segment has a lower average height than Alternative 1a. The first segment of the floodwall

has an average height of 11.1 feet above grade. The second segment of the floodwall has an average height of 8.09 feet above grade and the third segment of the floodwall has an average height of 6.29 feet above grade. The floodwall segment along the Den Brook reach, adjacent to Route 46, has an average height of 5.10 feet above grade.

### 3.7.4.2 Residual Damages and Benefits

Using HEC-FDA, Expected Annual Damages were calculated for the base year and future year with Alternative 1c in place, and EAD were calculated for the 50-year period of analysis, using the 2021 fiscal year USACE project evaluation discount rate of 2.5percent.

The AEP storm events of the project are the likelihood that a target elevation is exceeded by flood waters in any given year and can be considered as an indication of risk reduction provided by the alternative. The target elevation in the *with*-project conditions is 2% AEP storm events. A summary of EAD and benefits for Alternative 1c is presented in Table 9.

Table 9: Summary of Damages and Benefits for Alternative 1c (October-2020 price level, 2.5% Discount Rate)

Plan	Damage Reach	Without-Project Annual Damages	With-Project Annual Damages	Annual Benefits by Reach	Total Annual Benefits
<b>Alt-1c: 2% AEP Risk Reduction With 10 Stop Log Structures</b>	Den Brook	\$343,000	\$181,000	\$162,000	\$850,000
	Upper Rockaway	\$2,038,000	\$1,350,000	\$688,000	

## 3.7.5 Alternative 1d

### 3.7.5.1 Description

The flood protection systems and the dimensions of Alternative 1d are similar to Alternative 1c. The only difference is that four closure structures are eliminated. Hence, six closure structures or stop log structures are designed within Alternative 1d. The elimination of the closure structures would limit access to some businesses along Route 46.

### 3.7.5.2 Residual Damages and Benefits

Using HEC-FDA, Expected Annual Damages were calculated for the base year and future years with Alternative 1d in place, and EAD were calculated for the 50-year period of analysis, using the 2021 fiscal year USACE project evaluation discount rate of 2.5 percent.

The AEP storm events of the project are the likelihood that a target elevation is exceeded by flood waters in any given year and can be considered as an indication of risk reduction provided by the alternative. The target elevation in the *with*-project conditions is 2% AEP storm events. A summary of EAD and benefits for Alternative 1d is presented in Table 10.

Table 10: Summary of Damages and Benefits for Alternative 1d (October-2020 price level, 2.5% Discount Rate)

Plan	Damage Reach	Without-Project Annual Damages	With-Project Annual Damages	Annual Benefits by Reach	Total Annual Benefits
<b>Alt-1d: 2% AEP Risk Reduction With 6 Stop Log Structures</b>	Den Brook	\$343,000	\$181,000	\$162,000	\$850,000
	Upper Rockaway	\$2,038,000	\$1,350,000	\$688,000	

### 3.7.6 Alternative 1e

#### 3.7.6.1 Description

Alternative 1e is designed to keep floodwaters associated with the 4% AEP storm events from inundating the Township of Denville, NJ. As in Alternative 1a, Alternative 1e contains the same flood control structures but with eight closure structures or stop log structures instead of ten due to the lower flood stage elevation associated with the 4% storm events. The floodwall of Alternative 1e also has three segments along the Upper Rockaway reach. The first segment of the floodwall has an average height of 9.57 feet above grade. The second segment of the floodwall has an average height of 6.44 feet above grade and the third segment of the floodwall has an average height of 5.39 feet above grade. The floodwall segment along the Den Brook reach, adjacent to Route 46, has an average height of 3.69 feet above grade.

#### 3.7.6.2 Residual Damages and Benefits

Using HEC-FDA, Expected Annual Damages were calculated for the base year and future years with Alternative 1e in place, and EAD were calculated for the 50-year period of analysis, using the 2021 fiscal year USACE project evaluation discount rate of 2.5 percent.

The AEP storm events of the project are the likelihood that a target elevation is exceeded by flood waters in any given year and can be considered as an indication of risk reduction provided by the alternative. The target elevation in the *with*-project conditions is 4% AEP storm events. A summary of EAD and benefits for Alternative 1e is presented in Table 11.

Table 11: Summary of Damages and Benefits for Alternative 1e (October-2020 price level, 2.5% Discount Rate)

Plan	Damage Reach	Without-Project Annual Damages	With-Project Annual Damages	Annual Benefits by Reach	Total Annual Benefits
<b>Alt-1e: 4% AEP Risk Reduction With 8 Stop Log Structures</b>	Den Brook	\$343,000	\$224,000	\$119,000	\$674,000
	Upper Rockaway	\$2,038,000	\$1,483,000	\$555,000	

### 3.7.7 Alternative 1f

#### 3.7.7.1 Description

The flood protection systems and the dimensions of Alternative 1f are similar to Alternative 1e. The difference is that four closure structures are eliminated. Hence, four closure structures or stop log structures are designed within Alternative 1f. The elimination of the closure structures would limit access to some businesses along Route 46.

#### 3.7.7.2 Residual Damages and Benefits

Using HEC-FDA, Expected Annual Damages were calculated for the base year and future years with Alternative 1d in place, and EAD were calculated for the 50-year period of analysis, using the 2021 fiscal year USACE project evaluation discount rate of 2.5 percent.

The AEP storm events of the project are the likelihood that a target elevation is exceeded by flood waters in any given year and can be considered as an indication of risk reduction provided by the alternative. The target elevation in the *with*-project conditions is 4% AEP storm events. A summary of EAD and benefits for Alternative 1f is presented in Table 12.

Table 12: Summary of Damages and Benefits for Alternative 1f (October-2020 price level, 2.5% Discount Rate)

Plan	Damage Reach	Without-Project Annual Damages	With-Project Annual Damages	Annual Benefits by Reach	Total Annual Benefits
<b>Alt-1f: 4% AEP Risk Reduction With 4 Stop Log Structures</b>	Den Brook	\$343,000	\$224,000	\$119,000	\$674,000
	Upper Rockaway	\$2,038,000	\$1,483,000	\$555,000	

### 3.7.8 Alternative 2a

#### 3.7.8.1 Description

Alternative 2a is designed to protect a flood prone perimeter area associated with the 4% storm inundation floodwaters. The design protection contains four closure structures. It also includes a combination of elevating five roads, the construction of a Jersey barrier, and floodwalls on the Upper Rockaway and Den Brook reaches.

Corey Road, Gardner Road, Hinchman Avenue, Orchard Street, and Diamond Spring Road are respectively raised by 4.12, 3.78, 3.32, 3.30, and 1.32 feet. Second Avenue Jersey barrier construction, floodwalls on the Upper Rockaway reach, and Den Brook reach have an average height of 3.41, 5.58, and 3.2 feet respectively.

#### 3.7.8.2 Residual Damages and Benefits

Using HEC-FDA, Expected Annual Damages were calculated for the base year and future years with Alternative 2a in place, and EAD were calculated for the 50-year period of analysis, using the 2021 fiscal year USACE project evaluation discount rate of 2.5 percent.

The AEP storm events of the project are the likelihood that a target elevation is exceeded by flood waters in any given year and can be considered as an indication of risk reduction provided by the alternative. The

target elevation in the *with*-project conditions is 4% AEP storm events. A summary of EAD and benefits for Alternative 2a is presented in Table 13.

Table 13: Summary of Damages and Benefits for Alternative 2a (October-2020 price level, 2.5% Discount Rate)

Plan	Damage Reach	Without-Project Annual Damages	With-Project Annual Damages	Annual Benefits by Reach	Total Annual Benefits
<b>Alt-2a: Combination of Road raising and Floodwall</b>	Den Brook	\$343,000	\$295,000	\$48,000	\$454,000
	Upper Rockaway	\$2,038,000	\$1,632,000	\$406,000	

### 3.7.9 Alternative 2b

#### 3.7.9.1 Description

Alternative 2b is a modification of Alternative 2a. Alternative 2b does not include a Jersey barrier structure on Second Avenue and contains two closure structures. All roads and floodwalls elevation protection structures remain the same as in Alternative 2a.

#### 3.7.9.2 Residual Damages and Benefits

Using HEC-FDA, Expected Annual Damages were calculated for the base year and future years with Alternative 2b in place, and Equivalent Annual Damages were calculated for the 50-year period of analysis, using the 2021 fiscal year USACE project evaluation discount rate of 2.5 percent.

The AEP storm events of the project are the likelihood that a target elevation is exceeded by flood waters in any given year and can be considered as an indication of risk reduction provided by the alternative. The target elevation in the *with*-project conditions is 4% AEP storm events. A summary of EAD and benefits for Alternative 2b is presented in Table 14.

Table 14: Summary of Damages and Benefits for Alternative 2b (October-2020 price level, 2.5% Discount Rate)

Plan	Damage Reach	Without-Project Annual Damages	With-Project Annual Damages	Annual Benefits by Reach	Total Annual Benefits
<b>Alt-2b: Combination of Road raising and Floodwall</b>	Den Brook	\$343,000	\$265,000	\$78,000	\$924,000
	Upper Rockaway	\$2,038,000	\$1,192,000	\$846,000	

### 3.7.10 Alternative 2b Sensitivity Analysis

#### 3.7.10.1 Description

Alternative 2b sensitivity is a modification of Alternative 2b that includes two closure structures. In Alternative 2b sensitivity, the elevation of Orchard Street and Diamond Spring Road are eliminated. Snyder

Road is raised to a top height of 4.28 feet. All other flood protection structures remain the same as Alternative 2b.

### 3.7.10.2 Residual Damages and Benefits

Using HEC-FDA, Expected Annual Damages were calculated for the base year and future years with Alternative 2b Sensitivity Analysis in place, and EAD were calculated for the 50-year period of analysis, using the 2021 fiscal year USACE project evaluation discount rate of 2.5 percent.

The AEP storm events of the project are the likelihood that a target elevation is exceeded by flood waters in any given year and can be considered as an indication of risk reduction provided by the alternative. The target elevation in the *with*-project conditions is 4% AEP storm events. A summary of EAD and benefits for Alternative 2b Sensitivity Analysis is presented in Table 15.

Table 15: Summary of Damages and Benefits for Alternative 2b Sensitivity Analysis (October-2020 price level, 2.5% Discount Rate)

Plan	Damage Reach	Without-Project Annual Damages	With-Project Annual Damages	Annual Benefits by Reach	Total Annual Benefits
<b>Alt-2b Sensitivity Analysis: Combination of Road raising and Floodwall</b>	Den Brook	\$343,000	\$265,000	\$78,000	\$922,000
	Upper Rockaway	\$2,038,000	\$1,194,000	\$844,000	

The difference between alternatives 2b and 2b Sensitivity Analysis is that Orchard Street would be elevated in Alternative 2b while the parallel street to the northeast, Snyder Ave, would be elevated in alternative 2b Sensitivity Analysis. The later alternative reduced damages on some structures, but induced flooding, especially near Snyder Ave on Upper Rockaway reach. Overall, more damages occurred with Alternative 2b Sensitivity analysis.

### 3.7.11 Alternative 3

#### 3.7.11.1 Description

Alternative 3 includes a 20-foot wide by 8-foot-high by-pass culvert that will take a substantial amount of the 4% AEP storm floodwaters away from the project area and redistribute it further downstream. This diversion structure will divert floodwater into the three-sided open bottom by-pass box culvert, approximately 6,600 linear feet long, and discharge that floodwater through an outlet structure designed to reduce excessive energy while discharging the waters.

#### 3.7.11.2 Residual Damages and Benefits

Using HEC-FDA, Expected Annual Damages were calculated for the base year and future years with Alternative 3 in place, and EAD were calculated for the 50-year period of analysis, using the 2021 fiscal year USACE project evaluation discount rate of 2.5 percent.

The AEP storm events of the project are the likelihood that a target elevation is exceeded by flood waters in any given year and can be considered as an indication of risk reduction provided by the alternative. The

target elevation in the *with*-project conditions is 4% AEP storm events. A summary of EAD and benefits for Alternative 3 is presented in Table 16.

Table 16: Summary of Damages and Benefits for Alternative 3 (October-2020 price level, 2.5% Discount Rate)

Plan	Damage Reach	Without-Project Annual Damages	With-Project Annual Damages	Annual Benefits by Reach	Total Annual Benefits
<b>Alt-3: Bypass Culvert</b>	Den Brook	\$343,000	\$333,000	\$10,000	\$473,000
	Upper Rockaway	\$2,038,000	\$1,575,000	\$463,000	

### 3.7.12 Alternative 4 - Nonstructural Measures

A nonstructural alternative is one in which the physical mechanism and extent of flooding is largely unchanged but the existing buildings within the floodplain are adapted and/or the regulatory framework that governs new development is modified to reduce the damage incurred during flood events.

An iterative process was performed to arrive at the selected plan for nonstructural measures. First, the structures within the study area were grouped into clusters by neighborhood blocks, generally bounded by roads, as they shared similar flood characteristics. The economic and engineering variables were entered into the HEC-FDA model. A normal probability distribution, with a mean value and a standard deviation was used in the model to quantify the uncertainty associated with the key economic variables. Elevation structure consists of lifting the structure or its foundation height to protect the structures against the 1% AEP plus one foot of confidence level while floodproofing was employed on residential structures with basements (wet floodproofing) and nonresidential structures where the first floor is located below the 1% AEP in the floodplain.

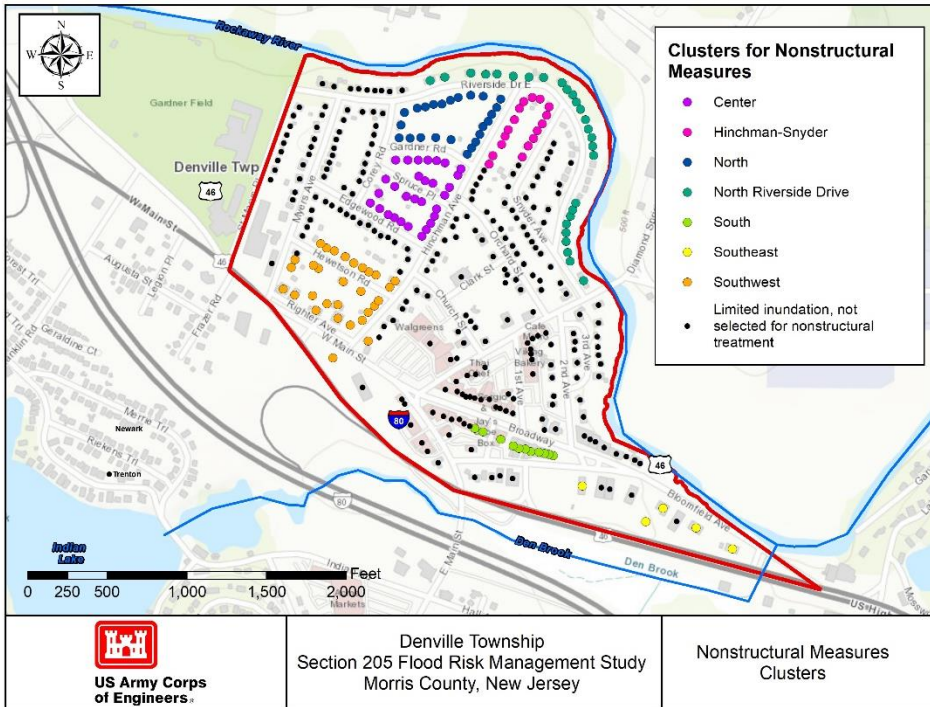
From the model detailed damage output and according to the plan formulation, the depth at 0.01 probability informs the additional height a structure will be lifted so that it can be protected against 1% AEP damages while the floodproofing height limit was set at 3 feet above the ground elevation.

The BCR for each cluster was computed and the clusters with negative net benefits were dropped. The structures within the seven clusters that remained (showed positive net benefits) were further evaluated. The annualized costs and benefits of nonstructural measures were developed for the remaining seven clusters, resulting in dropping 2 additional clusters from further study. Finally, the structures in the remaining five clusters were optimized per USACE policy. The purpose of the optimization was to reasonably maximize the net benefits of a chosen course of action.

The Southwest Cluster, containing 30 structures, was the first cluster to be evaluated to test the economic viability of the nonstructural measures. After briefing the non-Federal sponsor (NJDEP), the stakeholder (Township of Denville), and the USACE vertical team (VT) on the nonstructural measures, the Project Delivery Team (PDT) received consent to expand the nonstructural analysis to other structures in the study area. Several clusters were formed to account for all 372 structures in the study area. HEC-FDA models were run, and the BCR was computed for each cluster. According to the plan formulation, the clusters with

negative net benefits were dropped; this included the removal of 227 structures from further study. Seven clusters: Southwest, Center, North Riverside Dr, North, Hinchman-Snyder, South, and Southeast yielded BCRs greater than one and were moved forward for further analysis in this appendix. Figure 5 shows the seven clusters that were moved forward in the study area.

Figure 5: Seven Clusters with Positive Net Benefits Selected to TSP Milestone



Nonstructural treatments were applied to structures in the clusters using an algorithm that considered physical characteristics including building configuration, usage, footprint size, foundation type, and existing main floor elevation in order to select and cost the most appropriate/feasible treatment for each structure. The nonstructural analysis considered three physical measures with a combination of relocation and various nonphysical measures such as evacuation plans, land use regulation, flood emergency preparedness plans, flood insurance, flood mapping, flood warning systems, risk communication, and zoning. The three physical measures can be described under the following:

- Elevation: the structure is physically raised so that the main floor of the structure is at or above the specified design protection level.
- Dry floodproof: all openings are sealed or fitted with moveable watertight barriers and the exterior walls are treated to make them waterproof to the design protection level
- Wet floodproof: wet floodproofing is generally applied to structures with a main floor elevation already above the design protection level but that still incur significant damages due to the presence of basements and vulnerable utilities. Treatments include the vacating or filling of basements, removal of utilities, and the provision of equivalent facilities above the design protection level. Wet floodproofing also includes several minor treatments such as the raising of exterior air conditioning units and the provision of louvers in crawlspace walls to allow the equalization of hydrostatic pressure.

### 3.7.12.1. Residual Damages and Benefits

#### 3.7.12.1.1 Southwest Cluster

This cluster contains 30 structures, mostly residential. Six of these structures do not flood during a-1% AEP storm events, so they are not considered for further treatment. Fourteen structures will be elevated, six structures have been identified to receive dry floodproofing treatments, and four structures will receive wet floodproofing treatments. The six dry floodproofing structures have a large masonry construction or a slab foundation. Dry floodproofing has hydraulic limitations of 3 feet of impermeable barrier measured from the ground. A risk reduction to 1% AEP storm events would require impermeable barrier height of at least 3 feet, which is not acceptable hydraulically. Therefore, these structures would receive high risk reductions only. Table 17 shows the treatments applied to the structures and the HEC-FDA module assignments in the analyzed nonstructural alternative, and Table 18 summarizes damages and benefits in Upper Rockaway reach for the Southwest cluster.

Table 17: Measures and HEC-FDA Modules assigned to Southwest Structures

Structures Count	Nonstructural Measures	Module Assignment
6	Will not be subject to Treatment	Base
6	Will be dry flood proofed	Floodproof
4	Will be wet flood proofed	Floodproof
14	Will be elevated	Raise

Table 18: Summary of Damages and Benefits for Southwest Cluster (October-2020 price level, 2.5% Discount Rate)

Cluster	Damage Reach	Without-Project	With-Project	Annual Benefits
Southwest	Upper Rockaway	\$409,000	\$17,000	\$392,000

#### 3.7.12.1.2 Center Cluster

This cluster contains 30 residential structures. Seven of these structures do not flood during a-1% AEP events, so they are not considered for further treatment. Hence, they are not subject to treatments. Fourteen structures will be elevated, and nine structures have been identified to receive wet floodproofing treatments. Table 19 shows the treatments applied to the structures and the HEC-FDA module assignments in the analyzed nonstructural alternative, and Table 20 summarizes damages and benefits in Upper Rockaway reach for the Center cluster.

Table 19: Measures and HEC-FDA Modules assigned to Center Structures

Structures Count	Nonstructural Measures	Module Assignment
7	Will not be subject to Treatment	Base
None	Will be dry flood proofed	Floodproof
9	Will be wet flood proofed	Floodproof
14	Will be elevated	Raise

Table 20: Summary of Damages and Benefits for Center Cluster (October-2020 price level, 2.5% Discount Rate)

Cluster	Damage Reach	Without-Project	With-Project	Annual Benefits
Center	Upper Rockaway	\$232,000	\$33,000	\$199,000

### 3.7.12.1.3 North Riverside Drive Cluster

This cluster contains 27 structures, mostly residential. Seven of these structures do not flood during a-1% AEP storm events, so they are not considered for further treatment. Hence, they are not subject to treatments. Eighteen structures will be elevated, one structure will receive dry floodproofing, and another one has been identified to receive wet floodproofing treatments. The dry floodproofing structure has a large masonry construction or a slab foundation and will receive a 10% AEP risk damage reduction, and one of the structures that has been elevated will be protected against 1 percent AEP plus one foot of confidence level. Twenty-six structures in this cluster are located within the floodway. Treatments can be applied to structures in the floodway if the nonstructural solutions do not increase the stage and/or the velocity of the water in the floodway downstream and upstream. The structure that is receiving dry floodproofing is a facility that contains a sewer pump station. Dry floodproofing is suitable for a sewer pump facility. It is worth noting that the development in a floodway is discouraged but not prohibited by FEMA. Table 21 shows the treatments applied to the structures and the HEC-FDA module assignments in the analyzed nonstructural alternative, and Table 22 summarizes damages and benefits in Upper Rockaway reach for the North River Drive cluster.

Table 21: Measures and HEC-FDA Modules assigned to North Riverside Drive Structures

Structures Count	Nonstructural Measures	Module Assignment
7	Will not be subject to Treatment	Base
1	Will be dry flood proofed	Floodproof
1	Will be wet flood proofed	Floodproof
18	Will be elevated	Raise

Table 22: Summary of Damages and Benefits for North Riverside Drive Cluster (October-2020 price level, 2.5% Discount Rate)

Cluster	Damage Reach	<i>Without-Project</i>	<i>With-Project</i>	Annual Benefits
<b>North Riverside Drive</b>	Upper Rockaway	\$429,000	\$17,000	\$412,000

#### 3.7.12.1.4 North Cluster

This cluster contains 24 residential structures. Seven of these structures do not flood during a-1% AEP storm events, so they are not considered for further treatment. Twelve structures will be elevated, and five structures have been identified to receive wet floodproofing treatments. Table 23 shows the treatments applied to the structures and the HEC-FDA module assignments in the analyzed nonstructural alternative, and Table 24 summarizes damages and benefits in Upper Rockaway reach for the North cluster.

Table 23: Measures and HEC-FDA Modules assigned to North Structures

Structures Count	Nonstructural Measures	Module Assignment
<b>7</b>	Will not be subject to Treatment	Base
<b>None</b>	Will be dry flood proofed	Floodproof
<b>5</b>	Will be wet flood proofed	Floodproof
<b>12</b>	Will be elevated	Raise

Table 24: Summary of Damages and Benefits for North Cluster (October-2020 price level, 2.5% Discount Rate)

Cluster	Damage Reach	<i>Without-Project</i>	<i>With-Project</i>	Annual Benefits
<b>North</b>	Upper Rockaway	\$218,000	\$18,000	\$200,000

#### 3.7.12.1.5 Hinchman-Snyder Cluster

This cluster contains 18 residential structures. Two of these structures do not flood during a-1% AEP storm events, so they are not considered for further treatment. Hence, they are not subject to treatments. Six structures will be elevated, and ten structures have been identified to receive wet floodproofing treatments. All the structures in this cluster are receiving 1% AEP risk reduction. Table 25 shows the treatments applied to the structures and the HEC-FDA module assignments in the analyzed nonstructural

alternative, and Table 26 summarizes damages and benefits in Upper Rockaway reach for the Hinchman-Snyder cluster.

Table 25: Measures and HEC-FDA Modules assigned to Hinchman-Snyder Structures

Structures Count	Nonstructural Measures	Module Assignment
2	Will not be subject to Treatment	Base
None	Will be dry flood proofed	Floodproof
10	Will be wet flood proofed	Floodproof
6	Will be elevated	Raise

Table 26: Summary of Damages and Benefits for Hinchman-Snyder Cluster (October-2020 price level, 2.5% Discount Rate)

Cluster	Damage Reach	Without-Project	With-Project	Annual Benefits
Hinchman-Snyder	Upper Rockaway	\$106,000	\$23,000	\$83,000

### 3.7.12.1.6 South Cluster

This cluster contains 11 nonresidential structures. All 11 structures have been identified to receive dry floodproofing treatments. Table 27 shows the treatments applied to the structures and the HEC-FDA module assignments in the analyzed nonstructural alternative, and Table 28 summarizes damages and benefits in Upper Rockaway reach for the South cluster.

Table 27: Measures and HEC-FDA Modules assigned to South Structures

Structures Count	Nonstructural Measures	Module Assignment
None	Will not be subject to Treatment	Base
11	Will be dry flood proofed	Floodproof
None	Will be wet flood proofed	Floodproof
None	Will be elevated	Raise

Table 28: Summary of Damages and Benefits for South Cluster (October-2020 price level, 2.5% Discount Rate)

Cluster	Damage Reach	Without-Project	With-Project	Annual Benefits
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<b>South</b>	Upper Rockaway	\$131,000	\$21,000	\$110,000
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### 3.7.12.1.7 Southeast Cluster

This cluster contains 5 nonresidential structures. One structure will be elevated, and the remaining four structures have been identified to receive dry floodproofing treatments. Table 29 shows the treatments applied to the structures and the HEC-FDA module assignments in the analyzed nonstructural alternative, and Table 30 summarizes damages and benefits in Upper Rockaway reach for the Southeast cluster.

Table 29: Measures and HEC-FDA Modules assigned to Southeast Structures

Structures Count	Nonstructural Measures	Module Assignment
<b>None</b>	Will not be subject to Treatment	Base
<b>4</b>	Will be dry flood proofed	Floodproof
<b>None</b>	Will be wet flood proofed	Floodproof
<b>1</b>	Will be elevated	Raise

Table 30: Summary of Damages and Benefits for Southeast Cluster (October-2020 price level, 2.5% Discount Rate)

Cluster	Damage Reach	<i>Without-Project</i>	<i>With-Project</i>	Annual Benefits
<b>Southeast</b>	Upper Rockaway	\$140,000	\$31,000	\$109,000

The total number of structures in the seven clusters is 145. Among them 116 are receiving nonstructural treatments because 29 are not in the 1% AEP floodplain.

### 3.7.12.2 Summary of Annualized Screening Benefits and BCRs

The *equivalent* annual benefits of the alternatives were compared to the average annual costs to develop a BCR for the plans. The average annual net benefits were calculated by subtracting the average annual costs from the expected annual benefits. The average annual net benefits were used to determine the economic justification of the project measures. With-project (2026) and future with-project hydraulic conditions (2075) were used to compute equivalent annual benefits over a 50-year project life using an interest rate of 2.50 percent.

Seven clusters of structures have been evaluated in the Denville Township floodplain. HEC-FDA models were run, and the BCR was computed for protection of each cluster to the 1 percent AEP level with the preliminary costs developed by the team prior to the TSP milestone. The clusters with negative net benefits were dropped. Five clusters; Southwest, Center, North River Side Dr, North, and Southeast shown in Figure 5 yielded BCRs greater than 1.0 and were moved forward for further analysis. Nonstructural cost estimates for the final array were developed through a joint effort between the Baltimore District Cost Engineering,

Economics, Real Estate, Cultural Resources, and the Huntington District Cost Engineering Branches and were used to select the clusters with positive net benefits.

The tables below show the costs of non-structural treatments at the 1 percent AEP level to structures in each cluster. At this level of protection, the total cost is higher than the CAP 205 project funding limit of approximately \$15 million (\$10 million Federal with a 65/35 cost share). The amount of \$1.2 million has already been used for this study. The remaining approximately \$14 million will be used to finalize the design and to implement the project. It is necessary to point out that not all the property owners will be willing to participate in the nonstructural measures. In the event the project cost is higher than the CAP 205 project limits, USACE will authorize the final design and implementation if the Non-Federal sponsor agrees to pay the full surplus amount. Table 31 presents the cost summary for the clusters and Table 32 presents the annualized benefits, the annualized costs, the average annual net benefits, and the BCR for each cluster.

Table 31: Nonstructural Cost by Cluster at 1% AEP Level (October-2020 price level, 2.5% Discount Rate)

Cluster	First Cost	IDC	Investment Cost	Annual O&M Cost	Average Annual Cost
Southwest	\$7,710,000	\$16,000	\$7,726,000	--	\$272,000
Center	\$5,360,000	\$11,000	\$5,371,000	--	\$189,000
North Riverside	\$5,616,000	\$12,000	\$5,628,000	--	\$198,000
North	\$3,941,000	\$8,000	\$3,949,000	--	\$139,000
Hinchman-Snyder	\$3,326,000	\$7,000	\$3,333,000	--	\$118,000
South	\$4,412,000	\$9,000	\$4,421,000	--	\$156,000
Southeast	\$1,883,000	\$4,000	\$1,887,000	--	\$67,000

Table 32: Nonstructural Annualized Benefits & Cost, Average Annual Net Benefits, and BCR at 1% AEP Level (October-2020 price level, 2.5% Discount Rate)

Cluster	Total Benefits	Total Cost	Annual Benefits	Annual Costs	AA Net Benefits	BCR
Southwest	\$11,118,000	\$7,726,000	\$392,000	\$272,000	\$120,000	1.44
Center	\$5,644,000	\$5,371,000	\$199,000	\$189,000	\$10,000	1.05
North Riverside	\$11,685,000	\$5,628,000	\$412,000	\$198,000	\$214,000	2.08

<b>North</b>	\$5,672,000	\$3,949,000	\$200,000	\$139,000	\$61,000	1.44
<b>Hinchman-Snyder</b>	<b>\$2,354,000</b>	<b>\$3,333,000</b>	<b>\$83,000</b>	<b>\$118,000</b>	<b>(\$35,000)</b>	<b>0.70</b>
<b>South</b>	<b>\$3,120,000</b>	<b>\$4,421,000</b>	<b>\$110,000</b>	<b>\$156,000</b>	<b>(\$46,000)</b>	<b>0.71</b>
<b>Southeast</b>	\$3,091,000	\$1,887,000	\$109,000	\$67,000	\$42,000	1.63

Hinchman-Snyder and South clusters yield negative net benefits in a-1% storm events, consequently BCRs are less than 1. They were not considered further in the analysis. Table 33 shows the aggregation of the five positive clusters.

Table 33: Aggregation of 5 Clusters with Positive Net Benefits in the 1% AEP floodplain (October-2020 price level, 2.5% Discount Rate)

<b>Cluster</b>	<b>Total Benefits</b>	<b>Total Cost</b>	<b>Annual Benefits</b>	<b>Annual Costs</b>	<b>AA Net Benefits</b>	<b>BCR</b>
<b>Aggregation</b>	\$37,210,000	\$24,561,000	\$1,312,000	\$865,000	\$447,000	1.52

The total number of structures eligible for nonstructural measures in these five clusters is 116. Among them 89 structures are receiving treatments while 27 are not within the 1% AEP storm events.

### 3.7.12.3 Recurrent Damages

Recurrent flood losses are potential damages that are expected to occur at various flood stages. The 1% AEP storm events could cause estimated damages to residential and nonresidential properties in the amount of \$16.5 million in the without-project condition and \$3.7 million in the with-project condition. Tables 34 and 35 present dollar amounts for recurring losses by different annual exceedance probabilities for without and with-project conditions, respectively.

Table 34: Existing Condition Damages by Flood Frequency

<b>Annual Exceedance Probability (AEP)</b>	<b>Damage by Category (\$000)</b>		<b>Total Damage (\$000)</b>
	<b>Residential</b>	<b>Nonresidential</b>	
<b>50%</b>	269	133	402
<b>20%</b>	881	435	1,317
<b>10%</b>	2,114	1,044	3,158
<b>4%</b>	6,058	2,993	9,050
<b>2%</b>	8,598	4,247	12,845

<b>1%</b>	11,069	5,468	16,537
<b>0.5%</b>	13,589	6,713	20,302
<b>0.2%</b>	15,776	7,794	23,570

Table 35: With-Project Condition Damages by Flood Frequency

Annual Exceedance Probability (AEP)	Damage by Category (\$000)		Total Damage (\$000)
	Residential	Nonresidential	
<b>50%</b>	0.01	0.00	0.01
<b>20%</b>	0.01	0.01	0.02
<b>10%</b>	2	1	3
<b>4%</b>	90	56	146
<b>2%</b>	505	312	817
<b>1%</b>	2,272	1,401	3,673
<b>0.5%</b>	5,591	3,446	9,037
<b>0.2%</b>	7,854	4,841	12,696

There is a total of 372 structures in the Township of Denville, NJ. Each structure falls in one of two categories, Residential or Nonresidential. Table 36 shows the number of structures in each flood event. A total of 31 (= 372 - 341) structures are getting wet above 0.20% AEP.

Table 36: Structures in Floodplain

Land Use Category	50% AEP	20% AEP	10% AEP	4% AEP	2% AEP	1% AEP	0.40% AEP	0.20% AEP
Residential	16	29	57	120	182	214	232	246
Nonresidential	2	5	11	43	72	83	91	95
<b>TOTAL</b>	<b>18</b>	<b>34</b>	<b>68</b>	<b>163</b>	<b>254</b>	<b>297</b>	<b>323</b>	<b>341</b>

The numbers of populations at risk in 2%, 1%, 0.4%, and 0.2% AEPs are respectively 473, 556, 603, and 637.

Tables 37, 38, and 39 show respectively the values of damageable property, single occurrence damages, and single occurrence damages as percentage of property value.

**Table 37: Value of Damageable Property**

	50% AEP	20% AEP	10% AEP	4% AEP	2% AEP	1% AEP	0.40% AEP	0.20% AEP
\$/str	220	263	272	277	265	267	298	299
Residential	3,527	7,637	15,522	33,286	48,238	57,095	69,041	73,447
Residential Content	1,763	4,210	8,153	17,035	24,511	28,939	34,912	37,115
\$/str	318	346	383	705	866	844	884	888
Nonresidential	637	1,732	4,218	30,304	62,339	70,041	80,477	84,402
Nonresidential Content	820	3,186	4,897	19,352	36,475	39,486	49,315	50,993

Note: Numbers are in \$000s

**Table 38: Single Occurrence Damages**

	50% AEP	20% AEP	10% AEP	4% AEP	2% AEP	1% AEP	0.40% AEP	0.20% AEP
Residential Structure	270	1,050	2,814	6,898	11,513	16,693	21,810	27,040
Residential Content	98	345	890	2,143	3,476	4,853	6,266	7,553
Nonresidential Structure	72	269	806	4,132	8,606	14,214	18,615	24,973
Nonresidential Content	166	554	1,352	5,366	9,825	14,916	19,450	25,366

Note: Numbers are in \$000s

**Table 39: Single Occurrence Damages as Percentage of Property Value**

	50% AEP	20% AEP	10% AEP	4% AEP	2% AEP	1% AEP	0.40% AEP	0.20% AEP
Residential Structure	7.66%	13.75%	18.13%	20.72%	23.87%	29.24%	31.59%	36.82%
Residential Content	5.55%	8.20%	10.92%	12.58%	14.18%	16.77%	17.95%	20.35%
Nonresidential Structure	11.34%	15.54%	19.11%	13.63%	13.80%	20.29%	23.13%	29.59%
Nonresidential Content	20.21%	17.40%	27.62%	27.73%	26.94%	37.78%	39.44%	49.74%

Structures are getting damages across all the annual exceedance probabilities.

## 4 Project Costs

### 4.1 Structural Costs

Structural cost estimates were developed by the Baltimore District Cost Engineering Branch in the October-2020 price level, FY 2021. The Total Project Cost Summary (TPCS) was developed using 20 percent contingencies for Account 11 (Levees & Floodwalls), 10 percent for Account 30 (Planning Engineering & Design), and 10 percent contingencies for Account 31 (Construction Management) for all structural alternatives analyzed during the TSP milestone.

For comparison to the benefits, which are average annual flood damages reduced, the first costs were annualized and were based on the FY21 discount rate and a 50-year period of analysis. Interest during construction (IDC) was added to the first costs using 2026 as a base year. Interest during construction was calculated using an end of year payment schedule and 2.50 percent annual discount rate. Table 40 shows the duration of the construction for each alternative, Table 41 displays the IDC calculation for Alternative-1a, and Table 42 summarizes the project first cost, the IDC, investment cost, O&M cost, and the average annual cost. Note that the methodology for IDC calculation is the same for each alternative. Hence, the economic analysis does not show the detailed IDC computation for the rest of the alternatives.

Table 40: Interest During Construction (IDC) Period for Structural Alternatives

Alternative	IDC Period (Years)
Alt-1a	5
Alt-1b	5
Alt-1c	4
Alt-1d	4
Alt-1e	3
Alt-1f	3
Alt-2a	3
Alt-2b	3
Alt-2b Sensitive	3
Alt-3	3

Table 41: IDC Computation for Alternative-1a

<b>Project First Cost:</b>	\$83,702,000		
<b>Construction Period in Months</b>	60		
<b>Monthly payment</b>	\$1,395,033		
<b>Annual Discount Rate</b>	2.50%		
<b>Monthly Interest Rate</b>	0.002059836		
Month	Payment	Interest Factor	Interest
1	1,395,033	0.12908249	180,074
2	1,395,033	0.12676154	176,837
3	1,395,033	0.12444537	173,605
.	.	.	.
.	.	.	.
.	.	.	.

59	1,395,033	0.00205984	2,874
60	1,395,033	0.00000000	0
		<b>Total</b>	<b>\$5,295,000</b>

The top of floodwalls and the number of closure structures are the main differences between alts 1s.

The alternatives 1a (10 closure structures) and 1b (6 closure structures) are designed to keep floodwaters associated with the 1% storm events.

The alternatives 1c (10 closure structures) and 1d (6 closure structures) are designed to keep floodwaters associated with the 2% storm events.

The alternatives 1e (8 closure structures) and 1f (4 closure structures) are designed to keep floodwaters associated with the 4% storm events.

Alternatives 2s consist of the combination of floodwall, closures structures, and roads raising.

Alternative 2a is designed to protect a flood prone perimeter area associated with the 4% storm inundation floodwaters. As alts 1s, the top of floodwalls and the number of closure structures are the main differences between alts 2s.

The alternatives 2a (4 closure structures), 2b (2 closure structures), and 2b Sensitive (2 closure structures, Snyder Rd) are designed to keep floodwaters associated with the 4% storm events.

The O&M costs consist of labor and materials to perform yearly inspections of floodwall, closure structures, road, and small repairs during the 50-year life cycle of the project.

Table 42: Structural Project Cost Summary (October-2020 price level, 2.5% Discount Rate)

Alternative	First Cost	IDC	Investment Cost	Annual O&M Cost	Average Annual Cost
<b>Alt-1a</b>	\$83,702,000	\$5,295,000	\$88,997,000	\$74,000	\$3,212,000
<b>Alt-1b</b>	\$81,171,000	\$5,135,000	\$86,306,000	\$74,000	\$3,117,000
<b>Alt-1c</b>	\$71,770,000	\$3,586,000	\$75,356,000	\$74,000	\$2,731,000
<b>Alt-1d</b>	\$69,412,000	\$3,469,000	\$72,881,000	\$74,000	\$2,644,000
<b>Alt-1e</b>	\$62,105,000	\$2,292,000	\$64,397,000	\$74,000	\$2,345,000
<b>Alt-1f</b>	\$59,788,000	\$2,206,000	\$61,994,000	\$74,000	\$2,260,000
<b>Alt-2a</b>	\$22,036,000	\$813,000	\$22,849,000	\$69,600	\$875,000
<b>Alt-2b</b>	\$25,850,000	\$954,000	\$26,804,000	\$69,600	\$1,015,000
<b>Alt-2b Sensitive</b>	\$25,659,000	\$947,000	\$26,606,000	\$69,600	\$1,008,000
<b>Alt-3</b>	\$58,743,000	\$2,168,000	\$60,911,000	\$15,000	\$2,163,000

#### 4.2 Nonstructural Costs

Nonstructural cost estimates for the final array were developed through a joint effort between the Baltimore District Cost Engineering and the Huntington District Cost Engineering Branches. The costs were

compared and adjusted based on the local contractors' costs. A 29% contingency was applied to all nonstructural cost estimates, excluding the real state contingency, during the final-level phase of the study. The contingency represents the uncertainty regarding the cost and schedule risk of these measures. The contingency amount was computed during an abbreviated cost risk analysis using some of the most significant factors impacting cost associated with the Township of Denville Feasibility Study.

Interest during construction was calculated for the nonstructural alternatives on an end-period basis payment schedule using a 2.50 percent federal discount rate. Based on the Township of Denville project, the construction period will last 90 days on a single structure.

Real estate costs were incorporated in the nonstructural analysis, which included relocation assistance costs for tenants, and administrative costs. While elevation is voluntary, homeowners are not qualified to receive relocation costs. This relocation cost is included in the project first cost. A 20 percent contingency was applied to the real estate costs, which is separate from the contingency applied to the square foot cost estimates for elevation and floodproofing. A 22.32 percent contingency was applied to Cultural Resources costs in the Township of Denville.

#### 4.2.1 Elevation

The estimate of the cost to elevate the structures was computed once the 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 for each structure in the HEC-FDA module, and the cost of fill in the basement if needed. The number of feet that each structure was raised was rounded to next highest one-foot increment. Elevation costs by structure were summed to yield an estimate of total structure elevation costs.

Composite costs were derived for structures by type: single floor slab on grade, multi-floor slab on grade, single floor crawl space, and multi-floor crawl space. These composite unit costs also vary by the number of feet that structures may be elevated. Table 43 displays the costs for each of the four categories analyzed and by the number of feet elevated. The costs in this table do not include contingency, or any other supporting cost such as construction management or pre-construction engineering and design (PED) phase.

The cost per square footage to raise an individual structure to the target height was multiplied by the average footprint square footage of each structure's occupancy type to compute the costs to elevate the structure. The total costs for all elevated structures were annualized over the 50-year period of analysis of the project using the FY21 federal discount rate of 2.50 percent.

Temporary relocation costs are based on the cost of relocating the occupant, as required per Uniform Relocation Assistance and Real Property Acquisition Act of 1970 (URA), that has been removed from the acquired parcel. The elevation of the structure is voluntary. Hence, in this analysis the costs associated with temporary relocation include only assisting the tenants with moving costs and to stay in a hotel for a period of 90 days. Temporary relocation costs by structure were summed to yield an estimate of total structure relocation cost that is added to the Real Estate costs.

#### 4.2.2 Dry Floodproofing

The dry floodproofing costs were applied to non-residential structures, and some large masonry construction or slab foundation residential structures. Separate cost estimates were developed to dry flood proof based on square footage.

Table 43: Nonstructural Elevation Costs (\$/Sq. Ft.)

<b>Single Floor Crawl Space</b>		
<i>Lift</i>	<i>AVG SF</i>	<i>SF Cost</i>
11	1394	\$151
12	1069	\$188
13	1352	\$169
14	1363	\$173
<b>Multi-Floor Crawl Space</b>		
<i>Lift</i>	<i>AVG SF</i>	<i>SF Cost</i>
11	1449	\$152
12	1509	\$156
13	1530	\$161
14	1333	\$175
15	1090	\$206
<b>Single Floor Slab on Grade</b>		
<i>Lift</i>	<i>AVG SF</i>	<i>SF Cost</i>
7	1077	\$155
11	1140	\$179
12	1166	\$184
13	1600	\$164
14	1877	\$159
15	1157	\$203
16	1382	\$187
<b>Multi Floor Slab on Grade</b>		
<i>Lift</i>	<i>AVG SF</i>	<i>SF Cost</i>
5	4337	\$56
11	1670	\$155

12	1434	\$168
13	1665	\$159
14	1682	\$162
15	1244	\$207

### 4.2.3 Wet Floodproofing

The wet floodproofing costs were applied to non-residential structures, and some large masonry construction or slab foundation residential structures. The envelope of the structure for wet floodproofing included installing engineered flood vents, tearing out existing sheetrock, batt insulation, electrical outlets, and installing rigid foam wall insulation, Hardie® dry board, and elevating electric outlets. Costs for wet floodproofing also included blasting existing coatings and rust and applying two coats of epoxy coating. Costs include elevating some contents inside of the building.

### 4.2.4 Acquisition and Relocation

#### 4.2.4.1 Acquisition

The estimate of the cost of acquiring structures was evaluated during the plan formulation in the North Riverside Drive cluster. The treatment costs were compared to the maximum construction costs that the project can support based on BCR. One structure that has lower maximum construction supported costs relative to its treatment costs was selected. Acquisition costs are based on the cost of acquiring the parcel of land, the structure built on the land, and miscellaneous costs associated with the acquisition process. The cost of acquiring the parcel and the physical structure were provided by the Baltimore Real Estate Branch and was \$481,125. Added to the acquisition cost was the cost of demolition and restoration, which was evaluated to be \$220,000. Hence, the total acquisition cost was \$701,125. The depreciated replacement value of the structure was used to represent the cost of the structure, which was previously described as being sourced from Marshall & Swift. The structure elevated treatment cost was \$96,425 which is less than \$701,125, the total acquisition cost. The HEC-FDA model was run and the net benefits and the BCR were computed for the entire cluster. The net benefits without acquiring the structure were \$330,000 while it was \$310,000 with the acquisition of the structure. Hence, the acquisition alternative was ruled out before the TSP milestone.

## 5 Plan Evaluation and Comparison

The clusters that were determined to have positive BCRs for non-structural treatment at the 1 percent AEP level were reanalyzed at the 10 percent, 4 percent, and 2 percent levels. It was found that each of these were more cost effective than protection to the 1 percent AEP level. A total of 89 structures were found in the 1 percent AEP, while 28, 55, and 63 structures were in the 10, 4, and 2 percent AEP respectively. Similarly for the structural measures, the equivalent annual benefits were compared to the average annual cost to develop average annual net benefits and a BCR for each alternative. The average annual net benefits for each alternative were calculated by subtracting the average annual costs from the equivalent annual benefits. A BCR was derived by dividing average benefits by average annual costs. The average annual net benefits were used in conjunction with a BCR plan greater than 1.0 to identify the National Economic Development (NED) plan. For comparative purposes, Table 44 summarizes the equivalent annual benefits, average annual costs, the net benefits, and the BCR for each alternative.

The results in Table 44 show that the average annual net benefits are optimized in the Nonstructural 4% AEP aggregation. Since no other AEP aggregation (10% AEP, 2% AEP, or 1% AEP) exceeded the net benefits of the 4% AEP aggregation, and the net benefits are negative for all the structural alternatives. It was determined that the 4% AEP aggregation was optimized and would be utilized going forward.

As a result of the comparison of the alternatives, the Nonstructural 4% AEP Alternative was identified as the tentatively selected plan. The Nonstructural 4% AEP plan yielded the highest net benefits with a BCR greater than 1, which is the criterion used for identification of the NED Plan in accordance with the Federal objective. Therefore, the NED Plan, Nonstructural Alternative, was recommended to be the TSP.

Table 44: Summary of Benefits, Costs, and BCR for each Alternative (October-2020 price level, 2.5% Discount Rate)

Alternative	Total Benefits	Total Costs	Average Annual Benefits	Average Annual Costs	AA Net Benefits	BCR
<b>No Action</b>	---	---	---	---	---	---
<b>Alt-1a</b>	\$26,575,000	\$90,930,000	\$937,000	\$3,212,000	(\$2,269,000)	0.29
<b>Alt-1b</b>	\$26,575,000	\$88,405,000	\$937,000	\$3,117,000	(\$2,180,000)	0.30
<b>Alt-1c</b>	\$24,108,000	\$77,457,000	\$850,000	\$2,731,000	(\$1,881,000)	0.31
<b>Alt-1d</b>	\$24,108,000	\$74,990,000	\$850,000	\$2,644,000	(\$1,794,000)	0.32
<b>Alt-1e</b>	\$19,116,000	\$66,510,000	\$674,000	\$2,345,000	(\$1,671,000)	0.29
<b>Alt-1f</b>	\$19,116,000	\$64,099,000	\$674,000	\$2,260,000	(\$1,586,000)	0.30
<b>Alt-2a</b>	\$12,876,000	\$24,817,000	\$454,000	\$875,000	(421,000)	0.52
<b>Alt-2b</b>	\$26,207,000	\$28,788,000	\$924,000	\$1,015,000	(91,000)	0.91
<b>Alt-2b Sensitive</b>	\$26,150,000	\$28,589,000	\$922,000	\$1,008,000	(86,000)	0.91
<b>Alt-3</b>	\$13,415,000	\$61,348,000	\$473,000	\$2,163,000	(\$1,690,000)	0.22
<b>Alt-4 Nonstructural 10% AEP (10YR)</b>	\$26,462,000	\$8,411,000	\$933,000	\$297,000	\$636,000	3.14
<b>Alt-4 Nonstructural 4% AEP (25YR)</b>	\$35,368,000	\$16,110,000	\$1,247,000	\$568,000	\$679,000	2.20
<b>Alt-4 Nonstructural 2% AEP (50YR)</b>	\$36,389,000	\$18,257,000	\$1,283,000	\$644,000	\$639,000	1.99

## 6 Tentatively Selected Plan

According to the USACE Planning and Guidance Notebook (ER 1105-2-103), Chapter 2-3, (4):

*Section 904 of the Water Resources Development Act of 1986 (WRDA of 1986) requires the Corps to address the following matters in the formulation and evaluation of alternative plans:*

- *Protecting and restoring the quality of the total environment.*
- *The well-being of the people of the United States*
- *The prevention of loss of life.*
- *The preservation of cultural and historical values*

The ER goes on to state in Chapter 3-3 (11), Flood Damage Reduction:

*... An essential element of the analysis of the recommended plan is the identification of residual risk for the sponsor and the flood plain occupants, including residual damages and potential for loss of life, due to exceedance of design capacity. ...*

Moreover, ER 1105-2-101, Planning, Risk Assessment for Flood Risk Management Studies, 5. Context:

*...All flood risk managers must balance the insights of USACE's professional staff with stakeholder concerns for such matters as residual risks, life safety, reliability, resiliency and cost while acknowledging no single solution will meet all objectives, and trade-offs must always be made....*

For projects to be considered in the federal (USACE) interest for construction, project benefits must be greater than the costs of project implementation, creating a BCR greater than 1.0 and positive net benefits. According to this guidance, when screening the alternatives in this study, Alternative 4 - nonstructural measures was selected as the tentatively selected plan for this study as it is the only alternative to return positive net benefits and a BCR greater than 1. None of the structural protection measures were economically viable and were dropped from further consideration. Table 44 above shows the breakdown of the average annual net benefits and BCRs. After selection, Alternative 4 was used for further evaluation. Later in this report, optimization of the nonstructural alternative is conducted to determine the specific optimal protection level by cluster and what treatment they will receive.

### 6.1 Discussion of Four Accounts

In the 1970 Flood Control Act, Congress identified four national accounts for use in water resources development planning: National Economic Development (NED), Regional Economic Development (RED), Environmental Quality (EQ), and Other Social Effects (OSE). NED and EQ are considered to be national objectives. For this study, these benefits are measured by looking at the changes between the with and without project conditions. RED benefits are described as benefits that would impact the region, but not have wider national affects such as local employment, income and revenue loss. EQ benefits are primarily driven by ecosystem restoration and are minimally present in this study area while OSE includes factors such as life loss, community identity, and traditions.

### 6.2 Regional Economic Development (RED)

Regional Economic Development changes are factors that have an impact on the local Denville economy but may not have wider effects in the outside region. A significant factor in this account is local businesses' revenue and job gain or loss as well as future business prospects. Localized flood events could lead to closure of businesses creating a loss in revenue for the business and income for its employees. Road and

bridge closures due to flooding may also contribute to revenue/income loss for the area from the decreased ease of travel in and out of the study area. Flood prone areas are also much less attractive for potential new companies who want to move in and would bring employment opportunities with them. Preserving a tax base is also an important contributor for local economies and keeping viable industries and workforce sustained is a large factor in contributing to that goal. As mentioned earlier in this report, the township saw many people leave the area following large flood events that caused severe damage. Losses like this cause a reduction in the employment and tax base in the study area.

The Certified RECONS 2.0 model was used to estimate RED benefits for the nonstructural plan in the Township of Denville. The total cost the recommended plan (\$18,257,000) was used as input into the RECONS model. This RED analysis, using RECONS, employs input-output economic analysis, which measures the interdependence among industries and workers in an economy. This analysis uses a matrix representation of a region’s economy to predict the effect of changes, the implementation of a USACE project, to the various industries that would be impacted. The greater the interdependence among industry sectors, the larger the multiplier effect on the economy.

Direct effects represent the impacts the new federal expenditures have on industries that directly support the new project. Labor and construction materials are direct components to the project. Indirect effects represent changes to secondary industries that support the direct industries.

Of the total expenditures, 99 percent will be captured within the local study area. The remainder of the expenditures will be captured within the state or national level. These direct expenditures generate additional economic activity, often called secondary or multiplier effects. The direct and secondary impacts are measured in output, jobs, labor income, and gross regional product (value added) as summarized in Table 45. The construction stimulus in the Township of Denville would generate 283 full-time equivalent jobs, \$27,360,000 dollars labor income, and \$49,103,000 dollars output in the national level.

Table 45: Summary of Regional Economic Development Impacts of the Recommended Plan (October-2020 price level, 2.5% Discount Rate)

Area	Local Capture	Output	Jobs*	Labor Income	Value Added
<b>Local</b>					
<i>Direct Impact</i>		\$18,195,000	109.2	\$16,552,000	\$15,544,000
<i>Secondary Impact</i>		\$17,751,000	82.5	\$6,976,000	\$11,719,000
<i>Secondary Impact</i>	\$18,195,000	\$35,947,000	191.7	\$23,529,000	\$27,263,000
<b>State</b>					
<i>Direct Impact</i>		\$18,195,000	120.2	\$16,661,000	\$15,544,000
<i>Secondary Impact</i>		\$20,566,000	101.2	\$7,690,000	\$12,907,000
<i>Total Impact</i>	\$18,195,000	\$38,761,000	221.4	\$24,350,000	\$28,451,000
<b>US</b>					
<i>Direct Impact</i>		\$18,229,000	131.9	\$17,222,000	\$15,563,000
<i>Secondary Impact</i>		\$30,873,000	151.3	\$10,138,000	\$17,356,000
<i>Total Impact</i>	\$18,229,000	\$49,103,000	283.2	\$27,360,000	\$32,919,000

### 6.3 Environmental Quality (EQ)

Environmental quality can include factors such as ecosystem restoration, habitat creation, and endangered species protection. Cultural resources are also included in this account such as historic buildings and preservation sites. When compared to other plan alternatives presented in this report, the selected nonstructural plan has little effect on the environment in Denville Township as changes will be made to the structures affected and not the surrounding floodplain area. While this will not cause any damage to the environmental quality of the area, it is also unlikely to improve it in an impactful way. The nonstructural plan would be an effective measure to protect culturally or historically important buildings in the study area and while optional, the owners of these types of buildings may be more inclined to participate to preserve their cultural status.

Heathy Community Planning New Jersey (HCP-NJ) data shows concerns to Air Cancer Risk and Surface Water Quality in the Township of Denville.

The nonstructural plan selected will have a minor contribution of improving environmental quality of the community.

### 6.4 Other Social Effects (OSE)

The potential for flooding creates a life safety risk for people working in, living in or passing through an affected area such as Denville. As referenced earlier in this report, the population of Denville Township was around 18,000 people as of 2020. With limited warning time, the potential for life loss is present in the study area due to the concentration of homes and businesses along the path of the rivers. There are also risks associated with hindered employment and cost of emergency vehicles from a flood event. While those affected will need to voluntarily participate in the nonstructural treatment, those who do, should gain from the investment in the form of increased structure value; however, once public investment is made to protect a structure there will be restrictions to future modifications to ensure continued effectiveness of the non-structural treatment. That could have a negative effect on value. The net result would be determined by the market.

With consultation with the local sponsor, the project delivery team evaluated the optimization of plans. In addition, as a result of the comparison of the alternatives, the nonstructural alternative was identified as the TSP. Its benefits were greater than its costs. In other words, the nonstructural alternative maximizes net benefits, which is the criterion used for identification of the NED Plan in accordance with the Federal objective. Therefore, the NED Plan, the nonstructural alternative, was recommended to be the TSP.

#### 6.4.1 Life Loss

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 qualitatively discussed. HEC-FIA and HEC-LifeSim modeling software quantify loss of life for alternatives, especially the structural alternatives, to determine if life safety risk decreases or increases as a result of federal investment. Based on historical data there is no concern of life loss in the study area. The recommended plan is only nonstructural solutions. Since elevation and floodproofing will not have any impact on the water surface profile over a 50-year period of analysis, life loss analysis was evaluated in the Township of Denville using a qualitative assessment.

#### 6.4.2 Health and Safety

The health and safety of people living in the community within the project area were considered. Heathy Community Planning New Jersey (HCP-NJ) was used to assess social vulnerability of the population in the

Township of Denville, NJ. Some indicators that have concerns in the recent years are Heart Attack, Cancer Deaths Stroke, Childhood Blood Lead, and Heat Related Illness. It has been determined the OSE will not have a significant impact on the recommended plan.

The PDT evaluated the optimization of plans. The OSE and EQ accounts were about the same across alternative plans. Since RECONS uses expenditures to forecast future jobs and value added to the economy, the higher the cost, the more jobs and value are added to the economy. Hence, RED should not be the driving factor in selection of the Comprehensive Benefits Plan. The TSP was identified as Alternative Alt4- NS 4% AEP, which is the alternative that maximizes the positive net benefits.

Table 46 presents a comparative summary of the four accounts as required by the *Comprehensive Documentation of Benefits in Decision Document* of January 5, 2021.

Table 46: Summary of the four P&G Accounts

PLAN SUMMARY		Alt-1a	Alt-1b	Alt-1c	Alt-1d	Alt-1e	Alt-1f	Alt-2a	Alt-2b	Alt-2b Sensitive	Alt-3	Alt-4 NS 10% AEP	Alt-4 NS 4% AEP	Alt-4 NS 2% AEP
<b>Description</b>		Floodwall 1% AEP 10-Closure	Floodwall 1% AEP 6-Closure	Floodwall 2% AEP 10-Closure	Floodwall 2% AEP 6-Closure	Floodwall 4% AEP 8-Closure	Floodwall 4% AEP 4-Closure	Floodwall, Roads 4% AEP 4-Closure	Floodwall, Roads 4% AEP 2-Closure	Floodwall, Snyder Rd 4% AEP 2-Closure	Bypass Culvert 4% AEP	Elevation & Floodproofing	Elevation & Floodproofing	Elevation & Floodproofing
<b>Total Cost of the Project</b>		\$90.9M	\$88.4M	\$77.5M	\$75.0M	\$66.5M	\$64.1M	\$24.8M	\$28.8M	\$28.6M	\$61.3M	\$8.4M	\$16.1M	\$18.3M
<b>Comprehensive Benefits</b>		Low net benefits, low community resilience, difficult access to shopping center	Low net benefits, low community resilience, difficult access to shopping center	Low net benefits, low community resilience, difficult access to shopping center	Low net benefits, low community resilience, difficult access to shopping center	Low net benefits, low community resilience, difficult access to shopping center	Low net benefits, low community resilience, difficult access to shopping center	Low net benefits, low community resilience, difficult access to shopping center	Low net benefits, low community resilience, difficult access to shopping center	Low net benefits, low community resilience, difficult access to shopping center	Low net benefits, low community resilience, difficult access to shopping center	Positive net benefits while maintaining historic neighborhood character, access to water, and community resilience.	Maximizes net benefits while maintaining historic neighborhood character, access to water, and community resilience.	Positive net benefits while maintaining historic neighborhood character, access to water, and community resilience.
<b>National Economic Development (NED)</b>	<b>Net Benefits</b>	\$-2.3M	\$-2.2M	\$-1.9M	\$-1.8M	\$-1.7M	\$-1.6M	\$-0.4M	\$-0.09M	\$-0.09M	\$-1.7M	\$0.6M	\$0.7M	\$0.6M
<b>Regional Economic Development (RED)</b>	<b>Local-US Jobs</b>	821-1,214	799-1,180	700-1,034	677-1,001	601-888	700-1,034	224-331	260-384	258-382	554-819	76-112	146-215	164-244
	<b>Local-US Outputs</b>	\$179.0M-\$244.6M	\$174.1M-\$237.8M	\$152.5M-\$208.3M	\$147.6M-\$201.7M	\$131.0M-\$178.9M	\$152.5M-\$208.3M	\$48.9M-\$66.7M	\$56.7M-\$77.4M	\$56.3M-\$76.9M	\$120.8M-\$165.0M	\$16.6M-\$22.6M	\$31.7M-\$43.3M	\$35.9M-\$49.1M
	<b>Employment Income</b>	\$117.2M-\$136.3M	\$113.9M-\$132.5M	\$99.8M-\$116.1M	\$96.6M-\$112.4M	\$85.7M-\$99.7M	\$99.8M-\$116.1M	\$32.0M-\$37.2M	\$37.1M-\$43.1M	\$36.8M-\$42.8M	\$79.1M-\$91.9M	\$10.8M-\$12.6M	\$20.8M-\$24.1M	\$23.5M-\$27.4M
<b>Environmental Quality (EQ)</b>		No significant impacts.												
<b>Other Social Effects (OSE)</b>	<b>Life Loss</b>	No significant impact										No impact		
	<b>Social Vulnerability and Resilience</b>	▲ Increased community resilience ▲ Increase commute time and change historical characteristic and cultural identity.										▲ Maintain historical character and cultural identity.		
	<b>Economic Vitality</b>	▲ Increase job opportunity, income, and outputs												

## 7 Nonstructural Participation Rate Estimation and Sensitivity Analysis

### 7.1 Participation Rate Estimation

A participation rate sensitivity analysis was performed to describe the uncertainty of a voluntary mitigation program’s effects on the net benefits, the BCR, and the total project cost.

Before the TSP milestone, the economics team and the PDT members utilized the National Nonstructural Committee’s Best Practice Guide 03 (BPG 2020-03), which provides guidance on how to compute various participation rates. Two approaches were used to develop participation rates. The first approach used was the random selection, while the second approach focused on the net benefits to select the structures that will participate in nonstructural flood risk mitigations.

The logical structure selection method utilized for the first approach was the random number generator, which randomly selected structure records. Three sensitivities; 20 percent, 60 percent, and 80 percent participation rates were developed. The random approach did not bracket the potential for highest or lowest benefits. The random approach also did not select the structures based on being damaged during the specific AEP flood events. Incoherencies were found when comparing the random selection BCR’s results for different participation rates.

In the final array, the team ruled out the random selection method and adopted the theory of the 80 percent best-case scenario and 80 percent worst-case scenario selection approach, where the structures selected were based on the net benefits. Table 47 presents the 80 percent best case scenario, the 80 percent worst case scenario, and the 100 percent participation rate results. 80 percent best case scenario includes the 80% of structures that bring the highest net benefits while the 80 percent worst case scenario includes the 80% of structures with the lowest net benefits.

Table 47: Participation Rates qualitative assessment was evaluated for the Township of Denville study.

Participation Rate	Total Benefits	Total Cost	Annual Benefits	Annual Cost	AA Net Benefits	BCR
<b>80% Worst Case Scenario</b>	\$23,087,000	\$12,192,000	\$814,000	\$430,000	\$384,000	1.89
<b>80% Best Case Scenario</b>	\$33,723,000	\$13,470,000	\$1,189,000	\$475,000	\$714,000	2.50
<b>100% Full Participation</b>	\$35,368,000	\$16,110,000	\$1,247,000	\$568,000	\$679,000	2.20

The average annual net benefits and the BCR are \$384,000 and 1.89 for 80 percent worst case scenario, and \$714,000 and 2.50 for 80 percent best case scenario, respectively. The total cost of construction in both cases is under the CAP 205 limit: \$12,192,000 for the 80 percent Worst Case Scenario and \$13,470,000 for the 80 percent Best Case Scenario. This analysis proves that the calculated BCR for non-structural is robust and not contingent on a small number of high-benefit properties.

### 7.2 Sensitivity Analysis: Local Factors

Local factors were considered that will lead the property owners within a portion of the study area to participate on the nonstructural measures. The protection level for the nonstructural solutions is set to

reduce risk for the 1% AEP plus one foot of confidence levels according to the plan formulation. Based on the local building ordinance, the lowest living floor should be elevated above the Base Floor Elevation plus one foot.

The local populace has traditionally lived and established businesses in this area for an extended period and have family connections within the region potentially dating back generations. This investment of time and resources in the Township of Denville region will lead to an unwillingness to relocate, and therefore result in an increase in willingness to mitigate structures and maintain residency within the area.

Investing in flood mitigation to reduce future risk can have multiple impacts on the structures economic value. All else held constant, reducing the flood damage to a structure has the potential to increase the market value of a structure. Competing with this is that the tax assessor’s office may determine the structure to be worth more and consequently require the homeowner to pay additional property taxes. Negotiating with local tax assessor offices to forgo increasing the values of properties for those who willingly participate in nonstructural measures could be a strategy to increase participation.

When examining the participation rate sensitivity analysis, the PDT members concluded that the Township of Denville would likely have a marginally higher participation rate than other study areas across the country based on the feedback received from the non-Federal sponsor (NJDEP) and the stakeholder (Township of Denville). These property owners and communities are the ones that need these mitigation opportunities the most, as they are the ones that take the longest to recover after a flooding event. This study needs to have a strong public outreach component to help educate the community on the long-term benefits of flood risk mitigation to be successful and live up to the expected participation rates presented above.

## 8 Project Performance

ER 1105-2-101, Risk Assessment for Flood Risk Management Studies, provides the requirement to describe project performance by annual exceedance probability (AEP), assurance (conditional non-exceedance probability), and long-term exceedance probability (LTEP). Project performance describing these attributes is computed within HEC-FDA and is based on a target stage 1% AEP plus one foot of confidence levels. Table 48 presents the project performance consistent with ER 1105-2-101 for the existing. The future without project conditions provides the same results and is not shown in this appendix because it did not impact the stages of the nonstructural treatments as the hydraulic stages would not change in the future condition.

Table 48: Project Performance Without Project Conditions

Reach Name	Target Stage AEP		Long-Term Risk (Years)			Conditions Non-Exceedance Probability by Events					
	Median	Expected	10	30	50	10%	4%	2%	1%	0.4%	0.2%
Upper Rockaway	32	32	98	100	100	0.51	0.04	0.02	0.02	0	0
Den Brook	100	100	100	100	100	0	0	0	0	0	0

In the recommended plan, no structures are located on Den Brook reach. It is worth noting that reaches were not developed to provide responses to the nonstructural project performance analysis.

## 9 Optimization of the TSP

During the TSP optimization, structure values and measure costs were updated to FY22. For comparison to the benefits, which are average annual flood damages reduced, the costs were annualized. They were based on the FY22 discount rate of 2.25 percent and a 50-year period of analysis. Structure values were indexed using the Building Cost Index (BCI) comparing October-2020 (FY21) price levels to October-2021 (FY22) price levels. Structure values increased about 7.5% from FY21 to FY22.

In the current fiscal year 2023, the optimization was updated to reflect October-2022 (FY23) price levels using a discount rate of 2.50 percent. Each cluster was analyzed to determine the most efficient aggregation of structures with three aggregations explored: 1% AEP, 2% AEP, and 4% AEP. The aggregation includes the structures in each floodplain but does not impact the level of performance (LOP) the structure would receive. Each structure would be either raised to the 1% AEP plus 1 foot of confidence levels or floodproofed to a level at 3 feet above ground elevation. Nonstructural measures for each structure were determined by the initial analysis and carried forward. All H&H data was also carried forward.

Interest during construction was calculated for the nonstructural alternatives on an end-period basis payment schedule using a 2.50 percent federal discount rate, fiscal year 2023. Based on the Township of Denville project, the construction period will last 90 days on a single structure while it may take up to two years to implement nonstructural treatments for eligible structures. Table 49 shows the cost of nonstructural treatments for each cluster.

Table 49: FY 2023 Nonstructural Costs

Clusters	First Cost	IDC	Total Cost	Average Annualized Costs
Center	\$5,114,000	\$11,000	\$5,125,000	\$181,000
Hinchman Snyder	\$4,776,000	\$10,000	\$4,786,000	\$169,000
North	\$5,219,000	\$11,000	\$5,230,000	\$184,000
North Riverside Dr	\$6,611,000	\$14,000	\$6,625,000	\$234,000
South	\$5,037,000	\$10,000	\$5,047,000	\$178,000
Southeast	\$2,710,000	\$6,000	\$2,716,000	\$96,000
Southwest	\$7,175,000	\$15,000	\$7,190,000	\$254,000

Updated costs were provided by the Baltimore District Cost Engineering. This update indicated about a 91% increase in costs from original costs developed in FY21.

Table 50 presents FY21 and FY23 cost comparison in each cluster.

Table 50: Construction Cost Comparison

	Center	Hinchman-Snyder	North	North Riverside	South	Southeast	Southwest	Total
<b>2023 Costs</b>	\$5,125	\$4,786	\$5,230	\$6,625	\$5,047	\$2,716	\$7,190	\$36,719
<b>Original Cost</b>	\$3,240	\$2,006	\$2,382	\$3,395	\$2,561	\$1,088	\$4,570	\$19,242
<b>% Change</b>	58%	139%	120%	95%	97%	150%	57%	91%

Note: \$ in 000s

FDA version 1.4.3 was used during optimization. The aggregations were based on various AEPs. The aggregation with the highest net benefits was selected for the final array.

### 9.1 Southwest Cluster

The Southwest cluster consists of 30 structures. Six of these structures do not flood during a-1% AEP storm events, so they are not considered for further treatment. The without-project EAD was estimated at just over \$500,000. The 4% AEP aggregation was determined to maximize net benefits with 12 of the 30 structures being selected for nonstructural measures and annual net benefits above \$151,000. The specific breakdown of structures by AEP aggregation can be found in Table 51 below. Eleven additional structures were outside of the 1% AEP floodplain and were not included in any aggregation.

Table 51: Southwest Aggregation Optimization (October-2022 price level, 2.5% Discount Rate)

Southwest								
	Nonstructural Treatments Count	Raise	Floodproof	Expected Annual Damages	Average Annualized Benefits	Average Annualized Costs	BCR	Average Annualized Net Benefits
<b>Without</b>				\$500.50	\$ -	\$ -		\$ -
<b>1% AEP</b>	13	7	6	\$78.53	\$421.97	\$276.02	1.53	\$145.95
<b>2% AEP</b>	13	7	6	\$78.53	\$421.97	\$276.02	1.53	\$145.95
<b>4% AEP</b>	12	6	6	\$95.41	\$405.09	\$254.00	1.59	\$151.09

Note: \$ in 000s

### 9.2 Center Cluster

The Center cluster consists of 30 structures. Seven structures do not flood during a-1% AEP storm events, so they are not considered for further treatment. The without-project EAD was nearly \$294,000. The 4% AEP aggregation was determined to maximize net benefits with 12 of the 30 structures being selected for nonstructural measures and annual net benefits are \$61,800. The specific breakdown of structures by AEP aggregation can be found in Table 52 below.

Table 52: Center Aggregation Optimization (October-2022 price level, 2.5% Discount Rate)

Center								
	Nonstructural Treatments Count	Raise	Floodproof	Expected Annual Damages	Average Annualized Benefits	Average Annualized Costs	BCR	Average Annualized Net Benefits
<b>Without</b>				\$293.60	\$ -	\$ -		\$ -
<b>1% AEP</b>	23	14	9	\$30.92	\$262.68	\$346.92	0.76	(\$84.24)
<b>2% AEP</b>	15	11	4	\$40.90	\$252.70	\$226.25	1.12	\$26.45
<b>4% AEP</b>	12	10	2	\$50.80	\$242.80	\$181.00	1.34	\$61.80

Note: \$ in 000s

### 9.3 North Riverside Cluster

The North Riverside cluster consists of 27 structures. Eight of these structures do not flood during a-1% AEP storm events, so they are not considered for further treatment. The without-project EAD was estimated at \$543,000. The 4% AEP aggregation was determined to maximize net benefits with 14 of the 27 structures being selected for nonstructural measures and annual net benefits above \$269,000. The specific breakdown of structures by AEP aggregation can be found in Table 53 below.

Table 53: North Riverside Aggregation Optimization (October-2022 price level, 2.5% Discount Rate)

North Riverside								
	Nonstructural Treatments Count	Raise	Floodproof	Expected Annual Damages	Average Annualized Benefits	Average Annualized Costs	BCR	Average Annualized Net Benefits
<b>Without</b>				\$543.48	\$ -	\$ -		\$ -
<b>1% AEP</b>	19	18	1	\$19.35	\$524.14	\$318.20	1.65	\$205.94
<b>2% AEP</b>	15	14	1	\$28.63	\$514.85	\$250.84	2.05	\$264.01
<b>4% AEP</b>	14	13	1	\$40.00	\$503.49	\$234.00	2.15	\$269.49

Note: \$ in 000s

## 9.4 North Cluster

The North cluster consists of 24 structures. Seven structures do not flood during a-1% AEP storm events, so they are not considered for further treatment. The without-project EAD was estimated to be \$274,000. The 4% AEP aggregation was determined to maximize net benefits with 12 of the 24 structures being selected for nonstructural measures and annual net benefits just above \$60,000. The specific breakdown of structures by AEP aggregation can be found in Table 54 below.

Table 54: North Aggregation Optimization (October-2022 price level, 2.5% Discount Rate)

North								
	Nonstructural Treatments Count	Raise	Floodproof	Expected Annual Damages	Average Annualized Benefits	Average Annualized Costs	BCR	Average Annualized Net Benefits
<b>Without</b>				\$273.70	\$ -	\$ -		\$ -
<b>1% AEP</b>	17	12	5	\$18.60	\$255.10	\$261.04	0.98	(\$5.94)
<b>2% AEP</b>	15	12	3	\$21.21	\$252.49	\$230.01	1.10	\$22.48
<b>4% AEP</b>	12	11	1	\$29.46	\$244.24	\$184.00	1.33	\$60.24

Note: \$ in 000s

## 9.5 Hinchman-Snyder Cluster

The Hinchman-Snyder cluster consists of 18 structures. Two of these structures do not flood during a-1% AEP storm events, so they are not considered for further treatment. The without-project EAD was estimated to be \$133,000. The 4% AEP aggregation was determined to maximize net benefits with 13 of the 18 structures being selected for nonstructural measures and annual net benefits are negative, (\$58,000). The specific breakdown of structures by AEP aggregation can be found in Table 55 below.

Table 55: Hinchman-Snyder Aggregation Optimization (October-2022 price level, 2.5% Discount Rate)

Hinchman-Snyder								
	Nonstructural Treatments Count	Raise	Floodproof	Expected Annual Damages	Average Annualized Benefits	Average Annualized Costs	BCR	Average Annualized Net Benefits
<b>Without</b>				\$133.28	\$ -	\$ -		\$ -
<b>1% AEP</b>	16	6	10	\$18.83	\$114.45	\$208.00	0.55	(\$93.55)
<b>2% AEP</b>	14	6	8	\$20.52	\$112.76	\$182.00	0.62	(\$69.24)
<b>4% AEP</b>	13	6	7	\$22.05	\$111.23	\$169.00	0.66	(\$57.77)

Note: \$ in 000s

## 9.6 South Cluster

The South cluster consists of 11 structures. The without-project EAD was estimated to be \$163,000. The 4% AEP aggregation was determined to maximize net benefits with eight of 11 structures being selected for nonstructural measures and annual net benefits are negative, (\$71,000). The specific breakdown of structures by AEP aggregation can be found in Table 56 below.

Table 56: South Aggregation Optimization (October-2022 price level, 2.5% Discount Rate)

South								
	Nonstructural Treatments Count	Raise	Floodproof	Expected Annual Damages	Average Annualized Benefits	Average Annualized Costs	BCR	Average Annualized Net Benefits
<b>Without</b>				\$162.73	\$ -	\$ -		\$ -
<b>1% AEP</b>	11	0	11	\$25.05	\$137.68	\$244.75	0.56	(\$107.07)
<b>2% AEP</b>	11	0	11	\$27.43	\$135.30	\$244.75	0.55	(\$109.45)
<b>4% AEP</b>	8	0	8	\$55.83	\$106.90	\$178.00	0.60	(\$71.10)

Note: \$ in 000s

## 9.7 Southeast Cluster

The Southeast cluster consists of five structures. The without-project EAD was estimated to \$172,000. The 2% AEP aggregation was determined to maximize net benefits with four of the five structures being selected for nonstructural measures and annual net benefits were \$34,000. The specific breakdown of structures by AEP aggregation can be found in Table 57 below.

Table 57: Southeast Aggregation Optimization (October-2022 price level, 2.5% Discount Rate)

Southeast								
	Nonstructural Treatments Count	Raise	Floodproof	Expected Annual Damages	Average Annualized Benefits	Average Annualized Costs	BCR	Annualized Net Benefits
<b>Without</b>				\$171.69	\$ -	\$ -		\$ -
<b>1% AEP</b>	5	1	4	\$37.88	\$133.82	\$120.00	1.12	\$13.82
<b>2% AEP</b>	4	0	4	\$41.89	\$129.81	\$96.00	1.35	\$33.81
<b>4% AEP</b>	4	0	4	\$44.27	\$127.43	\$96.00	1.33	\$31.43

Note: \$ in 000s

Table 58 summarizes various AEP aggregations that maximize net benefits in each cluster. A total of 75 structures are in the clusters.

Table 58: Maximum Net Benefits in Each Cluster (October-2022 price level, 2.5% Discount Rate)

Final Array by Cluster								
Cluster	Aggregation	Raise	Floodproof	Total Floodproofing Costs	Average Annualized Costs	Average Annualized Benefits	BCR	Annualized Net Benefit
<b>Center</b>	4% AEP	10	2	\$5,125	\$181.00	\$242.80	1.34	\$61.80
<b>Hinchman Snyder</b>	4% AEP	6	7	\$4,786	\$169.00	\$111.23	0.66	(\$57.77)
<b>North</b>	4% AEP	11	1	\$5,230.00	\$184.00	\$244.24	1.33	\$60.24
<b>North Riverside</b>	4% AEP	13	1	\$6,625	\$234.00	\$503.49	2.15	\$269.49
<b>South</b>	4% AEP	0	8	\$5,047	\$178.00	\$106.90	0.6	(\$71.10)
<b>Southeast</b>	2% AEP	0	4	\$2,716	\$96.00	\$129.81	1.35	\$33.81
<b>Southwest</b>	4% AEP	6	6	\$7,190	\$254.00	\$405.09	1.59	\$151.09
<b>Total</b>		<b>46</b>	<b>29</b>	<b>\$36,667</b>	<b>\$1,293.00</b>	<b>\$1,743.56</b>	<b>1.35</b>	<b>\$450.56</b>

Note: \$ in 000s

Hinchman Snyder and South clusters yield negative net benefits. Both clusters are not considered further in the analysis. Table 59 shows clusters with positive net benefits. There are a total of 54 structures.

Table 59: Clusters with Positive Nets Benefits (October-2022 price level, 2.5% Discount Rate)

Cluster	Aggregation	Raise	Floodproof	Total Floodproofing Costs	Average Annual Costs	Average Annual Benefits	BCR	Annualized Net Benefit
Center	4% AEP	10	2	\$5,125.00	\$181.00	\$242.80	1.34	\$61.80
North	4% AEP	11	1	\$5,230.00	\$184.00	\$244.24	1.33	\$60.24
North Riverside	4% AEP	13	1	\$6,625.00	\$234.00	\$503.49	2.15	\$269.49
Southeast	2% AEP	0	4	\$2,716.00	\$96.00	\$129.81	1.35	\$33.81
Southwest	4% AEP	6	6	\$7,190.00	\$254.00	\$405.09	1.59	\$151.09
<b>Total</b>		<b>40</b>	<b>14</b>	<b>\$26,886.00</b>	<b>\$949.00</b>	<b>\$1,525.43</b>	<b>\$1.61</b>	<b>\$576.43</b>

Note: \$ in 000s

## 10 Recommended Plan

As discussed earlier in the report, Alternative 4, the nonstructural solutions, was presented as the tentatively selected plan (TSP). The solution was further evaluated by clustering the structures based on location and the various AEPs, and each cluster was optimized as shown in Section 9. CAP Section 205 has a maximum Federal cost for planning, design, and construction of \$10 million with the non-federal sponsor contributing a maximum of approximately \$5.4 million, or 35% of the total. Costs above this amount are the responsibility of the non-federal sponsor. Therefore, the recommended plan to implement non-structural flood risk management treatments in the North, North Riverside, and Southwest clusters are shown in Table 60 with a total cost of \$19 million assuming a 100-percent participation rate. The average annualized net benefits are \$481,000 and the BCR is 1.72 in the fiscal year 2023 price level, 2.5% discount rate.

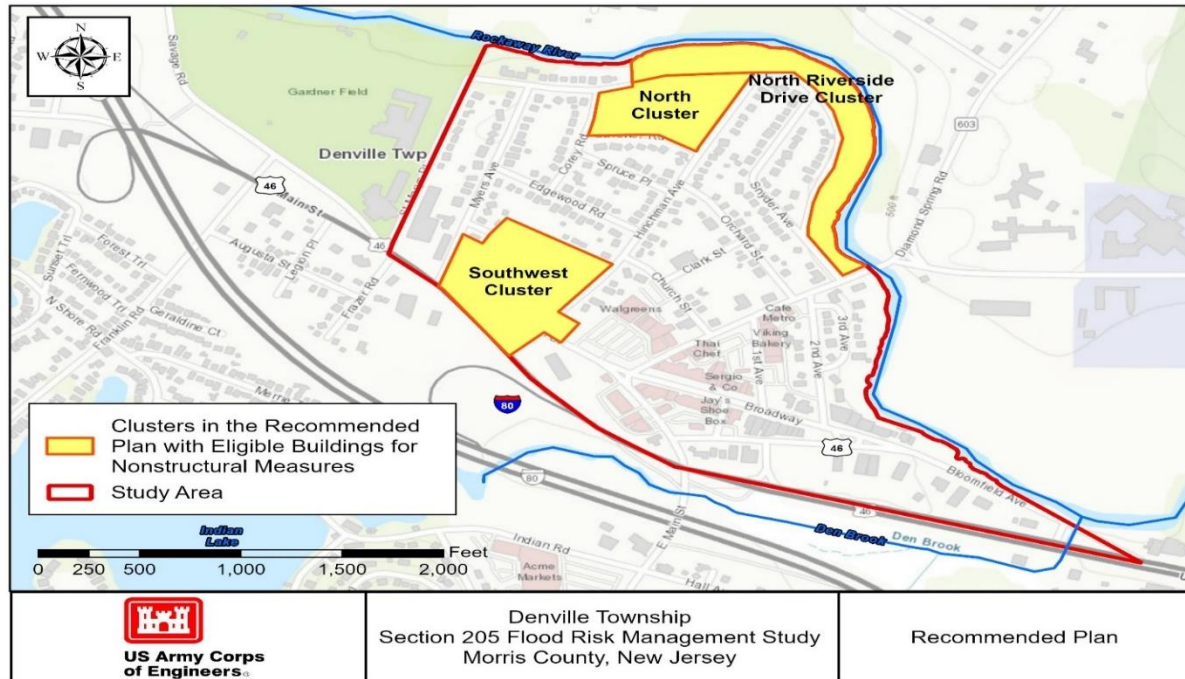
Table 60: Recommended Plan in FY 2023 (October-2022 price level, 2.5% Discount Rate)

Cluster	Aggregation	Raise	Floodproof	Total NS Treatments Costs	Average Annual Costs	Average Annual Benefits	BCR	Average Annualized Net Benefit
North	4% AEP	11	1	\$5,230	\$184.00	\$244.24	1.33	\$60.24
North Riverside	4% AEP	13	1	\$6,625	\$234.00	\$503.49	2.15	\$269.49
Southwest	4% AEP	6	6	\$7,190	\$254.00	\$405.09	1.59	\$151.09
<b>Total</b>		<b>30</b>	<b>8</b>	<b>\$19,045</b>	<b>\$672.00</b>	<b>\$1,152.82</b>	<b>1.72</b>	<b>\$480.82</b>

Note: \$ in 000s

Figure 6 shows the three clusters where nonstructural treatments to the building are proposed.

Figure 6: Clusters in FY 2023 Recommended Plan



Various combinations of clusters can be proposed as recommended plan to align with the CAP 205 cost limits. Since it is unlikely that all the 38 properties will participate to the nonstructural solutions, with the real participation rate, the cost of the project during the implementation will fall under the CAP 205 cost limits.

Public outreach should not be limited to these three clusters. Owners of structures that present the highest risk for flooding during frequent storm events (50% AEP, 20% AEP, 10% AEP...in general or structures with Base Flood Elevation below the ten percent water surface elevation) will likely be more willing to participate in implementing nonstructural treatments than those experiencing damages at 2% AEP or less frequencies. Structures that are not in the recommended plan can be reconsidered during construction to receive treatments as long as the funding will allow.

It is important to note that the recommended plan presented in Table 60 pictured the costs and benefits analyzed in the fiscal year 2023. In the fiscal year 2024, the updated Total Cost of the Project, and the Depreciated Replacement Values (DRV) of the structure were recomputed for the Final Integration Feasibility Analysis. The original DRV of the structures reflects October-2020 price level, FY 2021. In fiscal years 2022 and 2023, instead of updating the DRV of the structures and rerun the HEC-FDA model, an alternative method was used. That method consists of escalating the benefits to the new fiscal year using the RS Means historical cost indexes.

The methodology that consists of escalating the benefits to another fiscal year has large uncertainties built into it since Monte Carlo method is not used. Hence, in the fiscal year 2024, the updated DRV of structures was recomputed using RS Means Historical Cost Indexes and the economic model was rerun. Using 2021 and 2024 Square Foot Costs from RS Means data, the 2021 DRV of the structures were escalated to the FY 2024. Paterson City, NJ indices, the closest city found in RS Means Book to the study area were used. The structure values were appreciated only by 17.4 percent.

$$2024\text{ DRV} = \frac{\text{Index 2024}}{\text{Index 2021}} \times 2021\text{ DRV}$$

$$2024\text{ DRV} = \frac{274.3}{322.1} \times 2021\text{ DRV}$$

$$2024\text{ DRV} = 1.174 \times 2021\text{ DRV}$$

This light increase is attributed to the tax base falling from 2023 when city officials decreased the municipal tax base in the midst of a massive building boom. The seemingly incongruous situation of new construction rising while the city’s ratables are falling comes at a time when several hundred developments in Paterson have gotten tax breaks, many under the state “Growth Zone” law, designed to spur investments in some of the state’s struggling urban areas. Hence, the cost indexes dropped by 3.2 percent from 2023 to 2024 while they increased only by 2 percent from 2021 to 2022 and by 18.9 percent from FY 2022 to FY 2023.

The total cost of the project was increased by 20 percent from the FY 2023 to the FY 2024. It was \$19,045,000 in the FY 2023, and it is \$22,818,000 in the FY 2024. The marginal cost increase of nonstructural treatments surpassed the marginal DRV of the structures. Table 61 shows cost calculations and Table 62 summarizes costs, benefits, and BCR in each cluster in the FY 2024.

Table 61: Costs of the Project in Each Cluster (October-2023 price level, 2.75% Discount Rate)

Clusters	First Cost	IDC	Investment Cost	O&M	Total Cost	Average annualized Costs
North	\$6,126	\$14	\$6,140	\$0	\$6,140	\$227
North Riverside Dr	\$8,111	\$18	\$8,129	\$0	\$8,129	\$301
Southwest	\$8,530	\$19	\$8,549	\$0	\$8,549	\$317

Note: \$ in 000s

Table 62: Recommended Plan in FY 2024 (October-2023 price level, 2.75% Discount Rate)

Cluster	Aggregation	Raise	Floodproof	Total NS Treatments Costs	Total Benefits	Average Annual Costs	Average Annual Benefits	Average Annualized Net Benefit	BCR
North	4% AEP	11	1	\$6,140	\$6,209	\$227	\$230	\$3	1.0
North Riverside	4% AEP	13	1	\$8,129	\$12,635	\$301	\$468	\$167	1.6
Southwest	4% AEP	6	5	\$8,549	\$14,174	\$317	\$525	\$208	1.7
<b>Total</b>		<b>30</b>	<b>7</b>	<b>\$22,818</b>	<b>\$33,018</b>	<b>\$845</b>	<b>\$1,223</b>	<b>\$378</b>	<b>1.4</b>

Note: \$ in 000s

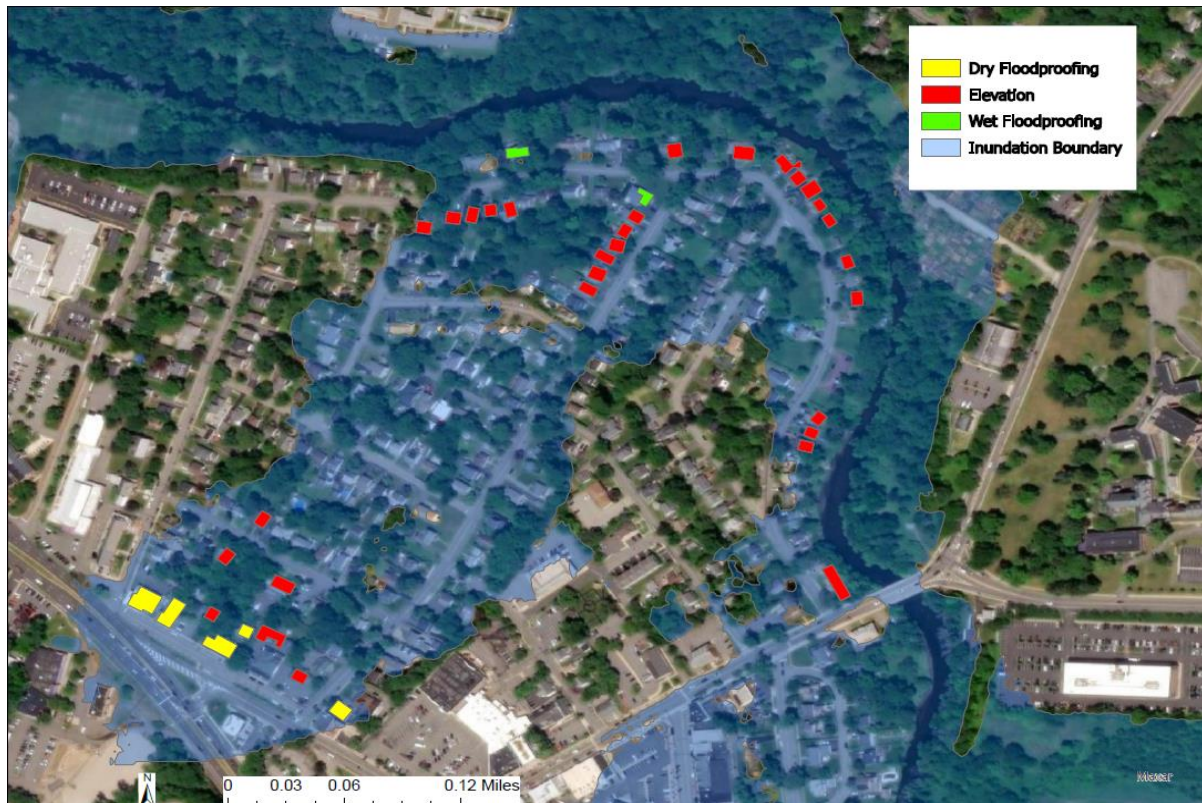
One of the structures proposed to receive floodproofing treatments in Southwest cluster was demolished and removed from the recommended plan in FY 2024. Hence, in the FY 2024 Thirty structures are recommended to be raised and seven structures are recommended to be treated with floodproofing measures. The total cost and the total benefits of the project are respectively \$22,818,000 and \$33,018,000 over a 50-year period of analysis. The total net benefits are \$10,205,000 with annualized net benefits of \$378,000. Table 63 shows the mitigation measure for the 37 structures receiving nonstructural treatments. The thirty structures proposed to receive elevation treatments will receive a 1% AEP flood risk reduction plus 1 foot of confidence level. The structures that will receive dry floodproofing treatments will be floodproofed at 3 feet above ground elevation while wet floodproofing will allow floodwaters to pass through some areas of the structure. Table 63 presents the mitigation strategy for the 37 assets.

Table 63: Mitigation Strategy for Recommended Plan

Mitigation Measure	Total Number of Structures	Residential	Non-residential
Elevation	30	28	2
Wet Floodproofing	2	1	1
Dry Floodproofing	5	0	5
<b>TOTAL</b>	<b>37</b>	<b>29</b>	<b>8</b>

Figure 7 shows nonstructural treatments received by each structure in the recommended plan.

Figure 7: Treatments of the 37 Structures in the Recommended Plan – FY 2024



## 11 Recommended Plan in FY 2025 with Major Cost Updates

The primary reason of the FY 2025 project cost increase is associated with the parametric estimates in the nonstructural plan and the design maturity. With a 10-percent design maturity, based on the Nonstructural Project Planning and Implementation guidance (22 July 2024), the current low level of design has significant risk and uncertainty that could increase costs during design and implementation. More site-specific analyses would need to be performed to bring the design maturity to the class 3 level. However, hydrologic and hydraulic efforts were used to better estimate the quantity to raise the structures associated with the economic benefits. Considering risks and assumptions noted, along with other concerns documented in Risk Register, the Cost and Scheduled Risk Analysis has increased Account 18: Cultural Resource Preservation contingency from 22.3% to 50.3% and Account 19: Buildings, Grounds & Utilities contingency from 33.0% to 61.0% for the defined project scope to capture the risk. A conditional certified cost will be required for this class 4 cost estimate at 10% design maturity. More information can be found in Design Maturity Memo.

There are three clusters (North, North Riverside, and Southwest) that contain 37 structures in the FY 2024 recommended plan. In October 2024, the BCR were reevaluated using an initial FY 2025 cost to quickly re-evaluate the RP before the final FY 2025 was developed.

Table 64: Initial FY 2025 First Cost

	North	North Riverside	Southwest	Total
<b>FY 2024 First Cost</b>	\$6,126	\$8,111	\$8,530	\$22,767
<b>FY 2025 Initial First Cost</b>	\$7,286	\$8,935	\$10,137	\$26,358
<b>% Change</b>	19%	10%	19%	16%

Note: \$ in 000s

The First Cost of the initial FY 2025 estimate was increased by 16 percent compared to FY 2024 First Cost.

Since North cluster BCR was 1.0 in FY 2024, and its cost is now increased by 19%, the updated BCR is now less than a unit. It has been determined to remove North cluster from the recommended plan.

In December 2024, North Riverside cluster and Southwest cluster costs were updated using 30 September 2024 Civil Works Construction Cost Index System (CWCCIS). Table 65 shows the FY 2025 costs.

Table 65: FY 2025 Costs of the Project (October-2024 price level, 3.0% Discount Rate)

Clusters	First Cost	IDC	Investment Cost	O&M	Total Cost	Average Annualized Costs
<b>North Riverside Dr</b>	\$9,152,000	\$23,000	\$9,175,000	\$0	\$9,175,000	\$357,000
<b>Southwest</b>	\$10,354,000	\$26,000	\$10,380,000	\$0	\$10,380,000	\$403,000

The benefits were also updated accordingly in the FY 2025. The price level was adjusted in the HEC-FDA model using October 2024 and October 2023 Building Cost Indices (BCI) from the Engineering News Record (ENR) by applying the following formula.

$$\text{Updated Price Index} = \frac{\text{October 2024 BCI}}{\text{October 2023 BCI}}$$

$$\text{Updated Price Index} = \frac{8404.93}{8255.58} = 1.018$$

The model was rerun using the FY 2025 discount rate of 3.0% and a 50-year period of analysis. Table 66 presents FY 2024 and FY 2025 average annualized benefits (AAB).

Table 66: FY 2024 AAB and FY 2025 AAB Comparison

	North Riverside	Southwest	Total
<b>FY 2024 AAB</b>	\$467.66	\$525.39	\$993.05
<b>FY 2025 AAB</b>	\$475.98	\$534.29	\$1,010.27
<b>% Change</b>	2%	2%	2%

Note: \$ in 000s

From FY 2024 to FY 2025, the average annualized benefits increased by 2 percent in each cluster, relatively lower than the increase of the cost.

Table 67 summarizes costs, benefits, and BCR in North Riverside and Southwest clusters.

Table 67: Final Recommended Plan in FY 2025 (October-2024 price level, 3.0% Discount Rate)

Cluster	Aggregation	Raise	Floodproof	Total NS Treatments Costs	Total NS Benefits	Average Annual Costs	Average Annual Benefits	Annualized Net Benefit	BCR
<b>North Riverside</b>	4% AEP	13	1	\$9,175,000	\$12,247,000	\$357,000	\$476,000	\$119,000	1.3
<b>Southwest</b>	4% AEP	6	5	\$10,380,000	\$13,740,000	\$403,000	\$534,000	\$131,000	1.3
<b>Total</b>		<b>19</b>	<b>6</b>	<b>\$19,555,000</b>	<b>\$25,987,000</b>	<b>\$760,000</b>	<b>\$1,010,000</b>	<b>\$250,000</b>	<b>1.3</b>

In the FY 2025 nineteen structures are recommended to be raised and six structures are recommended to receive floodproofing treatments. The total cost and the total benefits of the project are respectively \$19,555,000 and \$25,987,000 over a 50-year period of analysis. The total net benefits are \$6,432,000 with

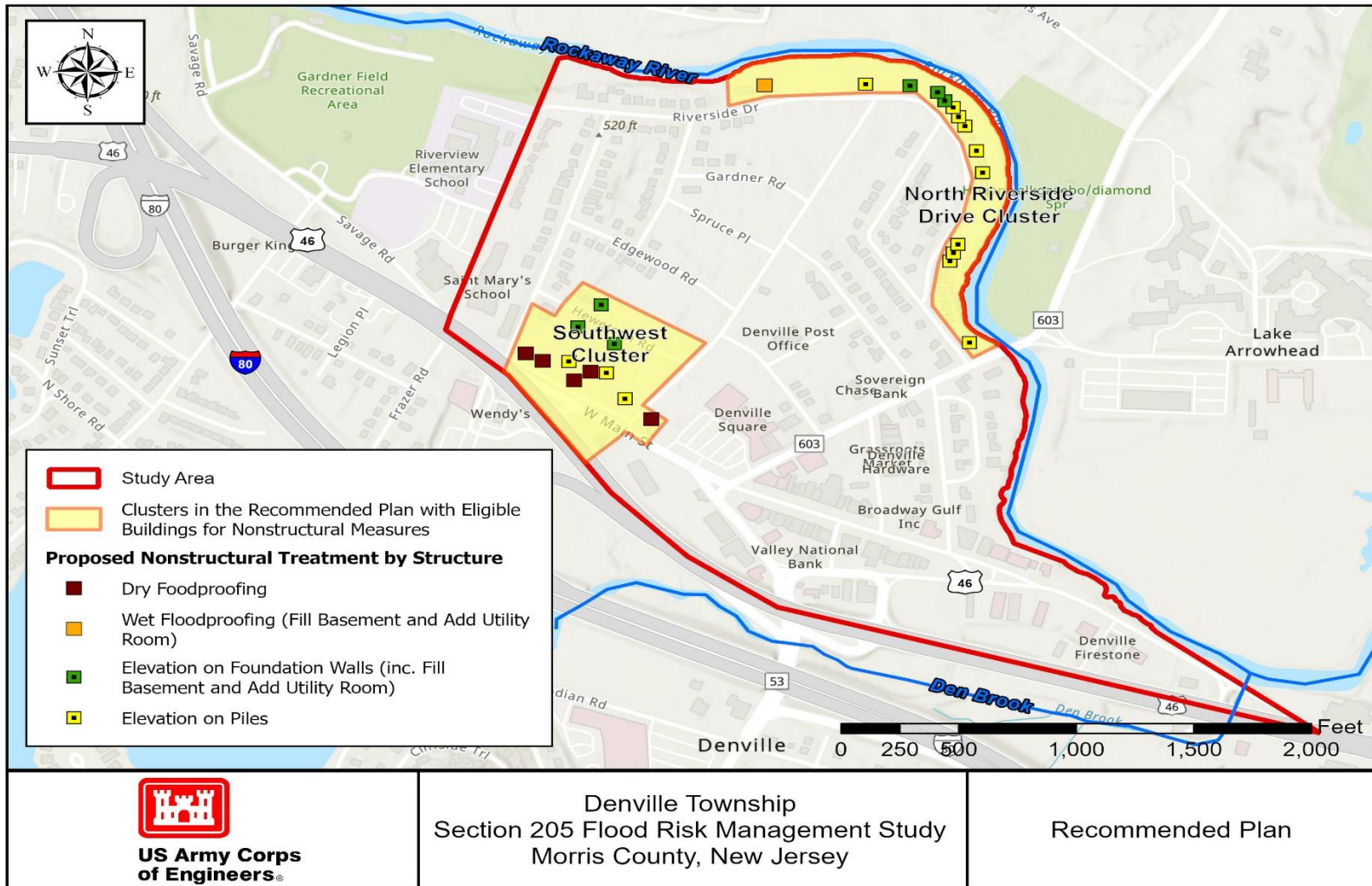
annualized net benefits of \$250,000. Table 68 shows the mitigation measure for the 25 structures receiving nonstructural treatments.

Table 68: Mitigation Strategy for Final Recommended Plan

Mitigation Measure	Total Number of Structures	Residential	Non-residential
Elevation	19	17	2
Wet Floodproofing	1	1	0
Dry Floodproofing	5	0	5
<b>TOTAL</b>	<b>25</b>	<b>18</b>	<b>7</b>

Figure 8 shows nonstructural treatments received by each structure in the FY 2025 final recommended plan.

Figure 8: Treatments of the 25 Structures in the FY 2025 Final Recommended Plan



## 12.0 Participation Rate Sensitivity Analysis

The Recommended Plan consists of 17 residential homes for elevation, 2 commercial buildings for elevation, 1 residential home for wet floodproofing, and 5 commercial buildings for dry floodproofing in the Township of Denville, NJ. The total project cost prepared for congressional Authorization is the estimated cost to implement 100% of the structures recommended for nonstructural measures. However, while project economics confirmed that 100% of these structures comprise a plan that reasonably maximizes National Economic Development (NED) benefits, these measures will be implemented on a voluntary basis. A participation rate scenario is a sensitivity analysis to determine the economic impact of various participation rates that will be used to communicate the uncertainty of implementing the nonstructural treatments to the stakeholders.

The PDT considered to analyze the best-case and the worst-case scenarios during the optimization. Hence, the highest and lowest 80-percent net benefits were computed in each cluster and for the aggregated recommended plan in order to help illustrate the uncertainty involved in this voluntary program.

### 12.1 North Riverside Cluster

The top 80 percent best scenario participation rate has positive net benefits of \$180,000 while the bottom 80 percent aggregation yields negative net benefits of \$55,000 in the North Riverside cluster.

Table 69: North Riverside Sensitivity Analysis (October-2024 price level, 3.0% Discount Rate)

North Riverside 4% AEP										
	Asset Count	Raise	Floodproof	Expected Annual Damages	Average Annualized Benefits	Average Annualized Costs	Total Benefits	Total Costs	Average Annualized Net Benefits	BCR
<b>Without</b>				\$482.65						
<b>100%</b>	14	13	1	\$6.67	\$475.98	\$357.00	\$12,247.00	\$9,175.00	118.98	1.3
<b>Top 80%</b>	11	11	0	\$21.61	\$461.04	\$280.50	\$11,862.00	\$7,217.20	180.54	1.6
<b>Bottom 80%</b>	11	10	1	\$257.20	\$225.45	\$280.50	\$5,801.00	\$7,217.20	(55.05)	0.8

Note: \$ in 000s

### 12.2 Southwest Cluster

Below table shows the participation rate sensitivity analysis for the Southwest cluster. The 80-percent best case scenario and the 80-percent worst case scenario in the Southwest cluster yield positive net benefits of \$133,550 and \$50,050 respectively.

Table 70: Southwest Sensitivity Analysis (October-2024 price level, 3.0% Discount Rate)

Southwest 4% AEP										
	Asset Count	Raise	Floodproof	Expected Annual Damages	Average Annualized Benefits	Average Annualized Costs	Total Benefits	Total Costs	Average Annualized Net Benefits	BCR
<b>Without</b>				\$571.53						
<b>100%</b>	11	6	5	\$37.24	\$534.29	\$403.00	\$13,740.00	\$10,380.00	\$131.29	1.3
<b>Top 80%</b>	9	6	3	\$108.25	\$463.28	\$329.73	\$11,920.00	\$8,483.80	\$133.55	1.4
<b>Bottom 80%</b>	9	5	4	\$191.75	\$379.78	\$329.73	\$9,772.00	\$8,483.80	\$50.05	1.2

Note: \$ in 000s

### 12.3 FY 2025 Final Recommended Plan

The participation rate sensitivity analysis for the final recommended plan indicates that the 80-percent best-case yield positive net benefits of \$314,090. While the 80-percent worst case scenarios yield negative net benefits of \$5,000, the benefit-to-cost ratio is equal to 1.0 as shown in Table 71.

Table 71: Final RP Sensitivity Analysis (October-2024 price level, 3.0% Discount Rate)

Recommended Plan 4% AEP										
	Asset Count	Raise	Floodproof	Expected Annual Damages	Average Annualized Benefits	Average Annualized Costs	Total Benefits	Total Costs	Average Annualized Net Benefits	BCR
<b>Without</b>				1,054.18						
<b>100%</b>	25	19	6	43.91	1,010.27	760.00	25,987.00	19,555.00	250.27	1.3
<b>Top 80%</b>	20	17	3	129.86	924.32	610.23	23,782.00	15,701.00	314.09	1.5
<b>Bottom 80%</b>	20	15	5	448.95	605.23	610.23	15,573.00	15,701.00	(5.00)	0.99

Note: \$ in 000s

The project cost of the 80-percent scenarios is approximately \$15 million. In the event the cost exceeds the CAP 205 project funding limits the Non-federal sponsor will pay the surplus before the Corps authorizes the final design and implementation.