Draft Final Integrated Interim Response Feasibility Report and Environmental Assessment For Initial Actionable Elements

NEW YORK-NEW JERSEY HARBOR AND TRIBUTARIES COASTAL STORM RISK MANAGEMENT FEASIBILITY STUDY

APPENDIX D ECONOMICS

1 Overview ... 6
2 Recommended Plan, East Riser ... 8
2.1 HEC-FDA 2.0.2 Inputs ... 8
2.1.1 Impact Areas ... 8
2.1.2 Hydraulic Inputs ... 10
2.1.3 Structure Inventory ... 14
2.1.4 Discounting Approach ... 18
2.1.5 Uncertainty ... 19
2.2 Draft Report Results ... 19
2.3 Final Report Results ... 20
2.3.1 National Economic Development (NED) ... 20
2.3.2 Regional Economic Development (RED) ... 27
2.3.3 Other Social Effects (OSE) ... 29
2.3.4 Life Safety ... 33
3 Draft Report Analysis of Deferred Actionable Element Sites - NED ... 36
3.1 Harlem River ... 36
3.1.1 HEC-FDA 2.0.2 Inputs ... 36
3.1.2 Structure Inventory ... 39
3.1.3 Occupancy Types ... 41
3.1.4 NYCT Tunnel Depth-Damage Function Development ... 42
3.1.5 Discounting Approach ... 46
3.1.6 Actionable Element Overview ... 46
3.1.7 Results ... 46
3.2 Oakwood Beach ... 48
3.2.1 Shoreline Stabilization ... 49
3.2.2 Wave Attenuation ... 50
3.2.3 Wildfire Risk Assessment ... 52
3.2.4 Wildfire Consequence ... 53
3.2.5 Estimated Wildfire Risk ... 55
3.2.6 Results ... 55
3.3 Comparison of Draft Report Alternatives ... 56
4 Draft Report Analysis of Deferred Actionable Element Sites - Regional Economic Development (RED) ... 57
4.1 Harlem River ... 57

4.2 Oakwood Beach ... 58
4.3 Impact Setting ... 59
5 Draft Report Analysis of Deferred Actionable Element Sites - Other Social Effects (OSE) ... 60
5.1 Harlem River ... 60
5.1.1 Life Safety ... 63
5.2 Oakwood Beach ... 64
6 References ... 65

LIST OF TABLES

Table 1: INTSLC – Equivalent Annual Damages (EqAD) Reduced (Benefits) for the East Riser Actionable Element ... 7
Table 2: Timelines for Evaluated Actionable Elements ... 7
Table 3: Draft Report - Stage-frequency functions for East Riser under the Without- and With-Project Conditions ... 11
Table 4: Flow-frequency functions for East Riser Impact Areas under the Base Year Without- and With-project conditions [CFS] ... 11
Table 5: Flow-frequency functions for East Riser Impact Areas under the Future Year Without- and With-project conditions [CFS] ... 12
Table 6: Stage Discharge functions for East Riser Impact Areas under the Future Year Without- and With-project conditions for INT SLC (Low, Most Likely, High Bound) [ft, NAVD88] ... 13
Table 7:Stage Discharge functions for East Riser Impact Areas under the Base Year Without- and With-project conditions for Low SLC (Low, Most Likely, High Bound) [ft, NAVD88] ... 13
Table 8: Summary of structures inventory included within the East Riser Impact Areas ... 15
Table 9: Updated Summary of structure inventory included within the East Riser Impact Areas ... 16
Table 10: Structure Count and Damageable Value in 1% and 0.2% AEP Floodplains ... 16
Table 11: Draft Report - Without- and With-project Expected Annual Damages (EAD) for the East Riser Actionable Element Impact Area, (HEC-FDA 2.0.2 outputs) ... 20
Table 12: Annualized coastal storm risk under the Without- and With-project condition and annualized coastal storm risk management benefit ... 20
Table 13: Probabilistic performance of the East Riser Actionable Element across Impact Areas ... 20
Table 14: Final Report - Without- and with-project Expected annual damages (EAD) for the East Riser Actionable Element by Damage Category, (HEC-FDA 2.0.2 outputs) (INTSLC) ... 21
Table 15: Final Report - Without- and with-project Expected annual damages (EAD) for the East Riser Actionable Element by Damage Category, (HEC-FDA 2.0.2 outputs) (LowSLC) ... 21
Table 16: Damages Reduced by AEP – Base Year (INTSLC) ... 22
Table 17: Damages Reduced by AEP - Future Year (INTSLC) ... 22
Table 18:Cost Breakdown for the East Riser Actionable Element ... 22
Table 19: INTSLC – Equivalent Annual Damages (EqAD) Reduced (Benefits) for the East Riser Actionable Element ... 23
Table 20:LowSLC - Equivalent Annual Damages (EqAD) Reduced (Benefits) for the East Riser Actionable Element ... 23
Table 21: HighSLC - Equivalent Annual Damages (EqAD) Reduced (Benefits) for the East Riser Actionable Element ... 23
Table 22: Probabilistic performance of the East Riser Actionable Element at each Impact Area for the Base Year Without- and With-Project Conditions (INTSLC) ... 25
Table 23: Probabilistic performance of the East Riser Actionable Element at each Impact Area for the Future Year Without- and With-Project Conditions (INTSLC) ... 25
Table 24: Probabilistic performance of the East Riser Actionable Element at each Impact Area for the Base Year Without- and With-Project Conditions (LowSLC) ... 26
Table 25: Probabilistic performance of the East Riser Actionable Element at each Impact Area for the Future Year Without- and With-Project Conditions (LowSLC) ... 26
Table 26: Overall Summary – East Riser ... 28
Table 27: Economic Setting ... 28
Table 28: Mental Health Impact of Flooding ... 32
Table 29: Without Project Displacement Costs ... 32
Table 30 Population at Risk (PAR) ... 35
Table 31: Life Loss Results ... 35
Table 32: Timelines for evaluated Actionable Elements ... 36

TABLE 33: SEA LEVEL CHANGE CONDITIONS CONSIDERED IN THIS STUDY AND CORRESPONDING FUTURE YEARS IN USACE SLC PROJECTIONS FOR THE BATTERY TIDE GAUGE IN NEW YORK CITY (STATION ID = 8518750) 38
TABLE 34: FREQUENCY FUNCTIONS (WATER SURFACE ELEVATIONS AT VARIOUS ANNUAL EXCEEDANCE PROBABILITIES; AEPS) UNDER THE SEA LEVEL CONDITIONS CONSIDERED IN THIS STUDY (NACCS SAVE POINT = 13,888) FOR THE HARLEM RIVER ACTIONABLE ELEMENT SITE 38
TABLE 35: SUMMARY OF STRUCTURES INVENTORY INCLUDED WITHIN THE HARLEM RIVER IMPACT AREA 40
TABLE 36: LINEAR AND QUADRATIC EQUATIONS CHARACTERIZING EXPECTED ANNUAL DAMAGES (EAD) OVER TIME UNDER USACE SEA LEVEL CHANGE (SLC) SCENARIOS 46
TABLE 37: WITHOUT- AND WITH-PROJECT EXPECTED ANNUAL DAMAGES (EAD) FOR THE HARLEM RIVER ACTIONABLE ELEMENT IMPACT AREA, (HEC-FDA 2.0.2 OUTPUTS) 47
TABLE 38: ANNUALIZED COASTAL STORM RISK AND PROJECT PERFORMANCE FOR THE HARLEM RIVER ACTIONABLE ELEMENT ACROSS USACE SLC SCENARIOS 47
TABLE 39: PROBABILISTIC PERFORMANCE OF HARLEM RIVER ACTIONABLE ELEMENT ACROSS SLC CONDITIONS 48
TABLE 40: SUMMARY OF QUALITATIVE ASSESSMENT OF WAVE ATTENUATION BENEFITS FOR THE OAKWOOD BEACH ACTIONABLE ELEMENT SITE 51
TABLE 41: ANNUALIZED WILDFIRE RISK UNDER THE WITHOUT- AND WITH-PROJECT CONDITION AND ANNUALIZED WILDFIRE RISK MANAGEMENT BENEFIT 55
TABLE 42: AVERAGE ANNUAL EQUIVALENT (AAEQ) ECONOMIC COSTS, BENEFITS, AND NET BENEFITS OF PROPOSED ACTIONABLE ELEMENT ALTERNATIVES 56
TABLE 43: OVERALL SUMMARY – HARLEM RIVER 57
TABLE 44: EAST HARLEM ECONOMIC ENVIRONMENT 58
TABLE 45: OVERALL SUMMARY - OAKWOOD BEACH 59
TABLE 46: OAKWOOD BEACH ECONOMIC ENVIRONMENT 59
TABLE 47: VULNERABLE POPULATIONS – HARLEM RIVER 60
TABLE 48: RESPIRATORY DISEASE PREVALENCE –HARLEM RIVER TRACTS 61
TABLE 49: DISPLACEMENT AT VARIOUS EXCEEDANCE PROBABILITIES –HARLEM RIVER 62
TABLE 50: DRIVERS OF ECONOMIC PRODUCTIVITY COMPARISON – HARLEM RIVER 62
TABLE 51: LSRI OUTPUT TABLE –HARLEM RIVER 64

LIST OF FIGURES

FIGURE 1: COMPARISON OF EAST RISER IMPACT AREAS DEVELOPED FOR THIS STUDY TO THOSE DEVELOPED FOR: A) SEPTEMBER 2022 DRAFT INTEGRATED FEASIBILITY REPORT/TIER 1 (PROGRAMMATIC) EIS, B) REBUILD BY DESIGN MEADOWLANDS (NJDEP, 2021C) 9
FIGURE 2: COMPARISON OF EAST RISER IMPACT AREAS DEVELOPED FOR THE 2025 DRAFT REPORT COMPARED TO THE 2026 FINAL REPORT 10
FIGURE 3: VISUAL COMPARISON OF STRUCTURES WITHIN THE EAST RISER IMPACT AREA AND REACH 12RBDMSU FROM SEPTEMBER 2022 DRAFT INTEGRATED FEASIBILITY REPORT/TIER 1 (PROGRAMMATIC) EIS 15
FIGURE 4: EXAMPLE OF STRUCTURE INVENTORY CHANGE BETWEEN DRAFT AND FINAL REPORTS 17
FIGURE 5: EXAMPLE DDF USED FOR DAMAGE CALCULATION 18
FIGURE 6: FEMA 1% FLOODPLAIN (FROM FEMA RESILIENCE ANALYSIS AND PLANNING TOOL) 30
FIGURE 7: SOCIAL VULNERABILITY STATISTICS 31
FIGURE 8: COMPARISON OF THE IMPACT AREA FOR THE HARLEM RIVER ACTIONABLE ELEMENT AND ECONOMIC REACH 20-B FROM SEPTEMBER 2022 DRAFT INTEGRATED FEASIBILITY REPORT/TIER 1 (PROGRAMMATIC) EIS (USACE, 2022B). 37
FIGURE 9: USACE SEA LEVEL CHANGE SCENARIOS (SLC) FOR THE BATTERY TIDE GAUGE IN NEW YORK CITY (STATION ID = 8518750) AND SPECIFIC SLC CONDITIONS USED IN THIS STUDY. 38
FIGURE 10: SAMPLE GRIDDED DATA HYDRAULIC INPUTS FOR 1% AEP EVENT WITH +0.49 FT SLC (USACE INTERMEDIATE, 2030) 39
FIGURE 11: VISUAL COMPARISON OF STRUCTURES WITHIN THE HARLEM RIVER IMPACT AREA AND REACH 20-B FROM THE SEPTEMBER 2022 DRAFT INTEGRATED FEASIBILITY REPORT/TIER 1 (PROGRAMMATIC) EIS. 40
FIGURE 12: DEPTH-DAMAGE FUNCTION FOR URBAN ROADWAY BRIDGES (WILLIAMS ET AL., 2025) 42
FIGURE 13: A) DEPTH-DAMAGE RELATIONSHIP CHARACTERIZING FRAGILITY OF A UNIT LENGTH OF SUBWAY TUNNEL; B) DAMAGE-VOLUME RELATIONSHIP UNDER CASE A (FLAT TUNNEL); C) DAMAGE-VOLUME RELATIONSHIP UNDER CASE B (VERTICAL SHAFT); D) DAMAGE-VOLUME RELATIONSHIP UNDER CASE C (COMBINATION OF CASES A AND B) 44
FIGURE 14: SAMPLE SURGE, AND WATER SURFACE ELEVATION OVER TIME AT THE 155TH ST STATION ENTRANCE 45
FIGURE 15: 155TH ST STATION AND NYCT TUNNEL: A) FLOOD DEPTH-VOLUME RELATIONSHIP, B) FLOOD DEPTH-DAMAGE RELATIONSHIP. 45
FIGURE 16: SHORELINE RECESSION FROM 1966 TO 2024 49
FIGURE 17: OBSERVATIONS OF SHORELINE EROSION VIA SATELLITE IMAGERY (GOOGLE EARTH, N.D.) 50
FIGURE 18: WILDFIRE HAZARD AND TRANSFORM FUNCTION CHARACTERIZING WILDFIRE RISK TO THE OAKWOOD BEACH ACTIONABLE ELEMENT SITE. 53
FIGURE 19: WITHOUT-PROJECT WILDFIRE CONSEQUENCE FUNCTION, CONSIDERING THE POTENTIAL FOR DAMAGE TO THE SSSI FLOODWALL ADJACENT TO THE OAKWOOD BEACH ACTIONABLE ELEMENT SITE 54
FIGURE 20: WITH-PROJECT WILDFIRE CONSEQUENCE FUNCTION, CONSIDERING THE POTENTIAL FOR DAMAGE TO THE SSSI FLOODWALL ADJACENT TO THE OAKWOOD BEACH ACTIONABLE ELEMENT SITE 55

1 OVERVIEW

The New York District (NYD) Corps of Engineers conducted a feasibility level study to evaluate coastal storm risk management (CSRM) on the New York New Jersey Harbors and Tributaries Study (NYNJHAT) area.

At the time of the release of the Draft Integrated Interim Feasibility Report and Environmental Assessment in July 2025, the Tentatively Selected Plan (TSP) chosen for advancement was Alternative C, the Total Net Benefits Plan. This alternative included the Harlem River, Oakwood Beach, and East Riser Actionable Elements. However, prior to release of the Draft Integrated Interim Response Feasibility Report and Environmental Assessment, the study team, which includes the NYD, New Jersey Department of Environmental Protection (NJDEP), New York State Department of Environmental Conservation (NYSDEC), New York City Department of Environmental Protection (NYCDEP), and New York State Department of State (NYSDOS) confirmed that the Harlem River Actionable Element would not be sufficiently developed or detailed to support USACE design maturity requirements within the timeline for inclusion in a Chief of Engineer’s Report, which could be considered by Congress for authorization in a potential Water Resources Development Act (WRDA) of 2026. Noting this with the need for more robust and meaningful public engagement, as well as the additional engineering analyses needed to meet the USACE engineering design requirement standards, the study team released the Draft Integrated Interim Response FR/EA in July of 2025 with the caveat that the Harlem River Actionable Element would be deferred to a later iteration of Actionable Elements to consider, subject to the future availability of funds.

The other Actionable Elements, East Riser and Oakwood Beach, have since been optimized after having undergone public review and coordination. These Actionable Elements and the analyses done to advance their associated engineering designs are outlined within this Interim Response Report. Specifically, the East Riser Actionable Element has been sufficiently studied and is ready for potential Congressional consideration, to be authorized in WRDA 2026 as a Recommended Plan, Alternative B.

The Oakwood Beach Actionable Element was initially justified as part of Alternative C, by considering a comprehensive benefits analysis, in which this site specifically maximized benefits within the EQ and OSE accounts, and had positive NED account benefits. While USACE recognizes the benefit this Actionable Element Project would provide and the public support for this element as a Nature-Based Solution, as the study team analysed Oakwood Beach further, it became evident that it would not be ready for inclusion in the final report as the minimum design maturity would not have been achieved nor would the project cost estimates been developed to meet acceptable requirements.. Therefore, USACE is recommending deferral of the Oakwood Beach Actionable Element until such time that the necessary information can be further developed to meet current regulations and policy. Accordingly, the Oakwood Beach Actionable Element has been removed as part of the NY District’s Recommended Plan for advancement through a Chief of Engineer’s Report, for Congressional authorization within a potential WRDA 2026.

After careful evaluation of the alternatives and their trade-offs, and consideration of the optimization done since the July 2025 Draft Report the study team selected Alternative B, East Riser Actionable Element, as the Recommended Plan. East Riser also considers multiple flood drivers as requested by the State of New Jersey through Section 8106(a) of WRDA 2022 through the confluence of coastal and riverine flood drivers.

The Recommended Plan includes channel modifications, two bridge culvert replacements, and a railroad bridge replacement on East Riser Channel in Carlstadt and Moonachie, New Jersey. Channel modifications, more specifically, include widening and deepening of the East Riser Channel, bank stabilization, and replanting of vegetation.

Section 2 of this appendix documents the updated economic assessment conducted for the Recommended Plan, East Riser Actionable Element as described in the main body of the Final Integrated Interim FR/EA. The economic analyses as presented here focus on the National Economic Development (NED) benefits for the East Riser Site. These benefits are primarily management of flood risk to structures and their contents within the Actionable Element site. Pursuant to current guidance on assessment of comprehensive benefits as outlined in ER 1105-2-103 (5-4(b)), this appendix also details assessments of other project benefits, some of which are quantitatively assessed or qualitatively described. NED CSRM damages and benefits are monetized via the Hydraulic Engineering Center - Flood Damage Reduction Analysis (HEC-FDA) software. Table 1 below summarizes the Benefits, Costs, and Benefit Cost Ratio (BCR) of the East Riser Recommended Plan.

Table 1: INTSLC – Equivalent Annual Damages (EqAD) Reduced (Benefits) for the East Riser Actionable Element

Impact Area	Flood Risk Management Benefit (Annualized)	Bridge Replacement Benefits	Average Annual Cost	Benefit-Cost Ratio (BCR)	Average Annual Net Benefit (AANB)
Amor Rd.	$410,000	-	-	-	-
Airport Culvert	$2,447,000	$130,000	-	-	-
Rt. 46	$9,459,000	-	-	-	
Airport South	$86,000	-	-	-	
Airport West	$86,000	-	-	-	
Moonachie Bridge	$150,000	-	-	-	
TOTAL	$12,638,000	$130,000	$8,426,000	1.5	$4,342,000

FY2026 Price Levels; Federal Discount Rate = 3.25%; 50-year period of analysis (2037-2086)

The base year of 2037 was used for all economic calculations with construction assumed to start in 2030. The key years and time periods associated with each alternative, applied in accordance with ER 1105-2-103, are presented in Table 2. All economic values presented in the East Riser section of the report are in FY2026 price levels. Where applicable, benefits and costs were discounted to the project base year presented in Table 2 using the FY2026 Project Evaluation and Formulation Rate (Federal discount rate) of 3.25%, as specified in EGM 26-01.

Table 2: Timelines for Evaluated Actionable Elements

Actionable Element	Start of Construction	End of Construction	Base Year	End of Period of Analysis	Years of Full Benefits
East Riser	2033	2037	2037	2086	50

What follows is a detailed description of the economic assessment conducted for the Recommended Plan, at the East Riser site. Following that analysis, is the economic analysis conducted at Harlem River and Oakwood Beach for the Draft Report. While no economic updates were made for these sites between the release of the Draft and Final Reports, they were included for informational purposes. The economic analysis and discussion of the actionable element sites that were included at the time of the release of the Draft Integrated Interim Response Feasibility Report and Environmental Assessment for Actionable Elements (DIIRFREA) have been since deferred to a later response effort.

2 RECOMMENDED PLAN, EAST RISER

Flood risk under the with- and without-project conditions for the East Riser Actionable Element site was assessed via HEC-FDA version 2.0.2 (IWR, 2023). Where appropriate, this study relies upon the existing inputs from a prior HEC-FDA version 1.4.2 model developed for the NJDEP Rebuild by Design Meadowlands (RBDM) feasibility study (NJDEP, 2021a) and updated inputs as described. Details of the economic assessment conducted as part of this prior study are provided in Appendix E (NJDEP, 2021c). There are several differences between HEC-FDA 1.4 and version 2.0.2, which necessitated the development of additional model inputs. Where applicable, this appendix details and describes these changes.

This study assessed fluvial flood risk within the southernmost portion of the East Riser Channel basin. Given the low elevation of the basin, fluvial flood risk in this area is heavily influenced by tidal tailwater conditions. Given the correlation of rainfall and tidal condition within the Actionable Element site (NJDEP, 2021b), the hydraulic modeling relied upon the 2-year tide as a tailwater boundary condition. Expected flow rates within the basin were assessed via HEC-HMS; extent and severity of flooding within the basin was characterized via HEC-RAS. Additional details on the hydraulic modeling can be found in the Engineering Appendix (Appendix B).

As part of the Rebuild by Design – East Riser Project, done by the NJDEP in 2019, the cost estimate for “Alternative 2” was around $128,000,000 for all project features, to include the pump station, and $118 Million without the pump station included, as USACE is currently recommending. This cost was escalated by USACE to reflect the FY25 price levels and was estimated at $249,000,000 (FY25 price level), with a 52.47% contingency included to account for risk and uncertainty, in the July 2025 Draft FR/EA. More information on the current costs projected for this Actionable Element can be found in Appendix C

NJDEP’s RBDM study recommended the channel modifications of East Riser and the pump station as one project. The intent was for both the channel modifications and pump station to work as a system. The NJDEP is implementing the pump station, and it is expected to be completed prior to the end of construction for the East Riser Actionable Element. Without channel modifications, the pump station would not provide flood risk management benefits at the intended level of performance. Consequently, it is likely that any reductions in water surface elevation provided by the pump station alone would be limited. To capture the true impact of the project, as agreed upon and USACE leadership and non-Federal sponsors and partners, the pump station and channel modifications are being treated as a system for the purposes of reporting project benefits. The with-project scenario includes both the channel modifications and the pump station.

What follows is a summary of the HEC-FDA 2.0.2 inputs developed and employed for the East Riser Actionable Element site. This summary is followed by a detailed description of the discounting approach, description of the actionable element modeled in HEC-FDA 2.0.2, and presentation of the economic analysis results both for the draft report release, as well as updates made for the final report.

2.1 HEC-FDA 2.0.2 INPUTS

2.1.1 Impact Areas

Appendix D of the September 2022 Draft Integrated Feasibility Report/Tier 1 (Programmatic) EIS (USACE, 2022b) presents the economic reaches considered during the formulation of the draft comprehensive plan. These reaches were originally delineated based on county boundaries, tidal water bodies, expected maximal extent of damage (corresponding to +20 ft NAVD88), and hydraulic separability. The East Riser Actionable Element site corresponds to a subsection of economic reach 12-RBDMSU (Rebuild by Design Meadowlands Shore-Based Measures Upper Area), as shown in Figure 1. In alignment with the NJ Rebuild by Design Meadowlands (RBDM) study, wherein the economic model reaches (NJDEP, 2021c) were informed by drainage basin delineations (NJDEP, 2021b) and further informed by additional drainage basin delineation provided via USGS StreamStats (USGS, 2025), this study developed a refined set of impact areas, specific to the proposed actionable element study area, shown in Figure 1**Error! Reference source not found.**. In addition to the primary drainage basin of interest, East Riser Channel South, portions of adjacent RDBM subbasins were also included as these areas are also likely to be influenced by the proposed East Riser actionable element project.

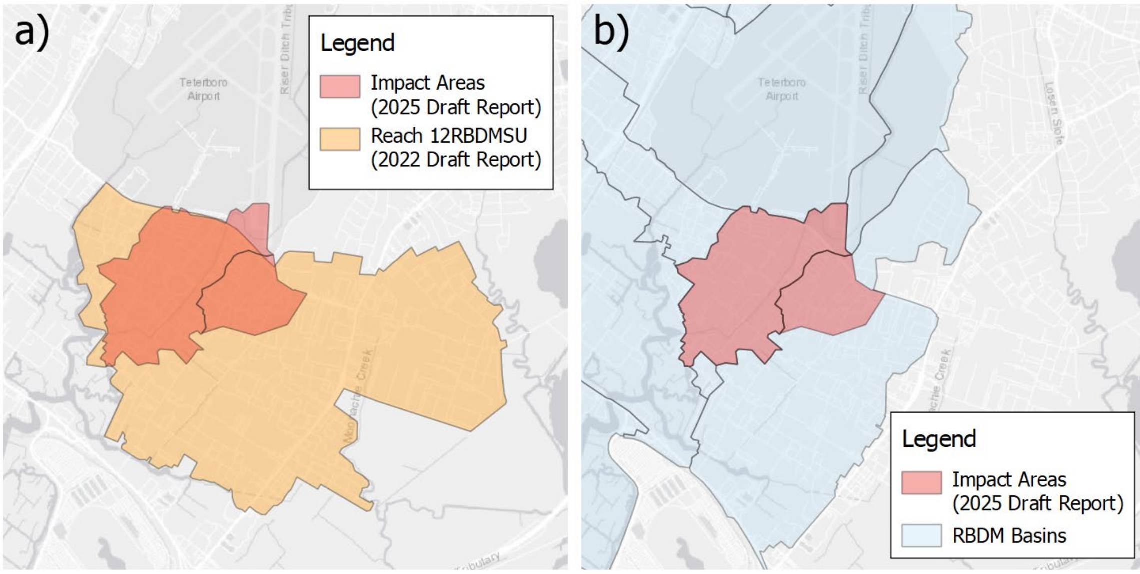


Figure 1: Comparison of East Riser impact areas developed for this study to those developed for: a) September 2022 Draft Integrated Feasibility Report/Tier 1 (Programmatic) EIS, b) Rebuild by Design Meadowlands (NJDEP, 2021c)

2.1.1.1 Updates for the Final Report

Following the submittal of the Draft Report, the Impact Area inputs into the HEC-FDA model were redrawn to better reflect the updated hydraulic inputs and expanded modeling extent. Figure 2 below shows the comparison of the impact areas used in the 2025 Draft Report compared to the new Impact Areas. These updated Impact Areas were created in conjunction with the Hydraulics team and were delineated based upon hydraulic separability and similar flow conditions.

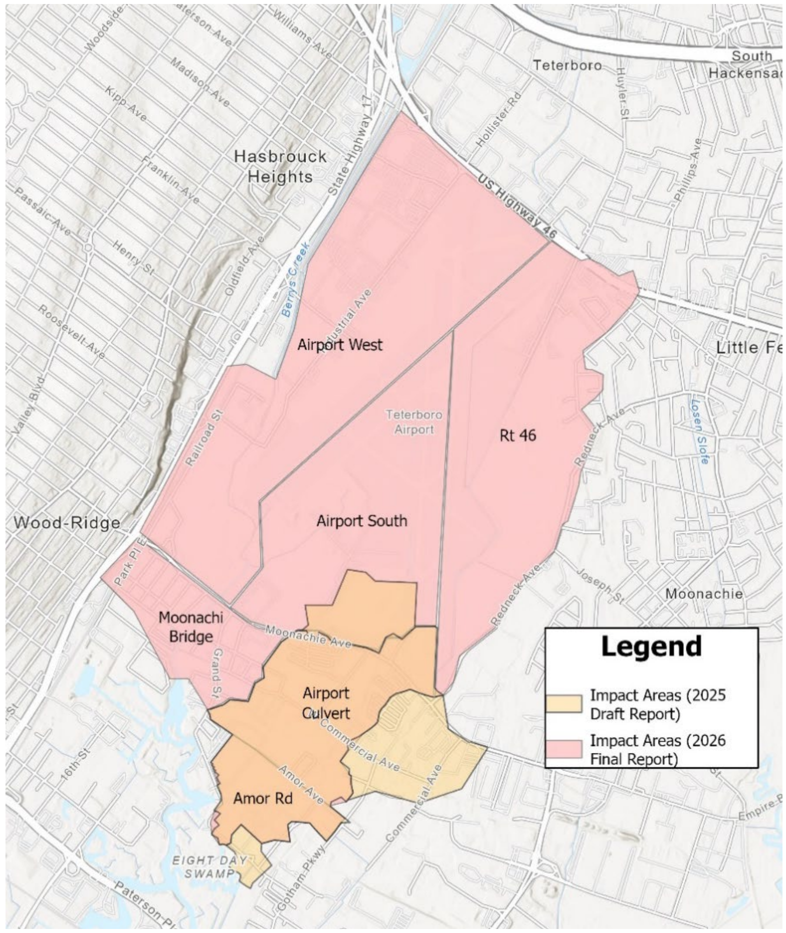


Figure 2: Comparison of East Riser impact areas developed for the 2025 Draft Report compared to the 2026 Final Report

2.1.2 Hydraulic Inputs

Given that the proposed actionable element project is primarily focused on reducing fluvial flood risk within the East Riser Actionable Element site, the economic analysis presented here considers existing and with-project fluvial flood risk. Due to the low elevation of the East Riser basin and its outfall into Berry's Creek, fluvial flood risk within the Actionable Element site is influenced by tidal boundary conditions. Informed by the hydrology and rainfall tide correlation analysis presented in the RBDM report (NJDEP, 2021b), fluvial flood risk was assessed considering the 1-in-2-year tide condition under present sea level. The East Riser Actionable Element site is also vulnerable to coastal storm risk, and the influence of SLC was evaluated during the Final Report phase of the study. Additional analysis of coastal storm risk with future low and intermediate SLC within the study area was included in the final analysis and is discussed below. The economics appendix of the September 2022 Draft Integrated FR/Tier 1 (Programmatic) EIS (USACE, 2022b) provides additional details on coastal storm risk within this portion of the overall study area.

This study initially relied on HEC-HMS and HEC-RAS modeling initially developed to comply with NJDEP permit requirements for the proposed RBDM project (NJDEP, 2021a). Additional model runs were completed to ensure that a total of 8 flood events were evaluated for each condition of interest. Additional details on this model can be found in Engineering Appendix (Appendix B). For this phase of the study, economic modeling assessed flood risk under the without-project condition and the with-project condition. Table 3 summarizes the existing without- and with-project frequency functions for the East Riser Channel south impact area.

Table 3: Draft Report - Stage-frequency functions for East Riser under the Without- and With-Project Conditions

Annual Exceedance Probability (AEP)	Existing Without-Project Condition [ft, NAVD88]	Existing With-Project Condition [ft, NAVD88]	With-Project Condition Reduction [ft]
99%	4.4	3.04	1.36
50%	5.08	4.13	0.95
20%	5.49	4.79	0.70
10%	5.77	5.23	0.54
4%	6.07	5.68	0.39
2%	6.25	5.94	0.31
1%	6.42	6.17	0.25
0.5%	6.62	6.38	0.24
0.2%	6.88	6.65	0.23

2.1.2.1 Updates for Final Report

Updates were made to the HEC-HMS and HEC-RAS models for the final report release which expanded the modeling area into West Riser. The expansion of the model was driven by a need to ensure the model area met the 1.5 square mile drainage area requirement for federal participation as detailed in Engineering Regulation 1165-2-21, paragraph 7.a. To account for uncertainties in the true tidal tailwater condition, the transition was made from Stage Frequency to Flow Frequency curves in the Economic modeling. The use of a flow frequency approach was selected so that the impact of uncertain tidal tailwater conditions could be explicitly incorporated into the analysis. By using the stage discharge approach, it was possible to model the different flood stages associated with the expected range of tailwater conditions, a Low, Most Likely, and High. The use of a stage frequency approach was considered but it was determined that the resulting uncertainty in flood stages did not reflect the key uncertainty associated with tailwater conditions. An equivalent record length of 50 years was used as an input for the Flow-Frequency functions. 50 years was chosen as the model is insensitive to changes in record length and there is wide uncertainty associated with the tailwater condition. Tables 4 and 5 summarize the Base and Future Year without- and with-project flow-frequency functions for the newly drawn East Riser Impact Areas.

Table 4: Flow-frequency functions for East Riser Impact Areas under the Base Year Without- and With-project conditions [CFS]

	Amor Rd.		Airport Culvert		Rt 46		Airport South		Airport West		Moonachie Bridge	
AEP	**FWOP**	**FWP**	**FWOP**	**FWP**	**FWOP**	**FWP**	**FWOP**	**FWP**	**FWOP**	**FWP**	**FWOP**	**FWP**
50%	328	451	212	325	338	349	338	349	360	360	410	402
20%	357	458	213	337	371	385	371	385	413	413	458	445
10%	366	470	214	360	393	409	393	409	424	424	540	524
4%	377	537	215	417	417	436	417	436	442	440	607	595
2%	390	610	216	426	437	455	437	455	444	441	609	608
1%	397	710	217	511	459	475	459	475	445	444	610	609
0.5%	407	802	218	550	479	498	479	498	446	448	611	610
0.2%	425	850	219	551	504	517	504	517	452	451	613	618

Table 5: Flow-frequency functions for East Riser Impact Areas under the Future Year Without- and With-project conditions [CFS][1]

	Amor Rd.		Airport Culvert		Rt 46		Airport South		Airport West		Moonachie Bridge	
AEP	**FWOP**	**FWP**	**FWOP**	**FWP**	**FWOP**	**FWP**	**FWOP**	**FWP**	**FWOP**	**FWP**	**FWOP**	**FWP**
50%	350	466	200	313	156	349	156	349	335	335	500	480
20%	358	544	201	356	157	384	157	384	382	383	573	553
10%	365	606	202	391	160	407	160	407	398	398	580	590
4%	372	692	203	463	162	434	162	434	413	410	585	592
2%	380	756	204	508	165	451	165	451	414	411	589	595
1%	393	798	205	511	170	472	170	472	415	412	591	597
0.5%	408	813	206	513	173	493	173	493	416	413	592	600
0.2%	450	884	207	515	226	511	226	511	417	414	593	601[i]

For the Lower Bound scenarios, the tidal boundary condition was set to be the normal tide graph of the Bergen Point, NY gage with an adjustment of the mean water level to match an intermediate RSLC projection for the base year of 2037 and future year 2086. This translates to a high tide elevation of 3.42 ft for the base year and 4.53 ft for 2086. For the Most Likely scenarios, a historic data analysis was conducted to understand the connection between precipitation and coastal events. For this analysis, the intermediate RSLC curve was used to adjust the maximum daily tidal water levels (coastal water levels) from the elevation of the original record date to an elevation equivalent to the base year of 2037 and future year of 2086. The mean value of this distribution is considered the Most Likely maximum water elevation for the tailwater condition. This translates to a peak water surface elevation of 4.27 ft for the base year (2037) and 5.38 ft for the future year (2086). The water level incorporates a normal tide as well as a small surge elevation. For the Upper Bound scenario, a low frequency tidal boundary condition was defined by assuming a coastal storm condition. The stage frequency curve of the Upper Bound scenario was set equivalent to expected value stage frequency curve of the 96 Random Tides simulation of the NACCS save point 4281. Additional details on the updates completed for the Final Report can be found in the Engineering Appendix (Appendix B).

In addition to an expanded modeling extent and stage discharge functions, Low and Intermediate Sea Level Change was considered as part of this analysis for the Final Report. The USACE high RSLC scenario was not modeled because under this scenario, the hydrologic and hydraulic model became unstable. However, it is anticipated that sea levels represented by the tailwater condition would overtop the existing berms, leading to high residual damage that would need a full coastal storm risk management project to resolve. The stage-discharge functions for East Riser under Intermediate and Low Sea Level Change Conditions are shown below in Tables 6 and 7.

[1] Since HEC-FDA requires a monotonically increasing flow, some flows were modified to accommodate model requirements

Table 6: Stage Discharge functions for East Riser Impact Areas under the Future Year Without- and With-project conditions for INT SLC (Low, Most Likely, High Bound) [ft, NAVD88]

	Amor Rd						Airport Culvert						Rt. 46					
AEP	FWOP			FWP			FWOP			FWP			FWOP			FWP		
	Low	ML	High	Low	ML	High	Low	ML	High	Low	ML	High	Low	ML	High	Low	ML	High
50%	4.33	4.74	6.99	2.60	3.54	6.99	4.35	4.74	6.99	2.89	3.97	6.99	5.07	5.10	6.99	4.90	4.91	6.99
20%	4.49	4.93	8	3.26	3.99	8	4.57	4.92	8	3.51	4.23	8	5.16	5.19	8	5.07	5.10	8
10%	4.59	5.05	8.86	3.66	4.33	8.86	4.73	5.04	8.86	3.88	4.53	8.86	5.23	5.28	8.86	5.17	5.19	8.86
4%	4.68	5.21	9.71	4.12	4.66	9.71	4.90	5.21	9.71	4.33	4.83	9.71	5.36	5.50	9.71	5.30	5.39	9.71
2%	4.76	5.32	10.93	4.41	4.88	10.93	5.03	5.32	10.93	4.60	5.02	10.93	5.55	5.68	10.93	5.47	5.58	10.93
1%	4.91	5.42	11.95	4.62	5.07	11.95	5.15	5.43	11.95	4.81	5.20	11.95	5.73	5.89	11.95	5.66	5.77	11.95
0.5%	5.05	5.52	12.93	4.80	5.26	12.93	5.26	5.57	12.93	5.00	5.36	12.93	5.95	6.09	12.93	5.87	5.99	12.93
0.2%	5.23	5.73	14.11	5.02	5.48	14.11	5.55	5.88	14.11	5.29	5.62	14.11	6.21	6.36	14.11	6.14	6.25	14.11

	Airport South						Airport West						Moonachie Bridge					
AEP	FWOP			FWP			FWOP			FWP			FWOP			FWP		
	Low	ML	High	Low	ML	High	Low	ML	High	Low	ML	High	Low	ML	High	Low	ML	High
50%	4.24	4.5	6.99	4.17	4.38	6.99	4.33	4.50	6.99	4.33	4.42	6.99	4.22	4.44	6.99	4.22	4.38	6.99
20%	4.65	4.91	8	4.54	4.76	8	4.65	4.91	8	4.62	4.78	8	4.49	4.74	8	4.42	4.59	8
10%	4.97	5.18	8.86	4.86	5.02	8.86	4.97	5.18	8.86	4.87	5.03	8.86	4.64	4.94	8.86	4.61	4.79	8.86
4%	5.29	5.45	9.71	5.22	5.34	9.71	5.30	5.46	9.71	5.23	5.35	9.71	4.81	5.07	9.71	4.75	5.02	9.71
2%	5.51	5.65	10.93	5.42	5.54	10.93	5.52	5.66	10.93	5.43	5.55	10.93	4.94	5.26	10.93	4.86	5.11	10.93
1%	5.7	5.86	11.95	5.62	5.73	11.95	5.72	5.88	11.95	5.64	5.76	11.95	5.16	5.47	11.95	5.02	5.32	11.95
0.5%	5.91	6.06	12.93	5.84	5.95	12.93	5.94	6.09	12.93	5.86	5.98	12.93	5.44	5.72	12.93	5.29	5.55	12.93
0.2%	6.18	6.33	14.11	6.11	6.22	14.11	6.21	6.36	14.11	6.14	6.25	14.11	5.80	6.06	14.11	5.67	5.89	14.11

Table 7:Stage Discharge functions for East Riser Impact Areas under the Base Year Without- and With-project conditions for Low SLC (Low, Most Likely, High Bound) [ft, NAVD88]

	Amor Rd						Airport Culvert						Rt. 46					
AEP	FWOP			FWP			FWOP			FWP			FWOP			FWP		
	Low	ML	High	Low	ML	High	Low	ML	High	Low	ML	High	Low	ML	High	Low	ML	High
50%	3.56	4.06	5.88	2.58	2.59	5.88	3.85	4.09	5.88	2.76	2.78	5.88	5.02	5.03	5.88	4.87	4.88	5.88
20%	3.67	4.24	6.89	2.71	2.72	6.89	4.13	4.33	6.89	3.00	3.06	6.89	5.13	5.14	6.89	5.06	5.07	6.89
10%	3.76	4.35	7.75	3.27	3.31	7.75	4.31	4.52	7.75	3.51	3.61	7.75	5.20	5.21	7.75	5.15	5.16	7.75
4%	3.89	4.49	8.6	3.82	3.83	8.6	4.53	4.74	8.6	4.03	4.05	8.6	5.28	5.29	8.6	5.25	5.26	8.6
2%	4.02	4.64	9.82	4.02	4.10	9.82	4.71	4.89	9.82	4.26	4.31	9.82	5.35	5.36	9.82	5.32	5.33	9.82
1%	4.16	4.81	10.84	4.17	4.36	10.84	4.86	5.03	10.84	4.43	4.58	10.84	5.50	5.56	10.84	5.44	5.48	10.84

0.5%	4.33	4.98	11.82	4.33	4.58	11.82	4.99	5.16	11.82	4.59	4.79	11.82	5.70	5.76	11.82	5.65	5.69	11.82
0.2%	4.55	5.18	13	4.51	4.80	13	5.21	5.36	13	4.82	5.04	13	6.00	6.06	13	5.94	5.99	13

	Airport South						Airport West						Moonachie Bridge					
AEP	FWOP			FWP			FWOP			FWP			FWOP			FWP		
	Low	ML	High	Low	ML	High	Low	ML	High	Low	ML	High	Low	ML	High	Low	ML	High
50%	3.32	3.52	5.88	3.14	3.38	5.88	4.22	4.24	5.88	4.20	4.24	5.88	3.68	4.07	5.88	3.68	4.07	5.88
20%	4.13	4.23	6.89	4.00	4.07	6.89	4.56	4.57	6.89	4.55	4.57	6.89	3.88	4.27	6.89	3.88	4.27	6.89
10%	4.48	4.58	7.75	4.38	4.45	7.75	4.71	4.72	7.75	4.71	4.72	7.75	4.01	4.40	7.75	4.01	4.40	7.75
4%	4.96	5.05	8.6	4.87	4.93	8.6	4.96	5.06	8.6	4.87	4.94	8.6	4.21	4.52	8.6	4.21	4.52	8.6
2%	5.23	5.3	9.82	5.16	5.21	9.82	5.23	5.31	9.82	5.16	5.22	9.82	4.44	4.63	9.82	4.37	4.63	9.82
1%	5.44	5.52	10.84	5.39	5.44	10.84	5.45	5.53	10.84	5.40	5.45	10.84	4.63	4.82	10.84	4.54	4.74	10.84
0.5%	5.66	5.73	11.82	5.60	5.66	11.82	5.68	5.75	11.82	5.62	5.68	11.82	4.95	5.12	11.82	4.83	4.99	11.82
0.2%	5.96	6.02	13	5.90	5.96	13	5.99	6.05	13	5.94	5.99	13	5.42	5.55	13	5.29	5.41	13

2.1.3 Structure Inventory

The analysis presented in this study relies on the structure inventory developed as part of the RBDM project (NJDEP, 2021a). The structures in the study area primarily consist of commercial and industrial facilities, along with a number of manufactured homes, situated within two separate communities, one of which lies immediately adjacent to the eastern bank of East Riser Channel. While the structure inventory from the September 2022 Draft Integrated Feasibility Report/Tier 1 (Programmatic) EIS included structures within the East Riser Actionable Element site (i.e., those structures contained within economic reach 12 RBDMSU), the structure inventory developed for the RBDM project was partially informed by field surveys, which further refined usage, number of stories, foundation heights, basement configuration, structural conditions, and estimates of content values field surveys for structures within the Actionable Element site (NJDEP, 2021c).

The structure values for each of the assets in the inventory were calculated using the relevant survey data and the RS Means book which considers factors such as square footage, class of construction (luxury, average, economy, etc.) common material type, and a location cost adjustment factor to give an estimate on a structures depreciated replacement value. Vehicles were added to the HEC-FDA model following the methodology laid out in EGM 09-04 Generic Depth-Damage Relationships for Vehicles, taking the average number of vehicles per housing unit, the average value of preowned vehicles, and adjusting for the percentage of vehicles that were likely to evacuate during a storm event. A vehicle asset was added to each structure point and was assigned the ground elevation of the associated structure.

Consistent with the approach taken for the Harlem River Actionable Element site, structure and content values were escalated from 2016 to 2025 price levels using the Producer Price Index for Final Demand Construction (PPIDCS; BLS, 2025). Relying on the PPIDCS, asset values were escalated from 2016 price levels to 2025 price levels by applying an escalation factor of 1.56. This escalation factor differs from the one previously used for Harlem River as the escalation is being made from different starting price levels. For additional information detailing the structure inventory, see Appendix E of the RBDM study (NJDEP, 2021c).

Figure 3 provides a visual comparison of the structure inventory from the RBDM study (used in this report, shown in red) and the structure inventory from the September 2022 Draft Integrated Feasibility Report/Tier 1 (Programmatic) EIS (shown in orange). Table 8 summarizes the number of structures, expected structure value, and expected content values by occupancy type for the structures shown within the East Riser impact areas.

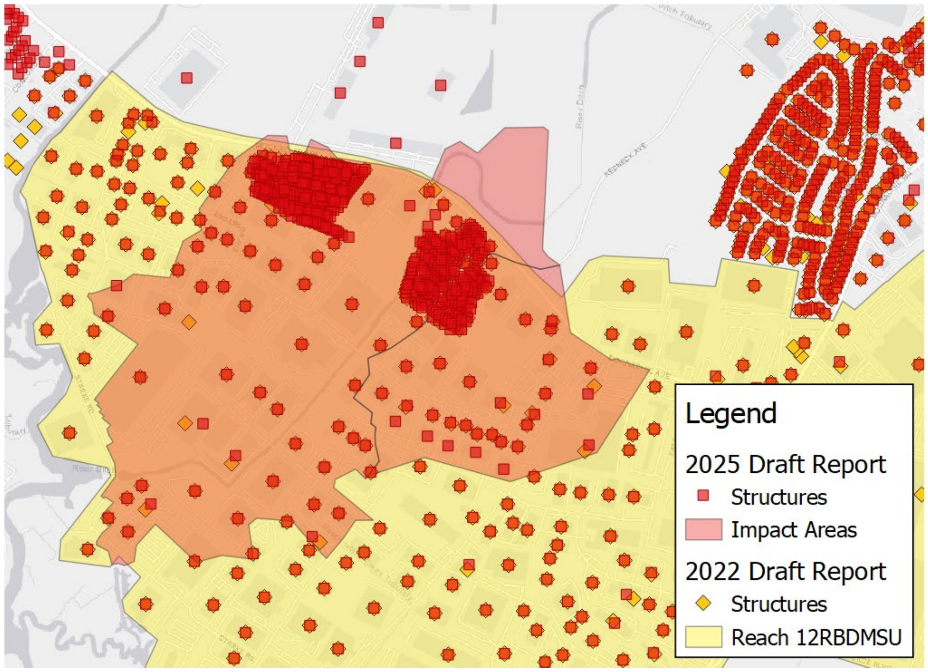


Figure 3: Visual comparison of structures within the East Riser impact area and Reach 12RBDMSU from September 2022 Draft Integrated Feasibility Report/Tier 1 (Programmatic) EIS

Table 8: Summary of structures inventory included within the East Riser Impact Areas

Occupancy Type	Number of Structures	Total Expected Structure Value	Total Expected Content Value
Residential	428	$46,210,000	$14,556,150
Commercial	19	$141,769,000	$44,657,000
Industrial	74	$579,039,000	$182,397,000
TOTAL	521	$767,018,000	$241,610,150

2.1.3.1 Updates for the Final Report

The structure inventory used for the Final Report remains largely the same as the one used for the 2025 Draft Report. Structure attributes such as occupancy type and ground elevation all remain the same between the two versions and no structures were removed as part of the effort for the 2026 Final Report. Structure values were updated to FY26 from FY25 Price levels using the Producer Price Index for Final Demand Construction. An escalation factor of 1.02 was used to update the structure values from FY25 to FY26. With the larger impact areas, the affected structure count rose to 742, an increase of 221. The primary updates to the structure inventory involved moving the structure points to the exterior of the building footprint, described below. Table 9 below shows the updated summary of structures within the East Riser Impact Areas and Table 10 shows the structure count and damageable value in the 1% and 0.2% floodplains.

Table 9: Updated Summary of structure inventory included within the East Riser Impact Areas

Occupancy Type	Number of Structures	Total Expected Structure Value	Total Expected Content Value
Residential	597	$109,957,000	$34,086,670
Commercial	42	$282,319,000	$87,518,890
Industrial	93	$693,885,000	$215,104,350
Municipal	5	$122,715,000	$38,041,650
Utilities	5	$5,000	$1,550
TOTAL	742	$1,208,881,000	$374,753,110

Table 10: Structure Count and Damageable Value in 1% and 0.2% AEP Floodplains

Occupancy Type	Number of Structures (1% AEP)	Total Damageable Structure Value	Number of Structures (0.2% AEP)	Total Damageable Structure Value
Residential	456	$56,218,000	468	$64,096,000
Commercial	22	$119,682,000	31	$189,745,000
Industrial	55	$378,448,000	67	$454,204,000
Municipal	4	$33,073,000	4	$33,073,000
Utilities	2	$3,000	3	$4,000
TOTAL	539	$587,423,000	573	$741,122,000

Due to the low-lying terrain and nature of the flow, it was determined as part of the hydraulic modeling, that the structures in the study area have a significant effect on the flow rates and direction, particularly the large, warehouse type structures common in the East Riser area. To account for this, the terrain used in the Hydraulic Modeling assumed the footprints of these structures to be elevated well beyond the ground elevation so that the water would view the structures as an obstacle obstructing flow.

To address concerns that HEC-FDA 2.0.2, which reads the hydraulic data at the structure point, would misinterpret the data as if the structure point is not touched by flood waters, the structure points for all assets within the New Impact Areas were moved to the area adjacent to the structure footprint. Where possible through desktop analysis, the structure point was moved to the location of the opening of a door or garage. The Figure 4 below shows an example of how a structure's point was moved.

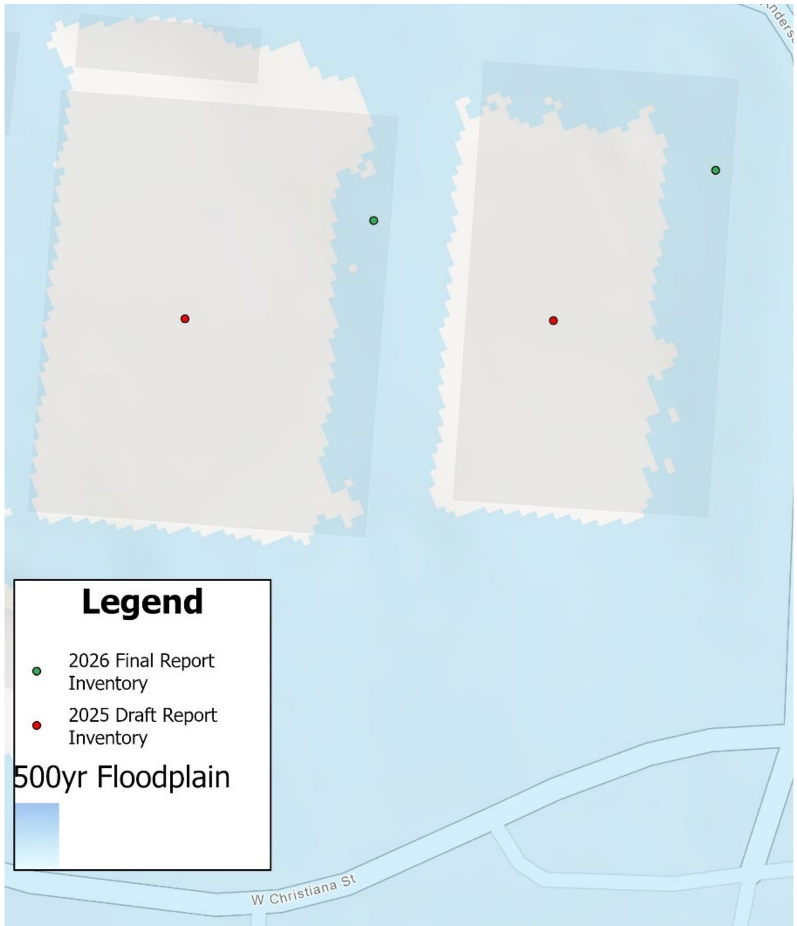


Figure 4: Example of Structure Inventory Change Between Draft and Final Reports

2.1.3.2 Occupancy Types and Depth Damage Functions

Similar to the structure inventory, this study relies upon the occupancy types developed for the RBDM study (NJDEP, 2021a). Given the additional field reconnaissance completed as part of the RBDMM study, though slightly different from those employed in the September 2022 Draft Integrated Feasibility Report/Tier 1 (Programmatic) EIS, these occupancy types were determined to be more representative of the structure-specific sensitivity to flooding. The East Riser Actionable Element site includes industrial, commercial, municipal residential, and utility structures. Utilities considered in the structure inventory include electrical substations and sewer pump stations that fall within the study area. Municipal structures included in the structure inventory consist of several mixed-use buildings owned by the Bergen County, a United States Post Office distribution center, and the Moonachie Department of Public Works. Corresponding structure and content depth damage functions were imported directly from the RBDBM study HEC-FDA v1.4.2 study files. The Specific Depth Damage Functions used in the RBDM study were developed by USACE for the Passaic River Basin (PRB) of which the East Riser site lies within. Additional explanation on the functions is provided below. Additional details on the structure inventory can be found in Appendix E of the RBDM report (NJDEP, 2021c). No updates were made to the occupancy types between the Draft and Final Reports.

Based on the type, usage and size of each structure inventoried, damage was calculated relative to the main floor elevation of the structure. For this analysis two separately developed classes of depth- percent damage functions were used for all structures in the project area.

- US Army Corps of Engineers generic damage functions for single-family residential and similar structures.

- Passaic River Basin (PRB) Study damage functions for other residential structures and all non-residential structures.
- Generic functions for motor vehicles (USACE 2009).

The USACE depth-damage functions for residential structures were sourced from Economics Guidance Memoranda EGM 01-03 (December 2000) and EGM 04-01, (October 2003). The PRB damage functions were originally developed in 1982 and were updated in 1995. These damage functions were found to be applicable as originally formulated and no adjustments to the damage functions are recommended.
In addition to multi-family residential structures and apartment buildings, the PRB damage functions were also used for non-residential structures, since they include numerous functions for specific non-residential usages. The PRB functions were considered appropriate for use in this study as the East Riser Actionable Element Site lies within the basin. Also, the PRB functions were considered applicable due to the similar nature of the building stock in the study area, and the similar nature of the expected flooding (a mix of salt and freshwater inundation). The most common structures in the inventory are two story residentials without basement (49% structure inventory) followed by two story residentials without basement (10% of structure inventory) and a variety of commercial structures. As the area has an industrial base, the team felt that the PRB functions would be most appropriate since these functions were developed specifically for the area and covers a wide range of commercial and industrial structure types whereas the North Atlantic Coast Comprehensive Study (NACCS), another survey for depth damage functions) commercial function options are comparatively limited and broadly defined.
A comparison of the NACCS vs the EGM residential functions show only slight differences in depth to percent damage with the EGM being more conservative. Furthermore, the team noted that the NACCS curves were developed for coastal studies, however this Actionable Element site was evaluated for a riverine solution, therefore the PRB and EGM functions were retained as appropriate for use at this site.

Damage categories include commercial, industrial, municipal, and utility structures, and an example of a PRB depth- damage function is provided below in Figure 5. This function was used for the large warehouse type structures commonly present in the study area.

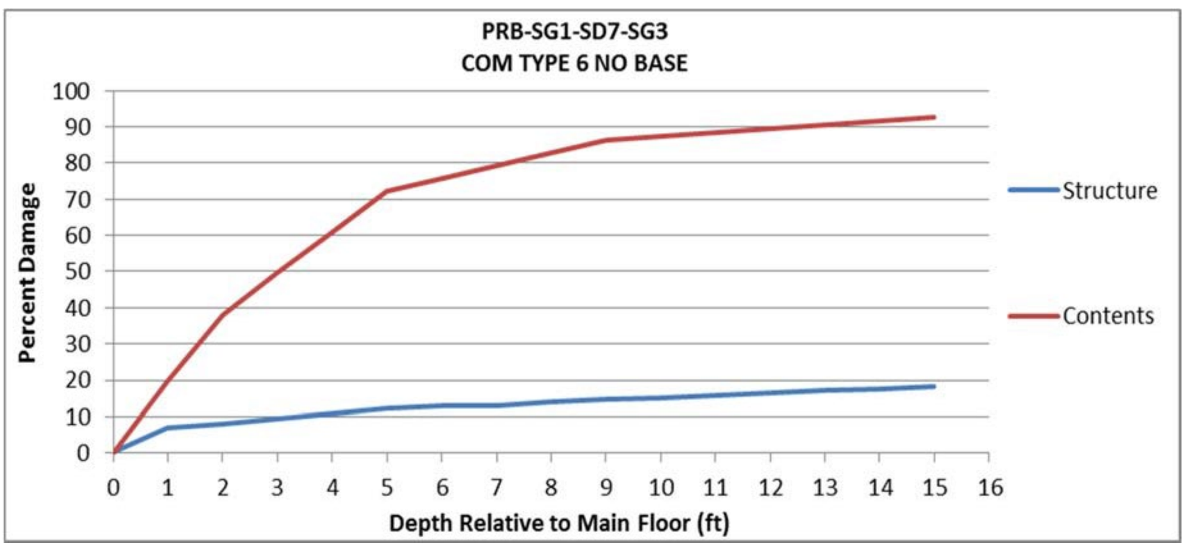


Figure 5: Example DDF used for Damage Calculation

2.1.4 Discounting Approach

Given that no future without- or with-project condition hydraulic modeling was available for the draft report, the study assumes that the existing without- and with-project conditions adequately represent without- and with-project flood risk for the entire period of analysis (2037-2086). Consequently, the expected annual damages (EAD) under the without- and with-project conditions are equivalent to the annualized flood risk over the full period of analysis. If additional future without- and with-project conditions introduces a linear nonstationary in EAD, future EAD values can be readily discounted and annualized in HEC-FDA 2.0.2 to develop annualized flood risk estimates.

2.1.5 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. The economic portion of risk and uncertainty 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 2.0.2 of the Hydrologic Engineering Center’s Flood Damage Analysis computer program 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:

- Flow Frequency
    - Confidence Intervals at the 97.5% and 2.5% level are automatically calculated within HEC-FDA 2.0.2
- Stage-Discharge functions
    - Functions were entered as a triangular distribution with a Low, Most Likely, and High bound. See section 2.1.2.1 for additional explanation on Hydraulic inputs
- Structure First Floor Elevation
    - A normal distribution with a 0.6 standard deviation was included to account for uncertainty in structure first floor elevation
- Structure and Content Depreciated Replacement Value
    - A normal distribution with a standard deviation that accounts for 10% of the structures value was included to account for uncertainty in structures depreciated replacement value
    - A triangular distribution, modeled as a percentage of Structure Value, was added to calculate Content Value with a low of 4.2% a most likely of 31.5% and a high of 42% of Structure Value
- Depth-Damage Functions
    - For Residential Structure Depth Damage Functions, 95% and 5% Confidence Intervals were imported into the model. For Commercial, Industrial, Municipal, and Utilities, Depth Damage Functions are entered with a deterministic relationship

2.2 DRAFT REPORT RESULTS

Expected annual damages (EAD) for the East Riser Actionable Element site were computed via HEC-FDA 2.0.2 given the inputs outlined above. These results are shown in Table 11, wherein total EAD for each impact area and EAD by occupancy type are provided for both the without- and with-project condition. In the without-project condition industrial structures (IND) within the Actionable Element site are responsible for the largest contribution of EAD, with commercial (COM) and residential (RES) structures responsible for a smaller portion of the overall EAD. Given that the proposed actionable element moderately reduces the severity and duration of flooding across the study area, all at-risk structures in the study area retain some residual risk. This residual risk reflects an expectation of a modest decrease in even-specific flood damages, proportional to the reduction in water surface elevation provided by the actionable element as shown in Table 11.

Table 11: Draft Report - Without- and With-project Expected Annual Damages (EAD) for the East Riser Actionable Element Impact Area, (HEC-FDA 2.0.2 outputs)

	Expected Annual Damage (EAD)							
	Without-Project				With-Project (Residual Risk)			
Impact Area	TOTAL	IND	COM	RES	TOTAL	IND	COM	RES
ERD South	$ 32,599,000	$ 16,065,000	$ 8,193,000	$ 8,341,000	$ 17,618,000	$ 9,144,000	$ 3,666,000	$ 4,808,000
Peach Island Creek	$ 1,078,000	$ 0	$ 14,000	$ 1,064,000	$ 552,000	$ 0	$ 4,000	$ 548,000
TOTAL	$ 33,677,000	$ 16,065,000	$ 8,207,000	$ 9,405,000	$ 18,170,000	$ 9,144,000	$ 3,670,000	$ 5,356,000

FY2025 Price Levels

Relying on these EAD values, and implementing the discounting approach outlined above, annualized fluvial flood risk under without- and with-project conditions, along with associated flood risk management benefits for each impact area scenario are shown in Table 12. Based on these results, under the intermediate SLC scenario, the proposed actionable element is expected to provide $15.5M [FY2025 price levels] in annualized flood risk management benefit to the Actionable Element site. Given the estimated $249,146,000 total cost and a $9,683,000 annual cost of the East Riser actionable element, this corresponds to a BCR of 1.6.

Table 12: Annualized coastal storm risk under the Without- and With-project condition and annualized coastal storm risk management benefit

	Flood Risk (Annualized)		Flood Risk Management Benefit (Annualized)	Benefit-Cost Ratio (BCR)	Average Annual Net Benefit (AANB)
Impact Area	Without-Project	With-Project			
ERD South	$ 32,600,000	$ 17,618,000	$ 14,982,000	-	-
Peach Island Creek	$ 1,078,000	$ 552,000	$ 526,000	-	-
TOTAL	$ 33,667,000	$ 18,170,000	$ 15,508,000	1.6	$ 5,825,000

FY2025 Price Levels; Federal Discount Rate = 3%; 50-year period of analysis (2037-2086)

Performance of the East Riser actionable element was also computed via HEC-FDA 2.0.2, pursuant to ER 1105-2-101, using a performance threshold of +5 ft NAVD88. This threshold is the flood stage at which damages are expected to begin for residential structures within the manufactured home communities in the study area. As shown in Table 13, under the without-project condition, the annual exceedance probability for this threshold is expected to be 60.9% (i.e., in a given year, there is a 60.9% chance that this threshold will be exceeded). By contrast, under the with-project condition, the annual exceedance probability reduces to 14.8%. This reduction in annual exceedance probability translates to a modest reduction in the 10-year long-term exceedance probability for this threshold. Under the with-project condition, over a 10-year period, there is a 79.9% chance of threshold exceedance, compared to a greater than 99% chance in the without-project condition. Similarly, the assurance by event improves considerably, particularly for higher frequency events. For instance, under the with-project condition, there is a 27.5% chance that this threshold will not be exceeded by the 10% AEP event, compared to a 0.07% chance of non-exceedance in the without-project condition.

Table 13: Probabilistic performance of the East Riser Actionable Element across Impact Areas

Alternative	Annual Exceedance Probability		Long-Term Exceedance Probability			Assurance by Event				
	Expected	90% Assurance	10-yr period	30-yr period	50-yr period	10%	2%	1%	0.40%	0.20%
Without-Project	60.9%	78.2%	>99.9%	>99.9%	>99.9%	0.07%	0.04%	0.03%	0.03%	0.01%
With-Project	14.8%	24.8%	79.9%	99.2%	>99.9%	27.5%	4.5%	3.0%	1.3%	0.38%

2.3 FINAL REPORT RESULTS

2.3.1 National Economic Development (NED)

2.3.1.1 Bridge Replacement Benefits

The recommended plan of the East Riser Actionable Element includes the replacement of the Lead spur railroad bridge to accommodate the wider channel. As the expected useful life of the replacement bridge is greater than that of the existing bridge, there is an extension of the transportation service being provided. Since the total cost of the new bridge is included in the first cost of the project, benefits can be claimed from this extension in useful life as well as the reduction in O&M costs for a newer bridge.

While evaluating the actionable element, the NJDEP estimated that remaining life of the Lead spur bridge was 25 years. Given the new bridges' estimated life span of 75 years, this corresponds to an increase in useful life expectancy of 50 years. The credit is a constant annuity in years 26-75 of the period of analysis. Given the replacement cost of a new bridge provided by NJDEP of $7,280,00 and the an average annual O&M savings of roughly $69,700 with a new bridge, an annual benefit can be calculated. Given the 25-year remaining bridge useful lifespan, and the 50-year extension this corresponds to $130,000 in advanced bridge replacement benefits. The credit is a constant annuity in years 26-75 of the period of analysis and results in annual advanced bridge replacement benefits of $130,000 using the current FY26 interest rate of 3.25%.

2.3.1.2 Flood Risk Reduction Benefits

Expected annual damages (EAD) for the East Riser Actionable Element site were computed via HEC-FDA 2.0.2 given the inputs outlined above for the Final Report. These results are shown in Table 14 and Table 15, wherein total EAD by occupancy type are provided for both the without- and with-project condition given Intermediate and Low SLC. Given that the proposed actionable element moderately reduces the severity and duration of flooding across the study area, all at-risk structures in the study area retain some residual risk. This residual risk reflects an expectation of a decrease in flood damage, proportional to the reduction in water surface elevation provided by the actionable element as shown in Table 14.

Table 14: Final Report - Without- and with-project Expected annual damages (EAD) for the East Riser Actionable Element by Damage Category, (HEC-FDA 2.0.2 outputs) (INTSLC)

Damage Category	Without -Project EAD	With-Project EAD	EAD Reduced
Municipal	$1,023,000	$889,000	$134,000
Commercial	$ 10,536,000	$7,115,000	$3,421,000
Industrial	$26,821,000	$20,279,000	$6,542,000
Residential	$8,467,000	$6,154,000	$2,313,000
Utilities	$2,000	$2,000	-
TOTAL	$ 46,849,000	$34,439,000	$ 12,410,000

FY2026 Price Levels and Discount Rate

Table 15: Final Report - Without- and with-project Expected annual damages (EAD) for the East Riser Actionable Element by Damage Category, (HEC-FDA 2.0.2 outputs) (LowSLC)

Damage Category	Without -Project EAD	With-Project EAD	EAD Reduced
Municipal	$817,000	$742,000	$75,000
Commercial	$8,931,000	$5,666,000	$3,265,000
Industrial	$22,136,000	$16,262,000	$5,874,000
Residential	$7,636,000	$5,251,000	$2,385,000
Utilities	$2,000	$ 2,000	-
TOTAL	$39,522,000	$27,923,000	$11,599,000

FY2026 Price Levels and Discount Rate

The tables below show the Expected Annual Damages (EAD) reduced at each of the 8 AEPs for both the Base Year and Future Year conditions for the Intermediate Sea Level Change condition.

Table 16: Damages Reduced by AEP – Base Year (INTSLC)

Annual Exceedance Probability (AEP)	Without -Project EAD	With-Project EAD	EAD Reduced
50%	$11,068,000	$3,639,000	$7,429,000
20%	$16,000,000	$5,097,000	$10,903,000
10%	$19,828,000	$7,584,000	$12,244,000
4%	$26,599,000	$15,782,000	$10,817,000
2%	$33,772,000	$22,724,000	$11,048,000
1%	$43,250,000	$29,168,000	$14,082,000
0.5%	$51,246,000	$38,448,000	$12,798,000
0.2%	$64,044,000	$55,815,000	$8,229,000
TOTAL	$265,805,000	$178,256,000	$87,549,000

Table 17: Damages Reduced by AEP - Future Year (INTSLC)

Annual Exceedance Probability (AEP)	Without -Project EAD	With-Project EAD	EAD Reduced
50%	$ 26,201,000	$14,571,000	$11,630,000
20%	$34,963,000	$19,681,000	$15,282,000
10%	$41,010,000	$26,807,000	$14,203,000
4%	$48,636,000	$36,939,000	$11,697,000
2%	$55,330,000	$46,211,000	$9,119,000
1%	$62,308,000	$54,397,000	$7,911,000
0.5%	$70,546,000	$62,954,000	$7,592,000
0.2%	$85,132,000	$76,405,000	$8,727,000
TOTAL	$424,126,000	$337,965,000	$86,161,000

The proposed actionable element is expected to provide $12,638,000 in equivalent annual flood risk management benefit to the Actionable Element site under the Intermediate SLC scenario The annual cost, which is compared to annual benefits to calculate net benefits and the benefit-to-cost ratio, is outlined in the table below.

Table 18:Cost Breakdown for the East Riser Actionable Element

Project First Construction Cost	$175,835,000
Interest During Construction[2]	$9,456,000
Total Investment Cost	$185,292,000
Annualized Investment Cost	$7,547,000
Annualized O&M Costs[3]	$879,000
Total Annual Cost	$8,426,000

FY2026 Price Levels; Federal Discount Rate = 3.25%; 50-year period of analysis

Given the estimated annual cost of $8,426,000 of the East Riser actionable element, this corresponds to a BCR of 1.5. Table 19 below summarizes the annualized benefits, net benefits, and BCR.

[2] Based on 40 months of construction at interest rate of 3.25%

Table 19: INTSLC – Equivalent Annual Damages (EqAD) Reduced (Benefits) for the East Riser Actionable Element

Impact Area	Flood Risk Management Benefit (Annualized)	Bridge Replacement Benefits	Average Annual Cost	Benefit-Cost Ratio (BCR)	Average Annual Net Benefit (AANB)
Amor Rd.	$410,000	-	-	-	-
Airport Culvert	$2,447,000	$130,000	-	-	-
Rt. 46	$9,459,000	-	-	-	
Airport South	$86,000	-	-	-	
Airport West	$86,000	-	-	-	
Moonachie Bridge	$150,000	-	-	-	
TOTAL	$12,638,000	$130,000	$8,426,000	1.5	$4,342,000

FY2026 Price Levels; Federal Discount Rate = 3.25%; 50-year period of analysis (2037-2086)

Under the Low SLC scenario, the proposed actionable element is expected to provide $11,811,000 in annualized flood risk management benefit to the Actionable Element site. Given the estimated annual cost $8,426,000 of the East Riser actionable element, this corresponds to a BCR of 1.4.

Table 20:LowSLC - Equivalent Annual Damages (EqAD) Reduced (Benefits) for the East Riser Actionable Element

Impact Area	Flood Risk Management Benefit (Annualized)	Bridge Replacement Benefits	Average Annual Cost	Benefit-Cost Ratio (BCR)	Average Annual Net Benefit (AANB)
Amor Rd.	$390,000	-	-	-	-
Airport Culvert	$2,399,000	$130,000	-	-	-
Rt. 46	$8,859,000	-	-	-	
Airport South	$80,000	-	-	-	
Airport West	$18,000	-	-	-	
Moonachie Bridge	$65,000	-	-	-	
TOTAL	$11,811,000.00	$130,000	$8,426,000	1.4	$3,515,000

FY2026 Price Levels; Federal Discount Rate = 3.25%; 50-year period of analysis (2037-2086)

Under the High SLC scenario, it is probable that the most likely exterior stage condition will overtop the existing berms along Berry's Creek near the East Riser tide gate during the period of analysis rendering the performance of the proposed Actionable Element project negligible. While this condition was not modeled, the results table below is included to show the risk should future SLC conditions trend towards the High Curve.

Table 21: HighSLC - Equivalent Annual Damages (EqAD) Reduced (Benefits) for the East Riser Actionable Element

Impact Area	Flood Risk Management Benefit (Annualized)	Bridge Replacement Benefits	Average Annual Cost	Benefit-Cost Ratio (BCR)	Average Annual Net Benefit (AANB)
Amor Rd.	$0	-	-	-	-
Airport Culvert	$0	$130,000	-	-	-
Rt. 46	$0	-	-	-	
Airport South	$0	-	-	-	
Airport West	$0	-	-	-	
Moonachie Bridge	$0	-	-	-	
TOTAL	$0	$130,000	$8,426,000	0.02	($8,296,000)

FY2026 Price Levels; Federal Discount Rate = 3.25%; 50-year period of analysis (2037-2086)

2.3.1.3 Performance and Residual Risk

Flood risk is the function of flood hazard at a location, and exposure and vulnerability to the flood hazard. Residual risk is the flood risk that remains after a project is in place. It is the exposure to loss remaining after other known risks have been countered, factored in, or managed or addressed. The Recommended Plan will not eliminate all flood risk to life and property in Moonachie and Carlstadt, NJ. While there would still be properties and infrastructure that are vulnerable to fluvial flood damages, this damage would be managed with the project in place. The East Riser Actionable Element manages risk from fluvial flood events and not from coastal storms. The area will remain vulnerable to inundation from coastal events should the Recommended Plan be constructed. Coastal flooding enters the area from Berry's Creek through low topography from the south, north, and northwest when water surface elevations in Berry's Creek are in the range of +4 to +5 feet NAVD88. The study area is also vulnerable to flooding from the Hackensack River to the east when flood stages are greater than +5 feet NAVD88. This means that when coastal water or storm surge reaches +4 to +5 feet NAVD88 in Berry's Creek or greater than +5 feet NAVD88 in the Hackensack River, the area would start to flood. During times of coincident flooding of both coastal and fluvial events, the Recommended Plan provides flood risk management benefits to the area only while coastal waters are below the elevations associated with the onset of coastal flooding. If coastal waters inundate the area, the coastal forces would dominate the area and the Recommended Plan would not be able to provide fluvial flood risk management benefits. As sea levels continue to rise throughout the period of analysis, coastal waters are projected to inundate the area more frequently, resulting in the Recommended Plan providing flood risk management benefits on a less frequent basis. As shown above, if sea level rise trends toward a High SLC scenario, the project is severely limited in the benefits it can provide.

In such a scenario, until coastal storm risk management features are implemented, much of the industrial area and manufactured home park would see significant flooding. Flood waters would make the main egress in and out of the East Riser area, Moonachie Avenue, which connects the area to State Highway 17, difficult or impossible to traverse adding risk to life safety. The low-lying nature of the surrounding topography would increase the drainage time, but as discussed below, the proposed project would help alleviate this issue. In the future, the non-Federal Sponsor, NJDEP, will be required to create and maintain Emergency Action or Community Preparedness Plans which would inform those who work or live within the area of potential risks, and ways to alleviate their risk. Additional discussion on Life Safety is included in section 2.3.4 below.

The project would, however, help provide some benefits in the aftermath of a coastal event. The area of Carlstadt and Moonachie is so low lying that when a storm surge enters the area, the water can stay in the area for days. The East Riser Actionable Element would increase the capacity of East Riser Channel to convey storm surge out of the area more quickly, reducing the risk of time-induced damages. The Recommended Plan would help the community recover from a coastal event, as it can expand storage capacity and help convey coastal waters out of the area faster than without the project.

Performance of the East Riser actionable element was also computed via HEC-FDA 2.0.2 for the final report, pursuant to ER 1105-2-101. Performance of the East Riser Actionable Element was calculated to a threshold of 5ft NAVD88. This threshold is roughly where flood waters would start to inundate many of the properties in the manufactured home community within the Actionable Element Site. The tables below show the performance under the Base and Future Year for both Intermediate and Low Sea Level Change conditions and further discussion is presented regarding the "Airport Culvert" Impact Area performance results, which is where the manufactured homes are located.

Annual exceedance probability is defined as the likelihood that the threshold stage of 5ft NAVD88 overtopped in a given year. Under intermediate SLC, in the base year, the expected AEP is 35% under the FWOP condition, which drops to 18% under the FWP condition. In the Future year, the expected AEP is 75% under the FWOP condition which drops to 43% under the FWP condition.

The long-term exceedance probability (LTEP) refers to the likelihood of multiple overtopping events within a given time period, in this case the 50-year period of analysis. Under the intermediate SLC scenario, the 10-year

LTEP starts at 99% in the base year FWOP condition and decreases to 86% in the base year FWP condition. In the future year, the 10-year LTEP starts at 100% in the FWOP condition and does not drop.

Assurance is defined as the likelihood that the random stage realization of the given event is below the defined threshold stage of 5ft. Under the intermediate SLC in the base year, the 1% AEP has a 11% chance to yield a stage lower than the threshold stage in the FWOP condition. In the FWP condition, this chance increases to 35%. In the future year FWOP, the 1% AEP has a 1% chance to yield a stage lower than the threshold stage in the FWOP condition which increases to 6% in the FWP condition.

Table 22: Probabilistic performance of the East Riser Actionable Element at each Impact Area for the Base Year Without- and With-Project Conditions (INTSLC)

Impact Area	Annual Exceedance Probability		Long-Term Exceedance Probability			Assurance by Event				
	Expected	90% Assurance	10-yr period	30-yr period	50-yr period	10%	2%	1%	0.40%	0.20%
Moonachie Bridge	32%	100%	98%	100%	100%	38%	17%	12%	9%	6%
Amor Rd	30%	100%	97%	100%	100%	45%	34%	23%	18%	12%
Airport Culvert	35%	100%	99%	100%	100%	33%	19%	11%	6%	2%
Rt 46	100%	100%	100%	100%	100%	0%	0%	0%	0%	0%
Airport West	45%	100%	100%	100%	100%	19%	3%	0%	0%	0%
Airport South	30%	100%	97%	100%	100%	27%	8%	4%	2%	1%

Impact Area	Annual Exceedance Probability		Long-Term Exceedance Probability			Assurance by Event				
	Expected	90% Assurance	10-yr period	30-yr period	50-yr period	10%	2%	1%	0.40%	0.20%
Moonachie Bridge	32%	100%	98%	100%	100%	39%	20%	13%	9%	6%
Amor Rd	16%	43%	82%	99%	100%	68%	46%	35%	25%	18%
Airport Culvert	18%	47%	86%	100%	100%	61%	35%	30%	18%	13%
Rt 46	86%	100%	100%	100%	100%	0%	0%	0%	0%	0%
Airport West	45%	100%	100%	100%	100%	19%	4%	3%	1%	0%
Airport South	27%	100%	96%	100%	100%	32%	11%	5%	3%	1%

Table 23: Probabilistic performance of the East Riser Actionable Element at each Impact Area for the Future Year Without- and With-Project Conditions (INTSLC)

Impact Area	Annual Exceedance Probability		Long-Term Exceedance Probability			Assurance by Event				
	Expected	90% Assurance	10-yr period	30-yr period	50-yr period	10%	2%	1%	0.40%	0.20%
Moonachie Bridge	66%	100%	100%	100%	100%	9%	4%	1%	0%	0%
Amor Rd	74%	100%	100%	100%	100%	9%	5%	3%	2%	1%
Airport Culvert	75%	100%	100%	100%	100%	6%	2%	1%	0%	0%
Rt 46	100%	100%	100%	100%	100%	0%	0%	0%	0%	0%
Airport West	71%	100%	100%	100%	100%	2%	0%	0%	0%	0%
Airport South	70%	100%	100%	100%	100%	2%	1%	0%	0%	0%

Impact Area	Annual Exceedance Probability	Long-Term Exceedance Probability	Assurance by Event

	Expected	90% Assurance	10-yr period	30-yr period	50-yr period	10%	2%	1%	0.40%	0.20%
Moonachie Bridge	64%	100%	100%	100%	100%	9%	6%	3%	2%	1%
Amor Rd	37%	100%	99%	100%	100%	38%	22%	12%	6%	4%
Airport Culvert	43%	100%	100%	100%	100%	33%	15%	6%	3%	2%
Rt 46	95%	100%	100%	100%	100%	0%	0%	0%	0%	0%
Airport West	69%	100%	100%	100%	100%	4%	0%	0%	0%	0%
Airport South	66%	100%	100%	100%	100%	5%	1%	0%	0%	0%

Table 24: Probabilistic performance of the East Riser Actionable Element at each Impact Area for the Base Year Without- and With-Project Conditions (LowSLC)

Impact Area	Annual Exceedance Probability		Long-Term Exceedance Probability			Assurance by Event				
	Expected	90% Assurance	10-yr period	30-yr period	50-yr period	10%	2%	1%	0.40%	0.20%
Moonachie Bridge	32%	100%	98%	100%	100%	38%	17%	12%	9%	6%
Amor Rd	30%	100%	97%	100%	100%	45%	34%	23%	18%	12%
Airport Culvert	35%	100%	99%	100%	100%	33%	19%	11%	6%	2%
Rt 46	100%	100%	100%	100%	100%	0%	0%	0%	0%	0%
Airport West	45%	100%	100%	100%	100%	19%	3%	0%	0%	0%
Airport South	30%	100%	97%	100%	100%	27%	8%	4%	2%	1%

Impact Area	Annual Exceedance Probability		Long-Term Exceedance Probability			Assurance by Event				
	Expected	90% Assurance	10-yr period	30-yr period	50-yr period	10%	2%	1%	0.40%	0.20%
Moonachie Bridge	32%	100%	98%	100%	100%	39%	20%	13%	9%	6%
Amor Rd	16%	43%	82%	99%	100%	68%	46%	35%	25%	18%
Airport Culvert	18%	47%	86%	100%	100%	61%	35%	30%	18%	13%
Rt 46	86%	100%	100%	100%	100%	0%	0%	0%	0%	0%
Airport West	45%	100%	100%	100%	100%	19%	4%	3%	1%	0%
Airport South	27%	100%	96%	100%	100%	32%	11%	5%	3%	1%

Table 25: Probabilistic performance of the East Riser Actionable Element at each Impact Area for the Future Year Without- and With-Project Conditions (LowSLC)

Impact Area	Annual Exceedance Probability		Long-Term Exceedance Probability			Assurance by Event				
	Expected	90% Assurance	10-yr period	30-yr period	50-yr period	10%	2%	1%	0.40%	0.20%
Moonachie Bridge	66%	100%	100%	100%	100%	9%	4%	1%	0%	0%
Amor Rd	74%	100%	100%	100%	100%	9%	5%	3%	2%	1%
Airport Culvert	75%	100%	100%	100%	100%	6%	2%	1%	0%	0%
Rt 46	100%	100%	100%	100%	100%	0%	0%	0%	0%	0%
Airport West	71%	100%	100%	100%	100%	2%	0%	0%	0%	0%

Airport South	70%	100%	100%	100%	100%	2%	1%	0%	0%	0%

Impact Area	Annual Exceedance Probability		Long-Term Exceedance Probability			Assurance by Event				
	Expected	90% Assurance	10-yr period	30-yr period	50-yr period	10%	2%	1%	0.40%	0.20%
Moonachie Bridge	64%	100%	100%	100%	100%	9%	6%	3%	2%	1%
Amor Rd	37%	100%	99%	100%	100%	38%	22%	12%	6%	4%
Airport Culvert	43%	100%	100%	100%	100%	33%	15%	6%	3%	2%
Rt 46	95%	100%	100%	100%	100%	0%	0%	0%	0%	0%
Airport West	69%	100%	100%	100%	100%	4%	0%	0%	0%	0%
Airport South	66%	100%	100%	100%	100%	5%	1%	0%	0%	0%

2.3.2 Regional Economic Development (RED)

The regional benefit associated with construction is the indirect and induced economic output that would be produced for an assumed construction cost. This analysis uses the USACE RECONS 2.0.2 input/output (I/O) model, developed by the Institute for Water Resources (IWR), to estimate the regional economic impacts of proposed construction work activities.

Regional economic impacts and contributions are measured as economic output, jobs, income, and value added for three levels of geographic impact area: local, state, and national. Estimates are based on the specific work activity associated with a project. The tool estimates the regional economic impacts and contributions of project expenditures and assesses impacts and contributions associated with project-related spending by systematically mapping expenditures to production and consumption sectors within a particular economy through a series of linkages among industries, households, and government. Changes to purchases of goods and services for final consumption (final demand change) drive I/O models. Each industry that produces goods and services generates demand for other goods and services. For example, when construction firms pay their workers and purchase supplies or services, such as electricians, plumbers, lumber, concrete, etc., economic activity is generated in the local or regional economy through salaries and business and household spending.

The multiplier for construction activity for a highway will differ from the multiplier for sand placement, therefore, the work activity for each project is carefully selected influenced by the type of structure being proposed. The more resources intense the work activity the more the contribution to the regional development account. The following presents the RED analysis results for East Riser.

For East Riser, a 2028 year of expenditure is assumed for this site, at a cost of $231 million. The work activity for the East Riser Actionable Element site is Construction and Major Rehabilitation of Earth Levees and Floodways within the Flood Risk Management business line.

The expenditures associated with All Work Activities, with Ability to Customize Impact Area and Work Activity at Bergen (NJ) are estimated to be $231,261,000[4]. Of this total expenditure, $208,905,000 will be captured within the local impact area. The remainder of the expenditures will be captured within the state impact area and the nation. These direct expenditures generate additional economic activity, often called secondary or multiplier effects. The direct and secondary impacts are measured in output, jobs, labor income, and gross regional product (value added) as summarized in Table 26. The regional economic effects are shown for the local, state, and national impact areas. In summary, the expenditure of $231,261,000 supports a total of 2,711.8 full-time equivalent jobs, $233,262,000 in labor income,

[4] First costs have increased to approximately $278 mil. The RED output will increase with cost increases and remains a favorable impact to the local and national economy.

$266,564,000 in the gross regional product, and $384,659,000 in economic output in the local impact area. More broadly, these expenditures support 4,095.9 full-time equivalent jobs, $310,030,000 in labor income, $397,854,000 in the gross regional product, and $644,877,000 in economic output in the nation.

Table 26: Overall Summary – East Riser

Area	Local Capture	Output	Jobs FTE	Labor Income	Value Added
Local					
Direct Impact		$208,905,000	1862.1	$166,147,000	$158,430,000
Secondary Impact		$175,754,000	849.8	$67,115,000	$108,134,000
Total Impact	$208,905,000	$384,659,000	2711.8	$233,262,000	$266,564,000
State					
Direct Impact		$221,908,000	2085.1	$174,976,000	$167,465,000
Secondary Impact		$221,315,000	1037.20	$80,395,000	$133,094,000
Total Impact	$221,908,000	$443,222,000	3122.4	$255,371,000	$300,560,000
U.S.					
Direct Impact		$228,810,000	2289.7	$176,522,000	$170,199,000
Secondary Impact		$416,067,000	1806.20	$133,508,000	$227,656,000
Total Impact	$228,810,000	$644,877,000	4095.9	$310,030,000	$397,854,000

*FTE = full time equivalent
Figures are rounded

RED Impact Setting

Communities with relatively higher rates of poverty or unemployment will benefit from the multiplier effect produced by infrastructure investment in the study area. Table 27 presents the economic impact environment for East Riser communities of Moonachie and Carlstadt Boroughs. The community level data is compared to state and county to highlight the potential need for economic development within the region. Moonachie fares well compared to state and county figures on the economic indicators. Carlstadt, however, has lower median income and higher poverty than both state and county and its unemployment rate is higher than county.

Table 27: Economic Setting

	New Jersey State	Bergen County	Carlstadt Borough	Moonachie Borough
Population	9,267,014	955,732	6,372	3,106
Households	3,478,355	353,307	2,639	937
Poverty	9.70%	6.60%	10.50%	4.00%

Median Income	$101,050	$123,715	$94,854	$108,359
Unemployment Rate*	6.20%	4.10%	5.40%	4.10%

ACS: 2023 5-Year Estimates. *The unemployment rate represents the number of unemployed people as a percentage of the civilian labor force for the five-year estimate.
Red indicates worse than both state and county; Yellow indicates worse than either state or county but not both; Green indicates better than both state and county.

2.3.3 Other Social Effects (OSE)

USACE Planning Guidance Notebook states the OSE account is a means of displaying and integrating into water resource planning information on alternative plan effects from perspectives that are not reflected in the other three accounts. The other social effects account displays plan effects on social aspects such as community impacts, health and safety, displacement, energy conservation and others. This section presents conditions that were considered during plan formulation, a detailed social effects analysis can be found in the Main Report of this study.

The challenge of benefit cost analysis of infrastructure projects on social aspects stems from attribution. It is difficult to differentiate between the impacts of the flood risk management project and other factors that may influence social outcomes. This section is limited to identifying and summarizing characteristics of locations within the study area that have greater concentrations of socially vulnerable populations. These demographics provide an opportunity to meaningfully and comprehensively call attention to those who may have relatively more difficulty preparing for and responding to storm events.

The study site at East Riser is particularly vulnerable to floods. There are several small creeks that are tidally influenced that serve as sources of flooding. Structures in the inventory fall between Berrys Creek to the west and East Riser to the east. Multiple sources of flooding coupled with the fact that development in this area is on low lying land illustrates the increased risks to floodplain inhabitants. Even for frequent, everyday chances of flooding events, there is over one foot of flooding, enough to increase risk to health and life safety in homes and on roadways. While these depths may be nuisance to many, serious harm can come to the most vulnerable especially for those with self-care difficulty.

For Moonachie and Carlstadt, both boroughs are located in low-lying areas of the Hackensack River watershed and are almost entirely situated in the 100-year (1% AEP) flood zone as shown in the image below (Figure 6). The most socially vulnerable populations within these communities are characterized by specific demographic and socioeconomic factors that limit their ability to prepare for and recover from disasters.

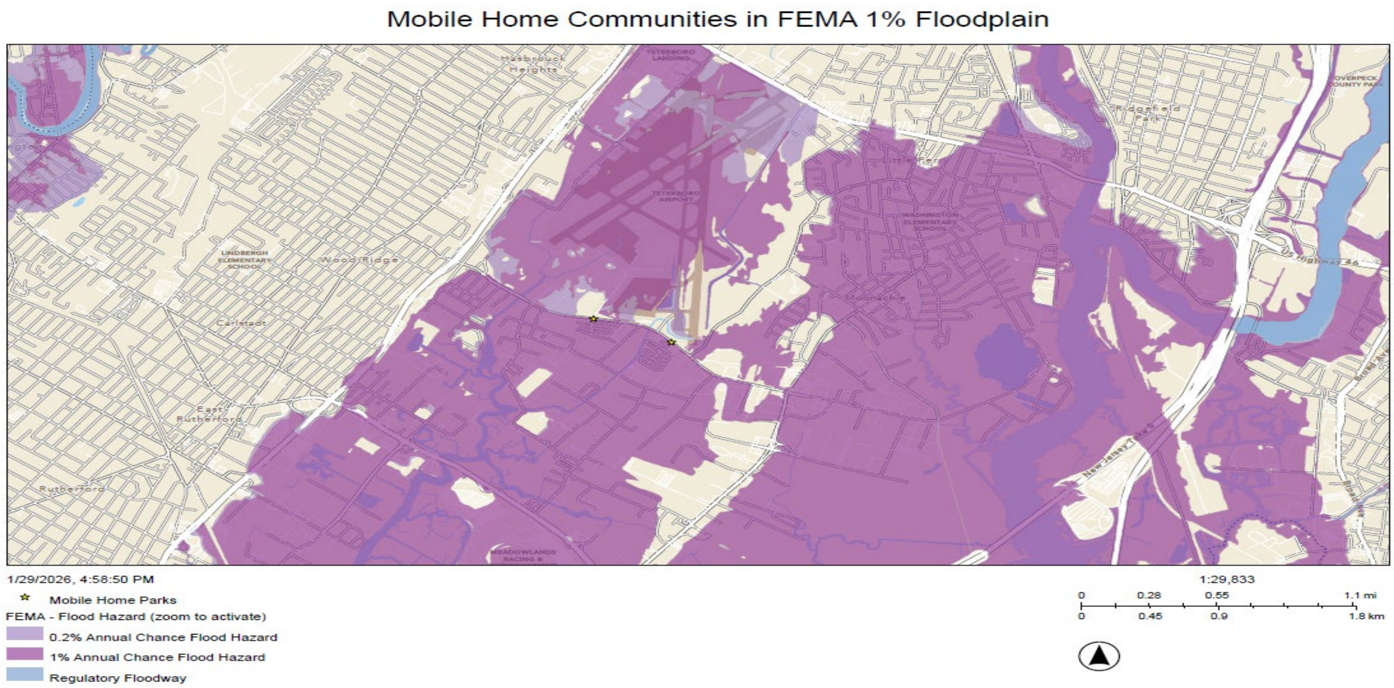


Figure 6: FEMA 1% Floodplain (from FEMA Resilience Analysis and Planning Tool)

As indicated by the star symbols on the map, the Moonachie manufactured home parks are located directly in the 1% chance floodplain. People living in manufactured homes are at risk of severe flood impacts if their homes are flooded because their home may be more susceptible to major damage and they cannot retreat to a second floor for refuge – their entire home is affected. Moonachie has a greater concentration of manufactured homes than in the county and state which can indicate a greater susceptibility to flood events and increased difficulty in recovering from flood events. It may be more difficult for manufactured homeowners to get loans as the cost of repairs may exceed the value of the home and residents generally may have limited financial resources for repairs or temporary relocation after a flood. Moonachie has a rent control ordinance in place for its manufactured home parks that helps residents manage costs, but this may make it more difficult for the locality to fund infrastructure improvements including flood resilience measures since benefit-cost analysis depends on the depreciated replacement value of homes.

The effects of flooding can be particularly catastrophic for those with a disability and Moonachie has a significantly greater percentage of people with self-care difficulties compared to state and county levels. People with self-care disabilities require assistance with daily living activities compounding challenges that significantly impact their safety and recovery. Evacuating may take longer due to the need to transport specialized equipment (e.g., wheelchairs, lifts) or wait for accessible transportation, which is often in short supply during emergencies.

Carlstadt also faces social vulnerabilities with larger populations living in poverty than both state and county. Poorer residents often live in dwellings that lack structural resilience, such as basement apartments, that are more likely to suffer severe damage from even minor flooding. The vulnerability statistics referred to here are summarized in Figure 7 and indicate the urgent need for flood risk management solutions for these vulnerable communities.

Social impacts of hazard exposure often fall disproportionately on the most vulnerable people in a society—the poor, children, the elderly, and the disabled. The image below (Figure 7) shows the percentage of age and physical vulnerabilities as well as poverty status for state, county and floodplain. The East Riser floodplain community is on par with state and county for most vulnerabilities presented below. However, there is an over-representation of people in manufactured homes and of those dependent on others for self-care.

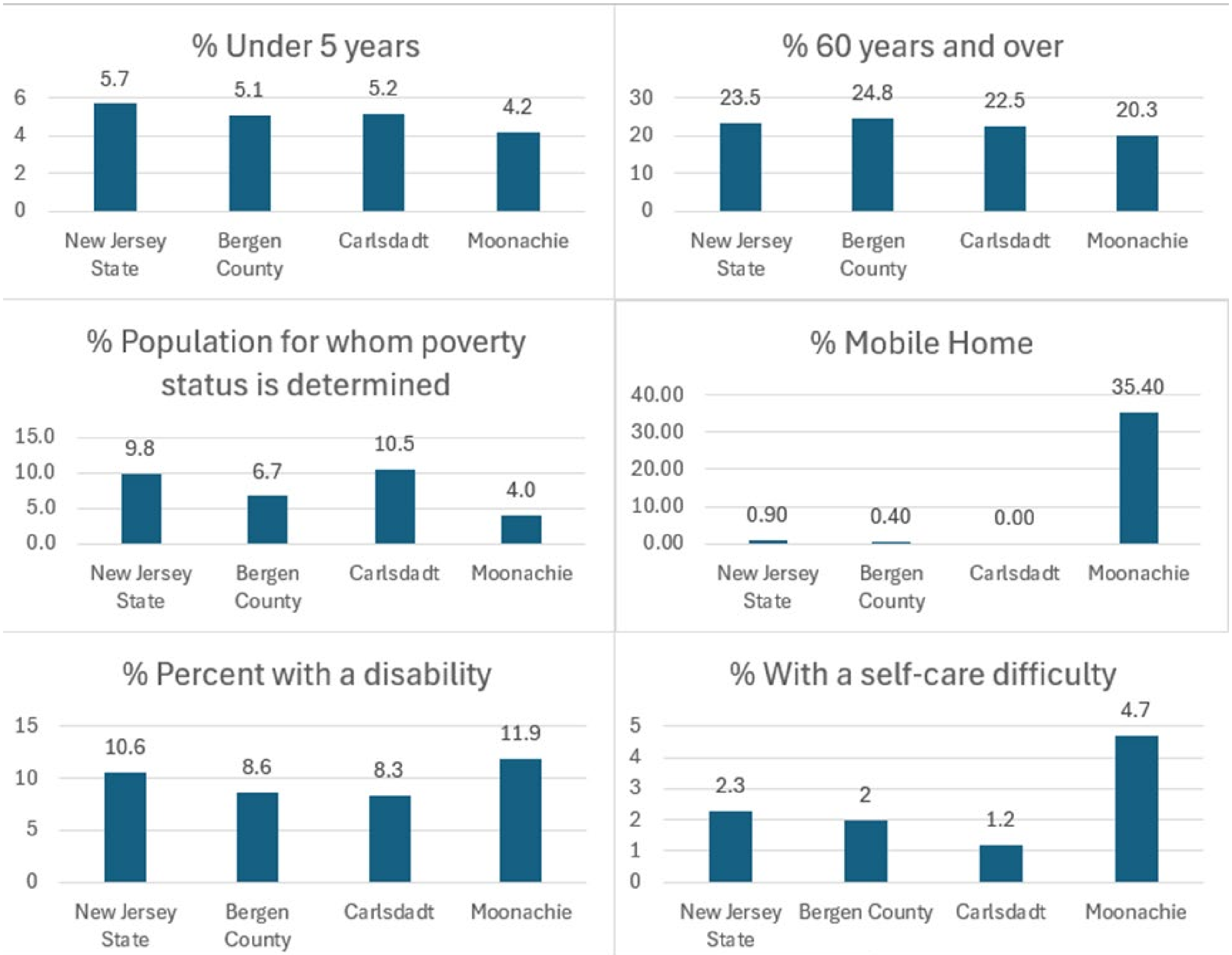


Figure 7: Social Vulnerability Statistics

Life, Health, and Safety

This section examines the impact of the proposed project on mental health. The analysis helps to evaluate the project based on the number of structures protected.

All the experiences that occur leading up to, during, and following a flooding event can have impacts on someone's mental health. Experiencing repetitive flood events compounds these impacts. While putting monetary value on mental health impacts is difficult, this analysis considers inhabitants of structures that experience flooding.

Mental health impacts are calculated using a method adapted from the USACE 1980 Tug Fork report and calculated using the following formula for the without and with project scenarios:

Mental health impacts= # people flooded at AEP event*PTSD incidence*Annual PTSD Compensation*Duration of mental health impacts

Number of people flooded at a specified flood event is derived using output from the HEC-FDA analysis and is a count of the number of structures that have nonzero dollar damages at that AEP. Post-traumatic stress disorder (PTSD) is used as an instance of mental health impact however it is acknowledged that depression and

anxiety can also be experienced by flood victims. The English National Cohort Study of Flooding and Health study determined the post flood incidence rate of PTSD to be 36%, this is likely a conservative estimate since mental health impacts may not be strictly pathological or detectable in the clinical record. For PTSD compensation, US Department of Veteran's Affairs rates for Veterans with a 50% disability rating (a 50% rating reflects serious symptoms leading to reduced work reliability and productivity) is used which is the basic monthly pay for a veteran with no dependents or $16,715/year (This amount applies to veterans who are likely receiving funding from additional sources the amount civilians will need will likely be higher). Finally, psychosocial recovery time from a disaster varies significantly from individual to individual, and some people never reach the point where they feel like they have fully recovered. The method assumes a 3-year duration of mental health impacts, but this is likely significantly underestimating the duration that many people will experience the impacts.
Table 28 presents the monetization of mental health impacts for the without and with project conditions. With-project, mental health impacts are reduced to ~$6mil providing benefits of ~$1.3mil at the .01 AEP.

Table 28: Mental Health Impact of Flooding

Without Project					With Project			
	.1 AEP	.01 AEP	.002 AEP			.1 AEP	.01 AEP	.002 AEP
# of structures	271	406	491		# of structures	165	331	455
Prevalence	0.36	0.36	0.36		Prevalence	0.36	0.36	0.36
Compensation	$16715	$16715	$16715		Compensation	$16715	$16715	$16715
Duration	3	3	3		Duration	3	3	3
Impact*	$4,900	$7,300	$8,900		Impact	$3,000	$6,000	$8,200

*Impact figures are rounded and in thousands.

Displacement

Displacement time is a category of damage that accounts for the duration for which people are forced to evacuate their structure. The source of the baseline estimates used is the Hazards U.S. (HAZUS) software (FEMA, 2022a), a risk assessment software for analyzing potential losses from disasters. The displacement cost consists of a one-time disruption cost along with a recurring monthly rental cost for the duration of the displacement. Duration of displacement considers the recovery time from when a structure has nonzero dollar damages by flooding until it can be reoccupied and is a function of the physical restoration time, contractor availability, hazardous materials removal processes, inspections, and permits and approvals. Estimates of the flood-specific restoration times for structures of different occupancy classes based on depth of flooding are mapped onto the structure inventory according to the HAZUS definitions. The total displacement cost is estimated by adding the disruption cost and the rental costs as expressed in the equation below:

Displacement Cost = (Disruption Cost x ft^2) + (Rental Cost x ft^{2}x Displacement Time)
Flooded structures are identified using the output from the HEC-FDA analysis output.

Costs associated with displacement for the project without are presented in Table 29.

Table 29: Without Project Displacement Costs

Without	Displacement Costs		
Impact Area	.10 AEP	.01 AEP	.002 AEP
Airport Culvert	$706,000	$623,000	$40,484,000
Airport South			$1,556,000
Airport West	$97,000	$97,000	$5,072,000
Amor Rd		$3,637,000	$9,068,000
Moonachie Bridge	$149,000	$1,757,000	$11,833,000

Rt 46			$13,877,000
Total	$952,000	$6,113,000	$81,890,000

At the .002 AEP, total displacement costs will exceed $80 mil for the without-project condition. Disruptions of this magnitude can be catastrophic for residents.

Long-term Productivity

Long-term productivity refers to the project's ability to ensure that the environment remains productive and functional for decades, rather than just providing a quick economic boost through short-term construction activities.

The purpose of the project is to improve the flow of water through the channel and allow it to remain within the banks. The analysis shows that there is no induced flooding that would leave residents worse off, and no downstream impacts are expected due to the presence of storage space in the study area and any increases in downstream flow would be absorbed by existing wetlands.

Once implemented and properly maintained, the channelization project will perform as intended delivering flood risk reduction to residents within the community. Enhancement will be realized when those who once experienced floods no longer must take time off from work or school to rebuild and repair when flood events happen.

2.3.4 Life Safety

Life safety is the risk to individuals who may be affected by coastal storms and other events. Individual life risk is influenced by location, exposure, and vulnerability within a risk managed area. Communities in the affected areas have historically experienced flooding from coastal storms. Residents generally understand the severe implications of staying in harm's way when a coastal storm is forecasted to affect the area. Because there is typically two to seven days' notice prior to hurricanes and tropical storms, residents are usually given sufficient warnings to evacuate. However, for smaller storms and rain events that cause flash flooding, residents may have only a few hours warning time. Residents should evacuate prior to storms to avoid being stranded, which could pose a danger to their welfare. Emergency vehicles may not be able to reach residents in distress due to the flooding of roads and homes. In addition, there is an increased risk of fire in communities due to the potential compromising of electrical and natural gas systems. The inherent erratic nature and unpredictability of a storm's path and intensity require early and safe evacuation. A policy of early, total evacuation should be continued even with the projects in place.

For East Riser, the proposed channelization will bring floodwater into the channel instead of pooling around businesses and residences, which will reduce life safety risk, as well as exposure to pollutants in the run-off.

Tolerable Risk Guidelines (TRG)

Tolerable risk guidelines are used in risk management to guide the process of examining and judging the significance of estimated risks obtained using risk assessment. Pursuing the management of flood risk within the risk framework is an explicit means of better understanding both the flooding and associated consequences, and the uncertainty in their estimation, and thus should support development of robust strategies for managing flood risk. The risk framework is a decision-making process that comprises three tasks that inform the tolerable risk guidelines: risk assessment, risk communication, and risk management.

- TOLERABLE RISK GUIDELINE 1 – Understanding the Risk (Risk Assessment) – there must be an understanding of the incremental risk associated with the project

- TOLERABLE RISK GUIDELINE 2 – Building Risk Awareness (Risk Communication) – there is a continuation of recognition and communication of the residual risk (awareness) in the community.
- TOLERABLE RISK GUIDELINE 3 – Fulfilling Daily Responsibilities (Risk Management) – determining if the risks associated with the project are being monitored and managed properly by those responsible for managing the risk.
- TOLERABLE RISK GUIDELINE 4 – Actions to Reduce Risk (Risk Management) – determining if there are cost effective, socially acceptable, or environmentally acceptable ways to reduce risks from an individual or societal risk perspective.

TRGs 2 and 3 have traditionally been within the purview of local officials through emergency action planning. Both communities at the county level have a general emergency warning system in place that will disseminate timely information to the public during large emergencies. Local planning offices will need stie specific descriptions of the flood threat and the actions residents need to take for safety purposes. A prepared community will offer options for its vulnerable populations. For risk management, it is Corps policy that the District Commander develop an operations and maintenance (O&M) manual for each project under a separate project cooperation agreement (PCA), this will ensure that the project operates as designed and manages risks due to potential failure. Once the project is handed over, the non-Federal sponsor is responsible for operations and maintenance in adherence to instruction in the manuals provided by the Corps.

TRGs 1 and 4, risk assessment and risk management, are within the purview of this effort and are put forth throughout the report. It is acknowledged that no plan or project will completely eliminate the risk of damage to property or life safety risk. In the framework of life safety, the single most effective way of reducing risk to life is evacuation. If residents take precaution and heed authoritative directions to take shelter prior to flood arrival, the chances of death due to drowning will be greatly minimized. Community leaders would do well to have specific ways to communicate warnings and safety instructions for vulnerable populations.

2.3.4.1 Life Safety Risk Tools

USACE has two main tools used to analyze life safety: the Life Safety Risk Indicator (LSRI) and LifeSim. The LSRI tool provides a screening-level, relative representation of the life risk that would be reduced if a flood risk management project was constructed. The LifeSim tool analyzes life loss in a risk framework using Monte Carlo sampling techniques to capture the natural variability of temporal uncertainty in the warning and evacuation process as well as the potential for life loss when put in threatening flood situations. The LSRI tool was used in preliminary evaluations for each site, but LifeSim was used only for the East Riser site that is being recommended. The use of LifeSim for the East Riser site is appropriate because the model is certified for use on flood risk management studies, or investigations of flood risk management solutions.

Screening level analysis showed that life loss was minimal under one specific hydraulic and response condition. The site was further examined for life loss under the risk framework considering several AEP events using the LifeSim tool, results for which are presented below.

LifeSim Results

Population at Risk

Total daytime population at risk (PAR) are presented in Table 30 for without and with project scenarios at select AEPs. The PAR represents the portion of the population that mobilize once warnings have been issued and received.

Table 30 Population at Risk (PAR)

Without Project	Total PAR
EX .10 AEP	1390
EX .50 AEP	1428
EX .01 AEP	1465
With Project	
WP .10 AEP	1292
WP .50 AEP	1422
WP .01 AEP	1448

Daytime life loss results using the intermediate scenario of sea level rise under minimal warning time are presented for selected percentiles and AEP scenarios for the without and with-project conditions in Table 31. LifeSim results show that median life loss is zero for each AEP.

Table 31: Life Loss Results

Without Project	Life Loss Total	Std Dev	Min	Max	Median	95%	5%	75%	25%
EX .10 AEP	0.04	0.20	0	2	0	0	0	0	0
EX .50 AEP	0.04	0.21	0	3	0	0	0	0	0
EX .01 AEP	0.04	0.21	0	2	0	0	0	0	0
With Project									
WP .10 AEP	0.04	0.20	0	2	0	0	0	0	0
WP .50 AEP	0.04	0.21	0	3	0	0	0	0	0
WP .01 AEP	0.04	0.21	0	1	0	0	0	0	0

Life safety risk in the East Riser floodplain is driven by a combination of hazardous physical conditions, human development patterns, and socioeconomic vulnerabilities. The topography of the East Rister site is relatively flat and lies between Watchung Mountains to the west and relatively high ground to the east. During coastal events, storm surges will move inland and spread evenly and linger, leading to sustained flooding across the area as experienced during Hurricane Sandy. East Riser is not only susceptible to coastal influences but to flash flooding where streams are overwhelmed by runoff turning roads into fast moving rivers. The area houses manufactured home communities, Teterboro Airport, an industrial zone, and other land uses. Manufactured home communities are particularly more vulnerable because the structures are usually placed on minimal foundations or ground-level blocks and are often situated on less expensive land typically in the floodplain. This inherently increases their exposure to flood events, making them highly susceptible to damage from rising water and strong currents. Floodwater can cause uplift if the home is not securely anchored and properly elevated creating a situation for great risk to life safety especially for those who choose to shelter in place. Further compounding the risk, are pockets within the East Riser site where the populations are low-income or high unemployment which decreases the likelihood of access to vehicles for evacuation, or they may not have somewhere to go when the evacuation order is given. Although there are no estimated deaths in this area, coastal influences exist that make life safety risk potentially high.

3 DRAFT REPORT ANALYSIS OF DEFERRED ACTIONABLE ELEMENT SITES - NED

All economic values presented in the following sections of the report are in FY2025 price levels for Harlem River and Oakwood Beach. Where applicable, benefits and costs were discounted to the project base year presented in Table 32 using the FY2025 Project Evaluation and Formulation Rate (Federal discount rate) of 3%, as specified in EGM 25-01. For the Harlem River Actionable Element, the period of analysis differs between Engineering inputs (2045-2096) and Economic Modeling, shown below. Since the Actionable Element was deferred, no updates were made to the economic analysis to ensure alignment. Any further analysis and optimization is subject to the future availability of funds.

Table 32: Timelines for evaluated Actionable Elements

Actionable Element	Start of Construction	End of Construction	Base Year	End of Period of Analysis	Years of Full Benefits
Harlem River	2033	2037	2037	2086	50
Oakwood Beach	2028	2037	2037	2086	50

3.1 HARLEM RIVER

Coastal flood risk under the with- and without-project conditions was assessed via HEC-FDA version 2.0.2 (IWR, 2023), relying primarily on the existing inputs for the HEC-FDA version 1.4.2 model developed for the September 2022 Draft Integrated Feasibility Report and Tier 1 (Programmatic) Environmental Impact Statement (USACE, 2022a). Details of the economic assessment conducted as part of this prior report are provided in Appendix D of the main report (USACE, 2022b). There are several differences between HEC-FDA 1.4 and version 2.0.2, which necessitated the development of additional model inputs. Where applicable, this appendix details and describes these changes.

The study assessed coastal flood risk at several different sea level conditions, reflecting the full range of potential sea level change over the period of economic analysis, pursuant to ER 1100-2-8162. These results were used to project coastal flood risk over time given USACE (low, intermediate, and high) sea level change scenarios. These projections were discounted to the base year of economic analysis and annualized using a 3% Federal discount rate pursuant to EGM 25-01.

What follows is a summary of the HEC-FDA 2.0.2 inputs developed and employed for the Harlem River Actionable Element site. This summary is followed by a detailed description of the discounting approach, description of the actionable element modeled in HEC-FDA 2.0.2, and presentation of the economic analysis results.

3.1.1 HEC-FDA 2.0.2 Inputs

3.1.1.1 Terrain Data

Prior versions of HEC-FDA included ground elevation data as part of the structure inventory. In contrast, HEC-FDA version 2.0.2 allows for the import of terrain data via a raster file. For the Harlem River Actionable Element site, the study employs a digital elevation model (DEM) with a horizontal spatial resolution of 1 foot and a vertical accuracy of 3 inches (NOAA, 2017). In conjunction with the structure-specific foundation height specified in the structure inventory, this terrain data directly informs the first-floor elevation of the structures within the Actionable Element site.

3.1.1.2 Impact Areas

Appendix D of the September 2022 Draft Integrated Feasibility Report/Tier 1 (Programmatic) EIS (USACE, 2022b) presents the economic reaches considered during the formulation of the draft comprehensive plan. These reaches were originally delineated based on county boundaries, tidal water bodies, expected maximal extent of damage (corresponding to +20 ft NAVD88), and hydraulic separability. The Harlem River Actionable Element site corresponds to a subsection of economic reach 20-B (Manhattan shoreline along Harlem River), as shown in Figure 8.

For the purposes of economic assessment, this Actionable Element site is represented by a single impact area[5] (i.e., economic reach) within the model. This impact area is hydraulically separable from the adjacent portions of economic reach 20-B. Along its northern edge, the impact area is bounded by high ground adjacent to Harlem River Drive. Further south along the Harlem River, the impact area follows localized high ground, approximately paralleling Adam Clayton Powell Jr Boulevard. The southernmost extent of the impact area is approximately bounded by 144th Street.

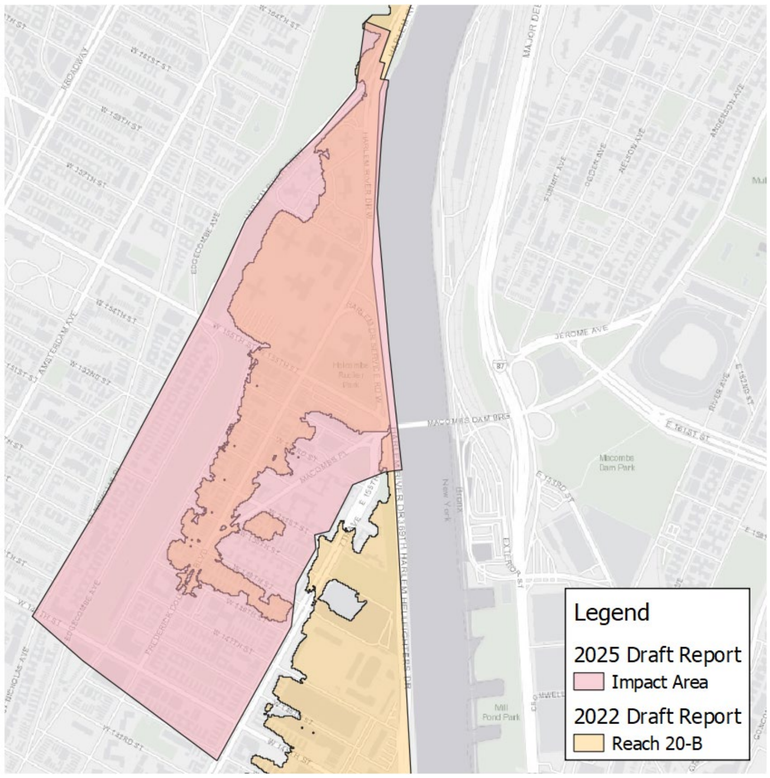


Figure 8: Comparison of the impact area for the Harlem River actionable element and economic reach 20-B from September 2022 Draft Integrated Feasibility Report/Tier 1 (Programmatic) EIS (USACE, 2022b).

3.1.1.3 Hydraulic Inputs

Prior versions of HEC-FDA, including the version used for the September 2022 Draft Integrated Feasibility Report/Tier 1 (Programmatic) EIS (USACE, 2022b) required 1-dimensional hydraulic inputs, specified via model reach. In contrast, HEC-FDA 2.0.2 requires 2-dimensional hydraulic inputs (i.e., event-specific maps of water surface elevations throughout a floodplain). 2-dimensional hydraulic inputs, in comparison to 1-dimensional hydraulic inputs, are more likely to characterize expected extents of flooding with greater fidelity and allow for the direct sampling of flood depths at specific structures. These hydraulic inputs were developed for several different future conditions, reflecting various future sea levels in the Actionable Element site. Sea level change (SLC) projections under the three USACE curves (low, intermediate, and high) were developed via the Sea Level Analysis Tool (SLAT). As a check, these values were also computed independently using Equation 3 in ER 1100-2-8162 and the linear SLC trend at the Battery tide gauge in New York City (Station ID = 8518750). Figure 99

[5] In HEC-FDA v1.4.2, study areas were discretized into smaller sub-regions, termed damage reaches, also sometimes referred to as economic reaches. Within HEC-FDA v2.0.2, these sub-regions are instead referred to as impact areas.

presents the SLC curves used in this study. From these SLC projections, forecasts of without- and with-project coastal flood risk were developed for n = 4 future SLC conditions (+0.49 ft, +1.06 ft, +1.53 ft, and +5.36 ft) corresponding to various points in future along the USACE intermediate and high projections. Table 34 also outlines these SLC conditions and their corresponding future years under the three USACE SLC projections.

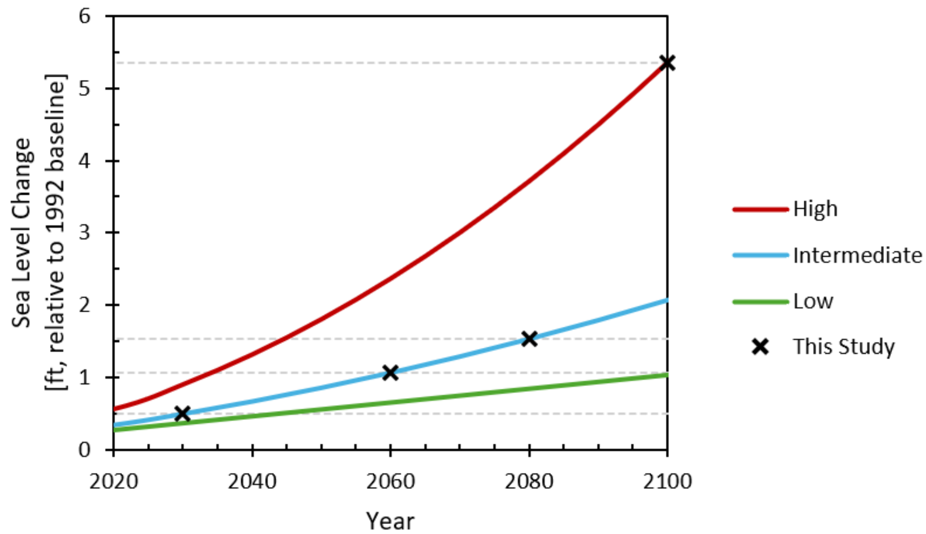


Figure 9: USACE sea level change scenarios (SLC) for the Battery tide gauge in New York City (Station ID = 8518750) and specific SLC conditions used in this study.

Table 33: Sea level change conditions considered in this study and corresponding future years in USACE SLC projections for the Battery tide gauge in New York City (Station ID = 8518750)

Sea Level Change [ft, 1992 baseline]	Year in Projection		
	Low	Intermediate	High
0.49	2043	2030	2018
1.06	2103	2060	2034
1.53	-	2080	2045
5.36	-	-	2100

In the September 2022 Draft Integrated Feasibility Report/Tier 1 (Programmatic) EIS, each economic reach was associated with a particular North Atlantic Coast Comprehensive Study (NACCS) hydrodynamic model save point, which directly informed the water surface profile for each reach. Reach 20-B (Manhattan shoreline along Harlem River) relied upon the water surface profile specified at NACCS save point 13,888. Following the same approach, the baseline mean sea level water surface profile was modulated by the projected increase in sea level to develop future water surface profiles and frequency functions. For each future sea level considered, this study evaluated eight coastal flood events of varying annual exceedance probability (99%, 50%, 20%, 5%, 2%, 1%, 0.5%, and 0.1%). Table 35 summarizes the frequency functions (i.e., water surface elevations vs. AEP) for these eight events for mean sea level (MSL) and future sea level conditions.

Table 34: Frequency functions (water surface elevations at various annual exceedance probabilities; AEPs) under the sea level conditions considered in this study (NACCS save point = 13,888) for the Harlem River Actionable Element site

Scenario	Year	SLC [ft]	AEP	99%	50%	20%	5%	2%	1%	0.5%	0.1%
MSL	**1992**	**0**		4.7	5.8	7.1	8.1	9.0	10.2	11.2	12.5
Intermediate	**2030**	**0.49**		5.2	6.3	7.6	9.5	10.7	11.7	12.9	16.8

Intermediate	**2060**	**1.06**	**WSEL**	5.8	6.9	8.2	10.1	11.3	12.3	13.5	17.4
Intermediate	**2080**	**1.53**	**[ft,**	6.2	7.3	8.7	10.6	11.8	12.7	14.0	17.9
High	**2100**	**5.36**	**NAVD88]**	10.1	11.1	12.5	14.4	15.6	16.6	17.8	21.7

2D mapping of the extent of flooding and associated water surface elevations was developed for each of the eight flood events across the four sea level conditions considered (32 total coastal flood events). Given that the hydrodynamic modeling developed as part of the NACCS study is not readily available in a 2D raster format, the NACCS save point water surface elevation was extrapolated over the Actionable Element site DEM via a raster calculation in QGIS. Though simplified, this approach is consistent with HEC-FDA version 1.4.2, which also relied upon a single water surface elevation to characterize extent and depth of flooding across an entire damage reach. Figure 10 provides an example of flood extent developed via this approach. In this manner, gridded data hydraulic inputs were generated for each sea level condition considered in the study. Note that for coastal flood events of higher water surface elevations, there are a few isolated pockets of flooding shown proximal to Frederick Douglass Boulevard. Absent a hydraulic connection to these locations (e.g., stormwater backflow) it is unlikely that these structures would experience inundation, though the inclusion of these areas is consistent with the 1D projection of flood extents within HEC-FDA v1.4.2.

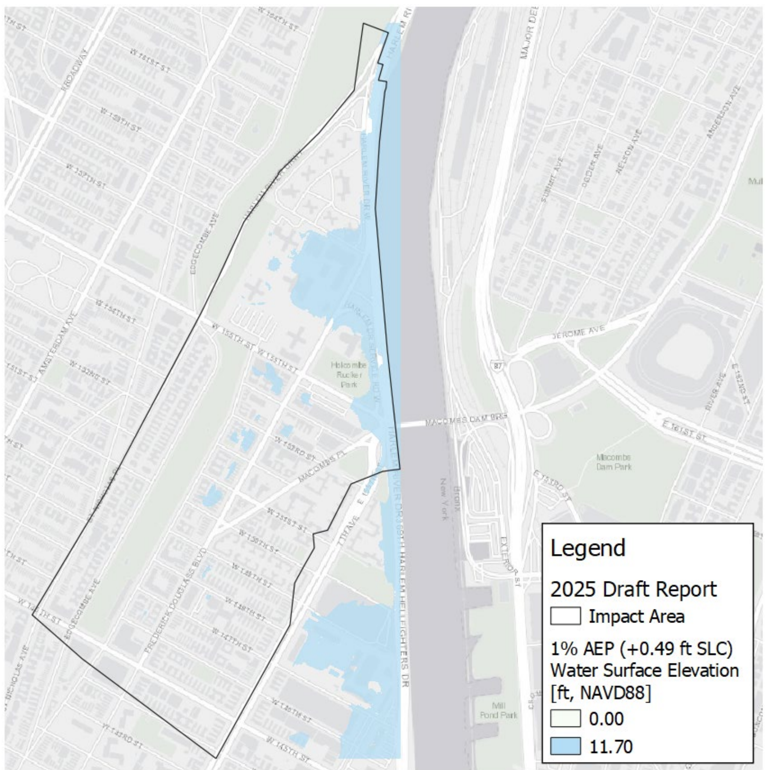


Figure 10: Sample gridded data hydraulic inputs for 1% AEP event with +0.49 ft SLC (USACE intermediate, 2030)

3.1.2 Structure Inventory

The analysis presented in this study largely relies upon the structure inventory developed for the September 2022 Draft Integrated Feasibility Report/Tier 1 (Programmatic) EIS; detailed information pertaining to this structure inventory, including how it was generated, can be found in Appendix D (USACE, 2022b). The original structure inventory asset value data was compiled in January 2018 price levels and subsequently escalated to February 2022 price levels via ENR building cost index (USACE, 2022b). For this interim response report, an alternative publicly available price index, the Federal Reserve's Producer Price Index for Final Demand

Construction (PPIDCS; BLS, 2025)[6] was used to escalate asset values from January 2018 to FY2025 price levels. The Producer Price Index tracks changes in all nonresidential construction project costs; at the time of writing, there is not a similar index for residential construction compiled by the Federal Reserve. Relying on the PPIDCS, asset values were escalated from January 2018 price levels to 2025 price levels by applying an escalation factor of 1.49.

Figure 11 provides a visual summary of the structures included within the inventory and additional structures from Reach 20-B of the September 2022 Draft Integrated Feasibility Report/Tier 1 (Programmatic) EIS that were not included in this study. Table 36 summarizes the number of structures, expected structure value, and expected content values by occupancy type for the structures shown within the impact area.

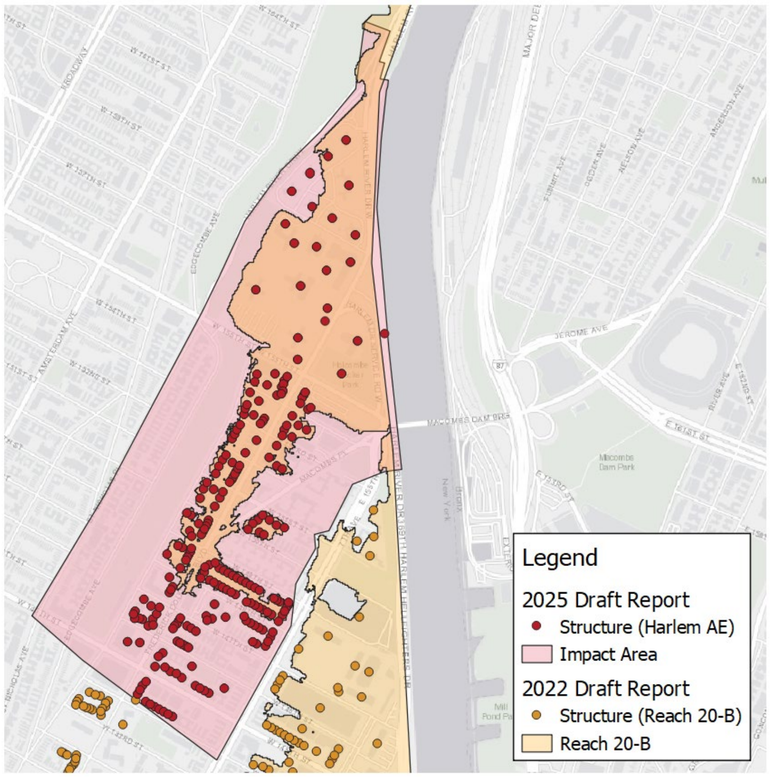


Figure 11: Visual comparison of structures within the Harlem River impact area and Reach 20-B from the September 2022 Draft Integrated Feasibility Report/Tier 1 (Programmatic) EIS.

Table 35: Summary of structures inventory included within the Harlem River impact area

Occupancy Type	Number of Structures	Total Expected Structure Value	Total Expected Content Value
Residential	207	$723,235,000	$361,617,500
Commercial	14	$94,265,000	$29,693,000
Infrastructure	2	$265,923,000	$0
TOTAL	223	$1,083,423,000	$391,310,500

In addition to the structure inventory compiled for the September 2022 Draft Integrated Feasibility Report/Tier 1 (Programmatic) EIS, an additional desktop survey was conducted to identify critical infrastructure assets within

[6] The USACE Civil Works Construction Cost Index System (CWCCIS) was also considered, though not ultimately used to escalate asset values, as this index tracks a different basket of goods (i.e., construction goods and services for a range of USACE for civil works projects) than that which is contained within the structure inventory.

the Actionable Element site. This survey identified the Metropolitan Transit Authority (MTA) New York City Transit (NYCT) 155th St Station and the B & D Line tunnel as additional critical infrastructure within the Harlem River Actionable Element impact area. NYCT has already developed deployable flood barriers at the primary 155 St Station opening and ventilation grates within the Actionable Element site. Per conversations with NYCT and MTA personnel, these assets are likely to be deployed in the future during a coastal flood event, regardless of whether a CSRM feature is constructed within the Actionable Element site. Regardless, the proposed CSRM feature would become the primary coastal flood risk management measure for the NYCT station and tunnel. Given the criticality of the NYCT station and tunnel to the population and economic vitality of NYC, the added layer of risk management provided by the CSRM feature would enhance the resilience of the NYCT subway system to coastal storms. Prior experiences and conversation with NYCT suggest that prior to arrival of a significant coastal storm, transit service will be suspended, though at minimum, the 155th St Station would be closed upon deployment of any localized barriers. Further, trains are unlikely to traverse an actively flooded segment of tunnel. Given this, life safety risk associated with inflow into the 155th St Station and tunnels is low and therefore not evaluated further as part of this effort.

Given this context, the NYCT station and tunnel are included in the structure inventory, though not evaluated further from a life safety perspective. Relying on prior replacement cost estimates for underground heavy rail stations (Martello, 2023) and assuming full depreciation to a terminal value equivalent to half the replacement cost, the 155 St station was valued at $75.9M. A 4,600-foot-long section of the subway tunnel and right-of-way, stretching from west of 155 St Station to the 161 St Station, consisting of three parallel tracks and the subway tunnel itself, was also included in the structure inventory. Relying on replacement costs for typical subway heavy rail assets (Martello, 2023) and a similar estimate of depreciation, this stretch of tunnel was valued at $163.1M. Uncertainty in these asset values was assumed to follow a normal distribution (standard deviation = 38%) in alignment with Martello (2023).

In addition to the NYCT assets within the impact area, an elevated portion of Harlem River Drive is also included in the structure inventory. More specifically, approximately 1,700 linear feet of Harlem River Drive Northbound is supported on a high-level platform, extending over the Harlem River shoreline (NYCEDC, 2016). Based on the data provided within the National Bridge Inventory (FHWA, 2025), this high-level platform (structure number 1055040) has an estimated replacement value of $26.9M (FY2025 price levels). Similar to transit infrastructure, uncertainty in this asset value was assumed to follow a normal distribution (standard deviation = 38%; Martello, 2023). Given the low elevation of this structure (low chord of road deck at approximately +4.6 ft NAVD88) it is particularly vulnerable to coastal inundation. Repairing significant damage to this structure is likely to require prolonged closures and detours of Harlem River Drive Northbound, which is likely to impose additional travel costs for road users. These additional costs have not been quantified as part of this analysis, though they are likely to be significant, given the high volume of traffic that regularly relies on this corridor. As of 2023, this section of Harlem River Drive Northbound carried an estimated 48,292 vehicles per day (i.e., average annual daily traffic; AADT; NYSDOT, n.d.). Even a modest increase in expected travel time for these road users (e.g., 15 minutes) is likely to yield substantial transportation delay costs. Pending data availability, the study will include these disruption costs when the Harlem River actionable element is resumed for a future response to the study authority.

3.1.3 Occupancy Types

These NYCT assets and Harlem River Drive notwithstanding, within the September 2022 Draft Integrated Feasibility Report/Tier 1 (Programmatic) EIS, inventory structures were classified based on their similarity to the building prototypes presented in the NACCS depth-damage report (USACE, 2015). More specifically, within the Actionable Element site, structures were either classified as either urban high rise (Prototype 4A), 3-story apartments with no basement (Prototype 1A-3), or Commercial Non/Pre-Engineered, Nonperishable Contents (Prototype 2 NP). These occupancy type assignments were left unchanged and imported directly from the previously developed HEC-FDA version 1.4.2 file (USACE, 2022b).

3.1.3.1 Harlem River Drive High-Level Platform

The Harlem River Drive Northbound high-level platform can be characterized as an urban bridge. Williams et al. (2025) provide an expert derived minimum and maximum depth-damage function for urban roadway bridges up to a flood depth of 3 meters (10 ft), wherein flood depth is specified relative to the low chord of the bridge deck. Relying on these curves, a most likely damage-function was also developed by averaging these minimum and maximum functions. Damage for flood depths greater than 10 feet were conservatively assessed to remain constant, rather than extrapolating beyond the damage level provided in the source data. This damage cap implies that additional hydrostatic and hydrodynamic loading imposed by greater flood depths is unlikely to impart additional structural damage to the bridge. The resultant depth-damage functions are presented in Figure 12.

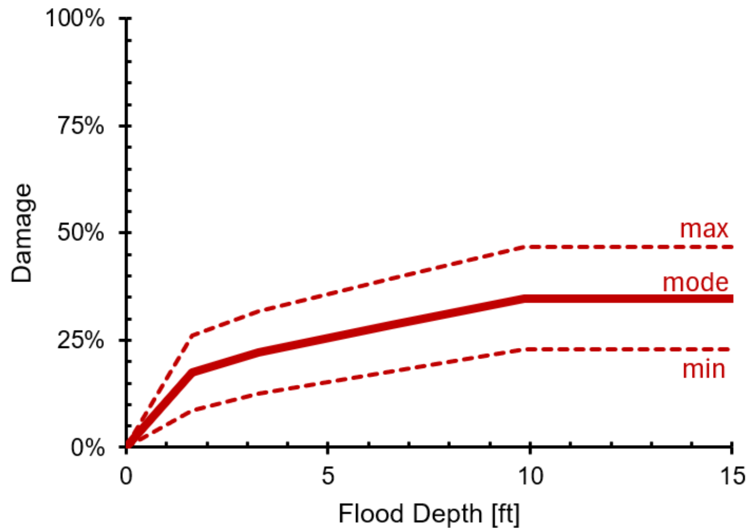


Figure 12: Depth-damage function for urban roadway bridges (Williams et al., 2025)

3.1.4 NYCT Tunnel Depth-Damage Function Development

The NYCT assets in the Actionable Element site (155th St Station and subway tunnel) were assigned a separate occupancy type and depth-damage function. This study developed a volume-informed depth-damage function for these assets following a methodology developed for the City of Boston CSRM Feasibility Study, which is currently ongoing at the time of writing. What follows is a detailed description of this methodology, adapted from the Baltimore CSRM feasibility study (USACE, 2024).

Unlike most other assets, which are well characterized by a single first floor elevation for the purposes of flood damage modelling, the depth of water within a flooded tunnel will vary along its profile. Consequently, the damage along the length of a flooded tunnel will also vary (Martello & Whittle, 2023). This variation is ultimately a function of the geometry of the tunnel, which informs a relationship between flood volume and damages within the tunnel. Applying a similar approach to the recent Baltimore CSRM Feasibility Study (USACE, 2024), this study developed a generalized tunnel volume-damage relationship. In isolation, this generalized volume-damage relationship is however of little value, as a relation between tunnel inflow volume and flood depth at tunnel openings is also required to develop a depth-damage relationship for a specific tunnel of interest. Relying on a sample set of water surface elevation time series data and hydraulic characteristics of the primary tunnel opening in the Actionable Element site (155th St Station entrance), inflow volumes are estimated for a series of flood events of specified depth. Given this tunnel-specific depth-volume relationship and generalized volume-damage relationship, a depth-damage relationship was developed for the 155th St Station and NYCT tunnel, thereby enabling inclusion of tunnel assets within HEC-FDA 2.0.

3.1.4.1 Volume-Damage Relationship

Developing a volume-damage relationship for a tunnel requires the selection or development of a relationship between flood depth and damage for a unit-length of tunnel. Here, this unit-length depth-damage function is a composite of the functions developed for linear assets included within a unit-length of tunnel: track, signal, third rail, power, lighting, and tunnel structure (Martello et al., 2023). This composite curve is a replacement cost-weighted average of depth-damage curves for each of linear asset types that comprise a segment of the transit tunnel right-of-way (ROW). More formally, the composite depth-damage curve for a ROW segment, $f_{ROW}(d)$, composed of n linear assets can be computed as follows:

$$f_{ROW}(d) = \sum_{i=1}^{n} w_i f_i(d)$$

Wherein the depth-damage function for each linear asset, $f_i(d)$, is multiplied by its respective percentage of the overall ROW replacement-cost, w_i, defined as:

$$w_i = c_i \sum_{i=1}^{n} \frac{1}{c_i}$$

where c_i is the expected replacement cost of a linear asset of interest. Note that the sum of all weights is unity. Under this approach, damage estimates for a given ROW segment are identically equivalent to the sum of the damage estimates for each individual ROW asset. Using this approach, replacement-cost weighted damage estimates were developed for a discrete set of flood depths. These discrete damage estimates were utilized to develop a continuous depth-damage function via a cubic regression:

$$f_{ROW}(d) = (1.74 \cdot 10^{-5})d^3 - (1.72 \cdot 10^{-3})d^2 + (6.28 \cdot 10^{-2})d$$

Lower and upper bound depth-damage functions were developed via the approach outlined in Egorova et al., (2008), applying an uncertainty parameter, k = 0.1. The resulting depth-damage functions shown in Figure 13a. As in the Baltimore CSRM study (USACE, 2024) and the Boston CSRM study (ongoing at the time of writing), the resultant damage function was validated via benchmarking (i.e., comparison of this curve relative to adjacent curves provided elsewhere in literature). Absent relevant empirical data, this type of qualitative comparison is the best available method for assessing the validity of depth-damage curves (Gerl et al., 2016; USACE, 2024). Comparing with adjacent curves for general infrastructure found in the literature (de Moel & Aerts, 2011; Vanneuville et al., 2003) and tunnel structure (Martello et al. 2023), the resulting curve aligns well (Figure 13a). Given that the replacement cost of the tunnel structure is more than 85% of the overall unit length replacement cost, the curve closely aligns with the tunnel structure curve (Martello et al., 2023). The upper bound generally aligns with the other infrastructure curves found in literature. These comparisons suggest that the composite unit-length depth-damage function could reasonably be applied to characterize tunnel damages.

Relying on this depth-damage relationship, a generalized volume damage relationship for a tunnel can be developed through the consideration of two hypothetical tunnel geometries, referred to here as cases A and B. Case A considers a perfectly flat tunnel with no slope. In such a tunnel, any volume of flood water will be distributed evenly across its entire length. That is, across the entirety of the tunnel, the flood depth, and therefore the damage estimate, is constant. The resulting volume-damage relationship under Case A is shown in Figure 1312b. Case B considers a tunnel with an infinite slope, that is, a vertical shaft. In such a tunnel (or shaft) any given increment of the tunnel is either fully flooded or completely dry. The resulting volume-damage relationship under Case B is shown in Figure 13.

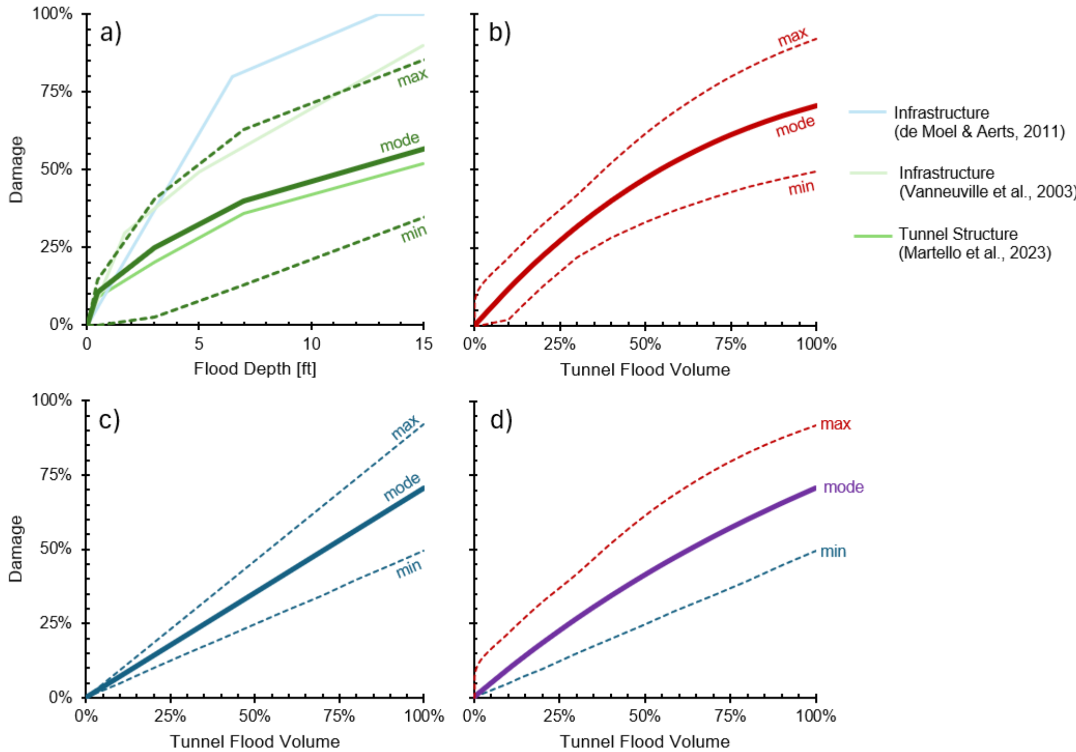


Figure 13: a) depth-damage relationship characterizing fragility of a unit length of subway tunnel; b) damage-volume relationship under case A (flat tunnel); c) damage-volume relationship under case B (vertical shaft); d) damage-volume relationship under case C (combination of cases A and B)

Tunnels are neither perfectly flat, nor vertical. The slope of a tunnel, which is typically well under a 10% grade, will vary along its longitudinal alignment, and this variation will affect this volume-damage relationship. Adequate characterization of this tunnel-specific variability in the volume-damage relationship for a given tunnel would require hydraulic modeling to characterize the relationship between inflow volume and flood depths along the profile of a tunnel. Rather than expend the significant additional modeling effort that would be required for each tunnel under this approach, here, it is assumed that Cases A and B can be combined to adequately represent a volume-damage relationship for all tunnels. That is, the upper bound of Case A and lower bound of Case B bound the range of possible volume-damage estimates, while an equally weighted average of the mode of Case A and B inform the mode of the generic volume-damage relationship. This equal weighting implies that the most likely average slope in a tunnel is 50%, much higher than what would be realistically expected. However, this assumption is purposefully conservative, as an equal weighting biases the volume-damage relationship closer to the lower bound. Figure 13d provides the resultant generic volume-damage relationship.

3.1.4.2 Depth-Damage Relationship

This generic damage-volume relationship can be employed alongside a tunnel-specific depth-volume relationship to develop a depth-damage relationship for a tunnel of interest. Developing a depth-volume relation for a specific road tunnel requires specification of the hydraulic characteristics of all tunnel openings. Relying on available data from as-built drawings and the study DEM, the elevation, slope, and width of all tunnel portals was found for each road tunnel. Given these characteristics, for a given depth of flooding at a tunnel opening, a corresponding inflow can be computed via a weir flow equation (Martello, 2023):

$$Q(t) = 3.33(w - 0.2d)d^{\frac{3}{2}}$$

Wherein the width of the opening, w, and the depth of flooding, d directly inform inflow into the tunnel. Using this approach, given a sample coastal flood event (defined by a tide and storm surge) a time series of water surface elevations can be used to estimate inflows over time into each tunnel opening. Figure 14 illustrates a sample coastal flood event, wherein water levels are developed based on a tide and a superimposed storm surge. Given a lowest critical location (LCL) for the 155th St Station entrance, the depth of water and corresponding inflows at a tunnel opening can be evaluated for each time step. Given these resultant inflow rates, the overall volume of inflow into each tunnel opening can be computed via numerical integration; the total volume of inflow into the tunnel can be found by summation of inflows at all tunnel openings (Martello & Whittle 2023). In this manner, a depth-volume relationship is developed for each road tunnel, wherein the flood depth corresponds to the maximum water depth at the lowest tunnel opening.

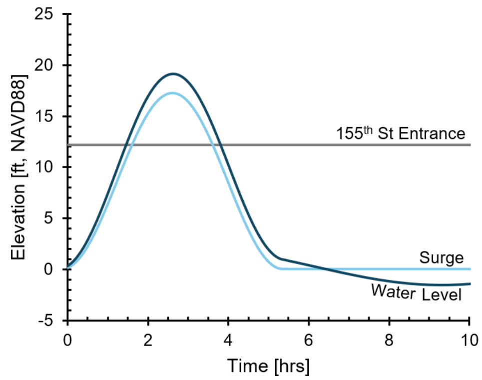


Figure 14: Sample surge, and water surface elevation over time at the 155th St Station entrance

Using this approach, inflow volumes and flood depths were computed for each road tunnel under a set of n=8 sample flood events (peak surge elevations of +12.2, +13.2, +14.2, +15.2, +16.2, +17.2, +18.2, +19.2 ft NAVD88). Inflow volumes were normalized by estimated tunnel volume (4,200,000 ft^3) to develop a percent of flooded tunnel volume. Figure 15a provides the resultant depth-volume relationship. Given this tunnel-specific depth-volume relationships and the generic tunnel volume-damage relationship (Figure 13d), Figure 15b presents a tunnel-specific depth-damage relationships for the 155th St Station and NYCT tunnel.

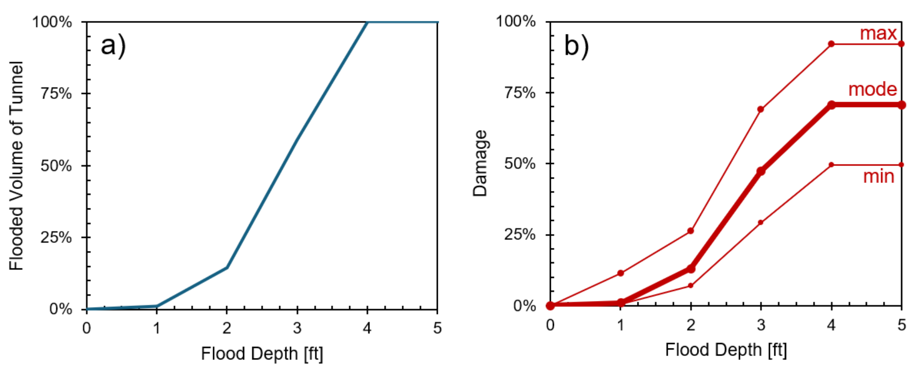


Figure 15: 155th St Station and NYCT tunnel: a) flood depth-volume relationship, b) flood depth-damage relationship.

3.1.5 Discounting Approach

This study employed HEC-FDA 2.0 to assess expected annual damages (EAD) under the with- and without-project condition for under several future sea level conditions, as highlighted above. While HEC-FDA 2.0 can nominally use this information to assess flood risk over the full period of economic benefits, it is not well suited for analyzing future conditions that change in a nonlinear manner over time, such as is the case under the USACE intermediate and high SLC projections. As such, flood risk over the full period of analysis was assessed and discounted outside of HEC-FDA. Using EAD outputs for the four sea level conditions highlighted in Table 37, projections of future EAD were interpolated via a linear equation for the (USACE low SLC) or a quadratic equation (USACE intermediate and high), ensuring monotonicity over time. Table 36 provides the quadratic coefficients used to characterize EAD over time under the low, intermediate and high SLC scenarios. EAD for without- and with-project conditions were evaluated over a 50-year period of analysis for each of the three USACE SLC projections. These future EAD values were subsequently discounted to the base year of analysis and annualized using the FY25 Federal discount rate (3%, EGM 25-01).

Table 36: Linear and quadratic equations characterizing expected annual damages (EAD) over time under USACE sea level change (SLC) scenarios

Variable	Sea Level Change (SLC) Scenario		
	Low	Intermediate	High
Equation	$EAD = b(year) + c$	$EAD = a(year)^2 + b(year) + c$	
a	-	-434.67	8,165.56
b	29,917	1,837,570	-33,238,157
c	-59,050,750	-1,936,980,733	33,828,057,678

3.1.6 Actionable Element Overview

The proposed actionable element was modeled within HEC-FDA as a lateral structure assigned to the Harlem River Actionable Element impact area, with a crest elevation[7] of +17.5 ft NAVD88. HEC-FDA 2.0 allows for the fragility of these structures to be characterized via a system response curve. Development of a system response curve is important when evaluating the expected performance of levee systems, as their probability of failure generally increases with flood severity. In contrast, floodwalls and seawalls are designed to ensure that they retain their structural integrity, even during overtopping events. As such, it was assumed that the proposed actionable element will not fail, even during overtopping events (i.e., the system response curve denotes a 0% failure probability at all flood stages).

3.1.7 Results

Expected annual damages (EAD) for the Harlem River impact area were computed for the four SLC conditions identified in Table 34: Sea level change conditions considered in this study and corresponding future years in USACE SLC projections for the Battery tide gauge in New York City (Station ID = 8518750)31 using HEC-FDA 2.0. These results are shown in Table 38: Without- and with-project Expected annual damages (EAD) for the Harlem River Actionable Element impact area, (HEC-FDA 2.0.2 outputs)35, wherein total EAD for the impact area and EAD by occupancy type are provided for both the without- and with-project condition. In the without-project condition, EAD for commercial and residential structures are similar in magnitude, with greater EAD shown for residential structures. EAD for infrastructure assets in the Actionable Element site (i.e., 155 St Station and subway tunnel, Harlem River Drive high-level platform) are greater than those estimated for commercial or residential structures. Under the without-project condition, EAD under the highest SLC condition (+5.36 ft) is an order of magnitude greater than under the next highest SLC condition (+1.53 ft). EAD (i.e., residual risk) under the with-project condition is similarly an order of magnitude greater under the highest SLC conditions. Residual

[7] Referred to as "Top of Levee Elevation" in HEC-FDA version 2.0.2

risk under the with-project condition is minimal, demonstrating that the proposed actionable element provides a robust level of risk management. For context, the crest elevation of the proposed actionable element (+17.5 ft NAVD88) corresponds to approximately a 0.15% annual exceedance probability with intermediate SLC at the end of period of analysis. Consequently, the CSRM benefit provided by the project is robust to SLC, providing a similar degree of risk management under the +0.49 ft, +1.06 ft, and +1.53 ft SLC conditions, while still providing significant CSRM benefit under the highest SLC condition.

Table 37: Without- and with-project Expected annual damages (EAD) for the Harlem River Actionable Element impact area, (HEC-FDA 2.0.2 outputs)

	Expected Annual Damage (EAD)							
	Without-Project				With-Project (Residual Risk)			
SLC [ft]	TOTAL	Commercial	Residential	Infrastructure	TOTAL	Commercial	Residential	Infrastructure
0.49	$ 2,069,000	$ 382,000	$ 391,000	$ 1,296,000	$ 1,000	<$1,000	<$1,000	<$1,000
1.06	$ 3,864,000	$ 484,000	$ 618,000	$ 2,763,000	$ 2,000	<$1,000	$ 1,000	$ 1,000
1.53	$ 4,626,000	$ 828,000	$ 745,000	$ 3,054,000	$ 3,000	<$1,000	$ 1,000	$ 1,000
5.36	$ 38,189,000	$ 9,467,000	$ 12,580,000	$ 16,142,000	$ 120,000	$ 19,000	$ 55,000	$ 46,000

FY2025 Price Levels

Relying on these EAD values, and implementing the discounting approach outlined above, annualized coastal storm risk under without- and with-project conditions, along with associated CSRM benefits for each SLC scenario are shown in Table 38: Annualized coastal storm risk and project performance for the Harlem River Actionable Element across USACE SLC scenarios. Based on these results, under the intermediate SLC scenario, the proposed actionable element is expected to provide $3.6M [FY2025 price levels] in annualized CSRM benefit to the Actionable Element site. Additionally, Table 38: Annualized coastal storm risk and project performance for the Harlem River Actionable Element across USACE SLC scenarios provides the benefit-cost ratio (BCR) and average annual net benefit (AANB) by SLC scenario. Given the estimated $761,984,000 cost of the Harlem River Actionable Element, this corresponds to a BCR of 0.1 under the intermediate SLC condition.

Table 38: Annualized coastal storm risk and project performance for the Harlem River Actionable Element across USACE SLC scenarios

	Coastal Storm Risk (Annualized)		CSRM Benefit (Annualized)	Average Annual Cost (AAC)	Benefit-Cost Ratio (BCR)	Average Annual Net Benefit (AANB)
SLC Scenario	Without-Project	With-Project				
Low	$ 2,475,000	$ 1,000	$ 2,474,000	$29,615,000	0.1	-$ 27,141,000
Intermediate	$ 3,616,000	$ 2,000	$ 3,614,000	$29,615,000	0.1	-$ 26,001,000
High	$ 8,577,000	$ 17,000	$ 8,560,000	$29,615,000	0.3	-$ 21,055,000

FY2025 Price Levels; Federal Discount Rate = 3%; 50-year period of analysis (2037-2086)

Performance of the Harlem River actionable element was also computed via HEC-FDA 2.0.2 pursuant to ER 1105-2-101. Performance was computed relative to the design still water level (+12.2 ft NAVD88). As shown in Table 39: Probabilistic performance of Harlem River Actionable Element across SLC conditions, the expected annual exceedance probability of the actionable element is 1.6% with SLC towards the end of period of analysis (USACE intermediate SLC in 2080). Annual exceedance probability, in this case, is defined as the likelihood that the lateral structure as described in the Harlem River Actionable Element is overtopped in a given year. Assurance is defined as the likelihood that the designed levee will be able to contain a defined threshold stage. The actionable element plan will pass the 3.0% AEP event with 90% assurance at the end of period of analysis under the intermediate SLC. The long-term exceedance probability (LTEP), which refers to the likelihood of multiple overtopping events within a given time period, increases with SLC. Under the intermediate SLC scenario, the 10-year LTEP starts at 8.7% in 2030 and increases to 14.9% by 2080. Conversely, assurance decreases over time under the intermediate SLC scenario. For example, under the 1% AEP event, assurance is 63.7% in 2030 and decreases to 36.6% by 2080.

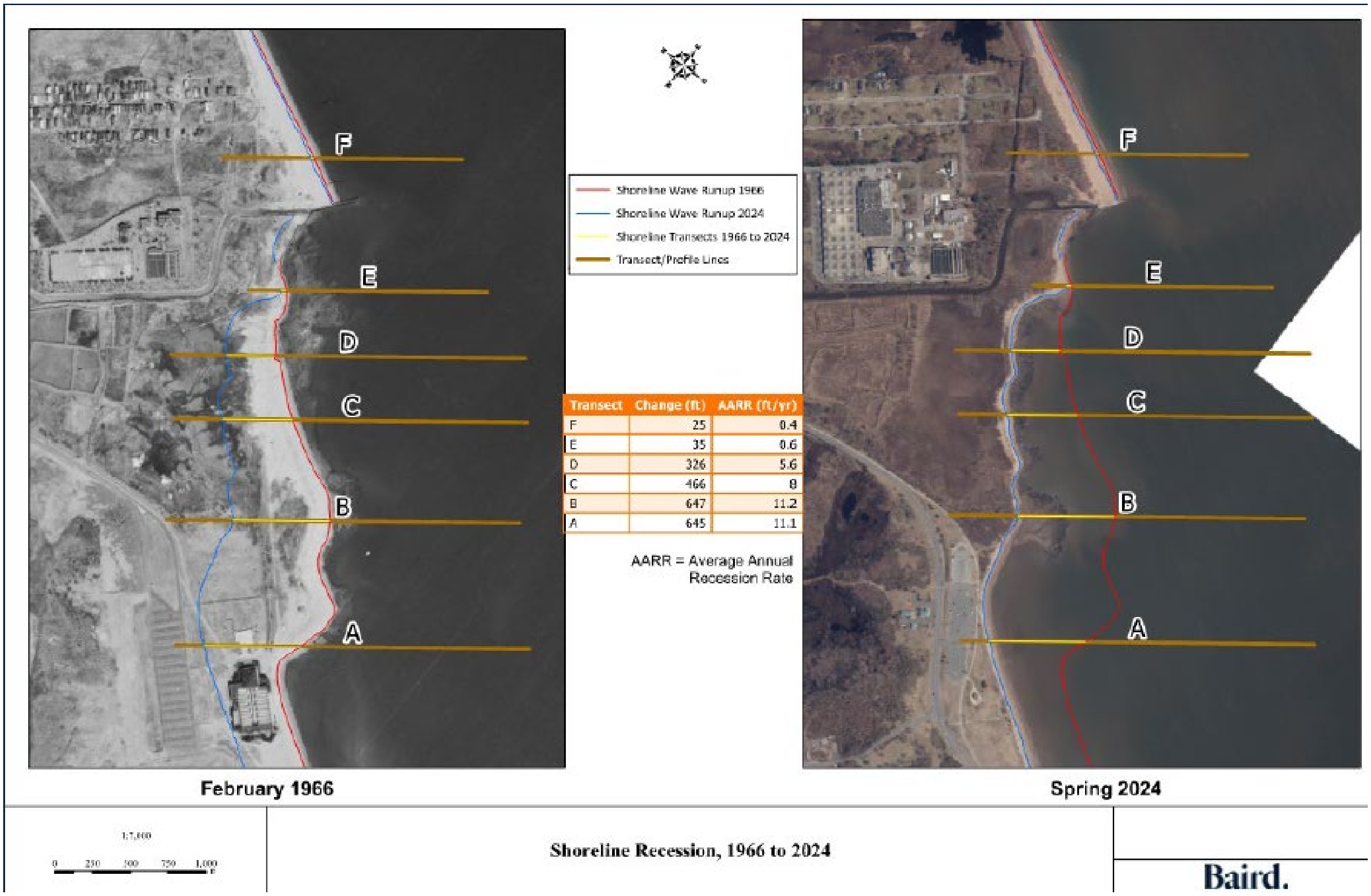
Table 39: Probabilistic performance of Harlem River Actionable Element across SLC conditions

SLC Scenario	Year	SLC [ft]	Annual Exceedance Probability		Long-Term Exceedance Probability			Assurance by Event				
			Expected	90% Assurance	10-yr period	30-yr period	50-yr period	10%	2%	1%	0.40%	0.20%
Int.	2030	0.49	0.9%	1.7%	8.7%	24.0%	36.7%	>99.9%	95.7%	63.7%	18.8%	1.9%
Int.	2060	1.06	1.2%	2.3%	11.7%	31.1%	46.2%	>99.9%	85.1%	47.4%	9.7%	0.7%
Int.	2080	1.53	1.6%	3.0%	14.9%	38.4%	55.4%	>99.9%	68.7%	36.6%	5.1%	0.2%
High	2100	5.39	25.3%	30.7%	94.6%	>99.9%	>99.9%	0.04%	<0.01%	<0.01%	<0.01%	<0.01%

3.2 OAKWOOD BEACH

The Oakwood Beach Actionable Element site encompasses an existing dune and wetland system within Great Kills Park, adjacent to Buffalo Street and the Oakwood Beach Wastewater Resource Recovery Facility (WWRF). The proposed actionable element, consisting primarily of dune and wetland restoration, is expected to provide CSRM benefit via long-term shoreline stabilization and wave attenuation. Stabilization of the shoreline and wetland restoration within the Actionable Element site is expected to provide coastal storm risk management benefit to Buffalo Street, and the wetland north of the Actionable Element site. This wetland contains contaminants that are likely to be mobilized if subject to erosion. Additionally, the existing wetland, which consists primarily of invasive phragmites, poses a significant and well documented wildfire risk (NYCDEP, 2012). The proposed wetland restoration would replace this invasive phragmites with spartina and other native plantings, which are less likely to burn as quickly or intensely as phragmites. This is expected to reduce wildfire risk to the South Short of Staten Island (SSSI) floodwall adjacent to the Oakwood Beach WWTP. The following sections detail the analysis conducted to assess the benefits of the proposed actionable element.

Notable coastal storm-driven erosion has occurred along the shoreline of Great Kills Park over the last several decades and is expected to continue. Though more noticeable along the shoreline immediately southwest of the Actionable Element Site, this erosion is steadily encroaching upon the existing maritime dune, fronting the tidal wetlands. Figure 16 transects B, C, D, and E are within the bounds of the proposed project. Erosion rates are highest at the southern extent of the project (Transect B). The average annual shoreline recession rate at transects B, C, D, and E, were 11.2, 8, 5.6, and 0.6 feet per year, respectively. If these rates were to continue through the 50-year period of analysis, there would be a 560-, 400-, 280-, and 30-foot recession of shoreline at Transects B, C, D, and E, respectively. In the future, absent additional shoreline stabilization measures, it is likely that wave action from coastal storms will continue to erode the existing shoreline and tidal wetland.



Transect	Change (ft)	AARR (ft/yr)
F	25	0.4
E	35	0.6
D	326	5.6
C	466	8
B	647	11.2
A	645	11.1

Figure 16: Shoreline Recession from 1966 to 2024

3.2.1 Shoreline Stabilization

Notable coastal storm-driven erosion has occurred along the shoreline of Great Kills Park over the past several decades. Though more immediately noticeable along the shoreline immediately southwest of the Actionable Element site, this erosion is steadily encroaching upon the existing natural dune fronting the tidal wetlands within the Actionable Element site. The crest elevation of this existing dune varies, though generally decreases from southwest to northeast, reaching a maximum crest elevation of approximately +9 ft NAVD88 within the Actionable Element site. At the northeastern extent of the Actionable Element site, proximal to the outfall of the tidal inlet, progressive failure of the existing erosion management structure has allowed for this erosion to accelerate in recent years. Further, sedimentation within the existing channel diversion structure has encouraged flow from the tidal inlet to redirect towards this failing erosion management structure, further accelerating this erosion. Figure 17 visually summarizes the observed shoreline change over time via satellite imagery.

Figure 17: Observations of shoreline erosion via satellite imagery (Google Earth, n.d.)

In the future, absent additional shoreline stabilization measures, it is likely that wave action from coastal storms will continue to erode the existing dune within the Actionable Element site. Additionally, absent shoreline stabilization measures at the outfall of the existing tidal channel, it is likely that its outflows will continue to accelerate shoreline erosion. Over time, further erosion of the existing natural dune will expose the existing wetland to greater wave action and coastal forcings, which is likely to degrade the condition of the existing wetland. Consequently, the proposed shoreline stabilization and dune restoration is integral to ensure adequate long-term function of the proposed wetland restoration.

3.2.2 Wave Attenuation

The long-term function and viability of the restored wetland will also provide a substantive coastal storm risk management benefit, primarily though attenuation of wave action during all flood events, though particularly for frequent, low-consequence coastal storm events. It is well documented that wetlands and similar nature-based features, such as mangroves, are capable of attenuating wave energy during coastal flood events (King et al., 2018). The degree of wave attenuation provided by a wetland is a function of several factors, though it is primarily influenced by the extent of vegetative cover (perpendicular to the shoreline) and the type of plant species populating the wetland (Lee & Nepf, 2024). The primary plant species in the existing wetland, an invasive phragmites, is quite effective at attenuating wave energy, though under existing conditions a sizable portion of the wetland is an intertidal mudflat without any vegetative cover. Though the primary plant species specified in the wetland restoration, spartina, is somewhat less effective at attenuating wave energy (Lee & Nepf, 2024) the proposed restoration effort would cover these intertidal mudflats, increasing the overall vegetative cover within the wetland.

Given that the degree of wave attenuation directly correlates with the extent of vegetative cover, the shortest section of the wetland is likely to provide the smallest degree of wave attenuation during a coastal storm event. At its shortest width perpendicular to the shoreline, the existing wetland is approximately 300 ft in length, with approximately half of that width consisting of barren mudflat. The wave attenuation benefits provided by the wetland are likely to be smallest along this longitudinal section of the wetland. Focusing on this portion of the wetland and informed by the results presented in Lee & Nepf (2024) and additional correspondence (I.H. Lee, personal communication, May 20, 2025), this study qualitatively evaluated the wave attenuation benefits of the wetland under the existing and with-project restored condition.

For the wetland section of interest under existing (i.e., current without-project) conditions, if healthy, the existing partially vegetated and phragmites-dominated wetland is likely to provide some degree of wave attenuation during coastal storm events, attenuating wave action in less severe events and likely reducing wave height by up to several feet under more severe coastal storm events (Lee & Nepf, 2024). Under the proposed future with-project condition, wherein the wetland consists primarily of spartina and other native plantings, it is likely that the wetland would provide a similar magnitude of wave attenuation. The existing without-project conditions is unlikely to be representative of the future without-project conditions, given observed changes in the wetland over time. As observed via satellite imagery, the vegetative cover within the wetland has been decreasing over time (i.e., the size of the barren mudflat has been increasing over time). It is likely that the existing wetland will continue to degrade in future, with further reductions in vegetative cover. As such, a minimal-vegetation condition is likely a more representative future-without project condition; this condition would not provide any wave attenuation. Under both the existing and proposed with-project conditions, if vegetation is dormant (e.g., during the winter months), the wave attenuation benefits would be greatly diminished, though given the expected increase in vegetative cover, it is likely that the restored wetland would provide marginally greater wave attenuation benefits, when compared to a without-vegetation condition. Table 40 summarizes this qualitative assessment of wave attenuation benefits.

Table 40: Summary of qualitative assessment of wave attenuation benefits for the Oakwood Beach Actionable Element site

Wetland Characteristics			**Wave Attenuation**	
Condition	**Primary Species**	**Vegetative Cover**	**Healthy Vegetation**	**Dormant Vegetation**
Existing (Current without-project)	Phragmites (invasive)	Moderate	Substantial	Minimal
Likely Future-Without Project (minimal vegetation)	Phragmites (invasive)	Minimal	Minimal	None
With-Project (Future with-project)	Spartina (native)	High	Substantial	Minimal

When compared to the condition of the existing phragmites-dominated wetland, the proposed wetland is likely to provide a comparable degree of wave attenuation. However, when compared to the likely future-without project condition, wherein vegetative cover is minimal, the proposed wetland restoration is likely to provide a significantly higher degree of wave attenuation. As such, the proposed wetland restoration is expected to provide a modest increase in wave attenuation over time, when compared to the without-project condition. When compared to a without-project condition, the restored wetland will provide greater erosion risk management for Buffalo Street, wetlands north of the Actionable Element site, and for a component of the South Shore of Staten Island (SSSI) project, the Oakwood Beach WWTP floodwall.

3.2.2.1 Benefit to South Shore of Staten Island Project

Based on review of internal USACE design documents for the South Shore of Staten Island (SSSI) floodwall, the wave attenuation provided by the existing wetland was neither modeled nor considered when estimating the wave heights, design elevations, or erosion scour protection. Instead, the design relies upon offshore wave heights and forcings as the basis of floodwall design. This approach is reasonable and conservative, particularly given the questionable long-term health and longevity of the existing wetland. However, it is possible that the proposed wetland restoration would significantly attenuate waves impacting the SSSI floodwall around the Oakwood Beach WWTP during a coastal storm event. As such, the current floodwall design, particularly the scour protection at the toe of the floodwall, is likely overly conservative. If further evaluated and quantified, the wave attenuation benefits of the wetland restoration present a value engineering opportunity for the SSSI floodwall, as they could reduce the design requirements and load conditions for the floodwall. This could yield a yet to be quantified cost savings for the SSSI project. If the design of the floodwall remains unchanged, these wave attenuation benefits would nonetheless provide benefit to the SSSI floodwall, as they would in effect provide an enhanced factor of safety for the floodwall, particularly for the scour protection at the toe of the CSRM measure.

3.2.3 Wildfire Risk Assessment

In addition to costal storm risk, the Oakwood Beach Actionable Element site is also vulnerable to wildfire risk. Though the overall risk of wildfires is quite low on average within New York City, particularly when compared to other places across the country, wildfires do regularly occur within the city limits. For instance, during a recent drought in 2024, New York City experienced a significant volume of wildfires, including a two-week span between November 1 to November 14, 2024, when the New York City Fire Department (FDNY) responded to 271 brush fires across all five boroughs (Lander, 2025). These brush fires often occur at the wild-urban interface, particularly in areas where parkland transitions to developed areas. The South Shore of Staten Island, inclusive of the Oakwood Beach Actionable Element site, is laced with such wild-urban interface, and is particularly vulnerable to wildfires.

Wildfires on the South Shore of Staten Island are typically fueled by phragmites. Fires fueled by phragmites typically have a very high flame length and a rapid rate of spread. Particularly when growing in the same location for several years, phragmites stands tend to be thick and dense, providing a high fine fuel load (approximately 8 tons/acre; NYCDEP, 2012). Under moderate fire conditions, phragmites can burn between 81 and 344 feet per minute, with flame lengths as long as 35 feet; under high fire behavior conditions, these fires can burn as much as 804 feet per minute with flame lengths upwards of 54 feet (NYCDEP, 2012). More recent statistics are limited, though such high fire conditions have been occurring with greater frequency within the NYC metro area (NYCDEP, 2012). When such fires reach the urban-wild interface, they pose a significant risk to adjacent structures. Based on these conditions, it is likely that under existing conditions, the SSSI floodwall would be at high wildfire risk. A wildfire risk assessment for the Oakwood Beach Actionable Element site and SSSI floodwall was conducted using RMC TotalRisk v1.0. The following subsections detail the components of this risk assessment.

3.2.3.1 Wildfire Hazard Analysis

Understanding the risk posed by wildfires in the study area first requires an understanding and characterization of the wildfire hazard within the study area. The data required to adequately characterize such hazard is rather limited, as such information is not sufficiently reported for the study area on a regular basis. However, sufficient information to characterize wildfire hazard analysis is available via a NYCDEP (2012) report, which highlights that, over a 14-year period from 1996 through 2010, 1,120 wildfires were recorded along the southern shore of Staten Island. Within an approximately 564-acre subset of the South Shore of Staten Island that includes the Actionable Element site, 301 fires were reported, of which approximately 4% (12 fires) were categorized as serious brush fires (NYCDEP, 2012). Given this observed wildfire frequency, assuming the spatial distribution of wildfire hazard is uniform across the area, there is a 4.3% chance of a wildfire affecting the Oakwood Beach Actionable Element site in any given year. For a bit of context, based on a nation-wide assessment of wildfire burn probability recently conducted by the US Forest Service (Dillon, 2023), this level of wildfire risk is analogous to that of the Pacific Palisades neighborhood of Los Angeles, California, which experienced catastrophic wildfires in January 2025.

Given this expected recurrence rate, this study characterized annual wildfire hazard via a two-part approach, using RMC TotalRisk v1.0. First, a probabilistic hazard function was selected. In any given year, it is most likely (>95% probability) that a wildfire will not occur within the study area. Additionally, it is possible that more than one fire may occur in the study area during a given year. As such, the gamma distribution was selected as the hazard function, as it can be heavily skewed towards a lower bound zero value, while retaining an unbounded upper bound. Second, a transformation function was developed to translate the continuous hazard function into a discrete number of wildfires. The corresponding hazard-transform was calibrated to yield an expected annual wildfire risk of 4.3% (gamma distribution: $\theta = 0.16, \kappa = 1.0$, effective record length = 14 years). The resultant hazard, transform, and wildfire occurrence functions are provided in Figure 18.

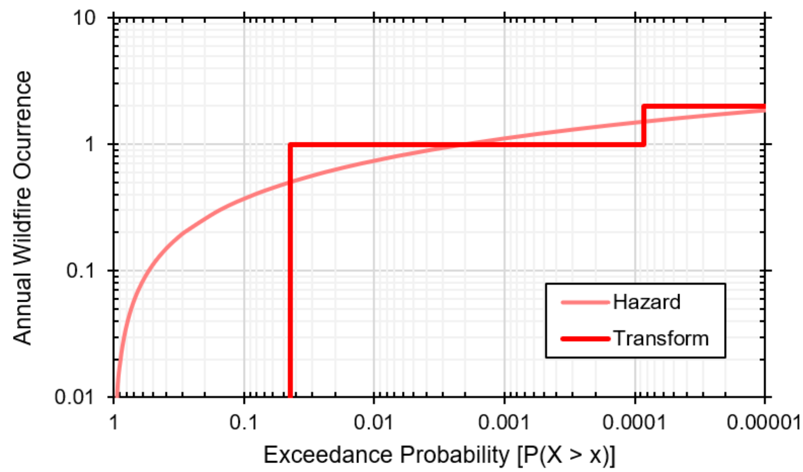


Figure 18: Wildfire hazard and transform function characterizing wildfire risk to the Oakwood Beach Actionable Element site.

3.2.4 Wildfire Consequence

The consequence of a wildfire in the Actionable Element site is uncertain. Under existing without-project conditions, wherein the wetland is dominated by phragmites, at a minimum, there will be some nominal cost of suppressing the wildfire[8]. However, given the proximity of the wetland to the proposed SSSI floodwall, it is possible, that a wildfire in the wetland could damage this floodwall. By contrast, under the with-project condition, while a comparatively lower fire fuel load spartina would likely still require fire suppression, it is comparatively far less likely that such a wildfire would reach sufficient intensity to damage the SSSI floodwall. Under both the without- and with-project conditions, the consequence of a single wildfire is characterized via a generalized beta distribution, wherein the most likely consequence is minimal damage ($\alpha = 6.0,\ \beta = 1.0$). The primary difference between the without- and with-project condition is the upper bound of wildfire damages. The remainder of this subsection details how the upper bound of these wildfire consequence functions were developed.

3.2.4.1 Without-project Wildfire Consequence Function

Given the expected rapidity and severity of a phragmites-fueled wildfire under even moderate fire conditions, it is possible that a wildfire event within the Actionable Element site would spread to the vegetated area in front of the proposed SSSI floodwall. Given the expected intensity of such a wildfire, dependent on fire conditions and duration, it is possible that this wildfire exposure could damage the reinforced concrete floodwall.

If exposed to fire for a prolonged duration, though the material itself is noncombustible, reinforced concrete can still be damaged by fire. At temperatures as low as 300 F, concrete can begin to spall (Borgerson & White, 2021). At temperatures above 570 F, the structural strength of reinforced concrete (RC) can become irreversibly compromised (Kline, 2020). At such temperatures, thermal expansion cracks are likely to develop and propagate within an RC structural member, particularly if the structural member is rapidly quenched during firefighting efforts (Kline, 2020). Additionally, at temperatures above 500F, within the range that phragmites can burn, water entrained in the interstitial void space of the concrete begins to vaporize and rapidly expand into steam (Kline, 2020; Borgerson & White, 2021). This can cause microfractures in the concrete between interstitial voids, significantly weakening the compressive strength of the concrete. Exposure to intense heat can also induce explosive spalling, wherein chunks of concrete rapidly delaminate from the reinforced concrete member (Kline, 2020). Assessment of structural strength in RC structures after a fire requires extensive non-destructive and destructive testing to identify which sections of structural members are compromised (Borgerson & White, 2021).

[8] For simplicity within this analysis, this nominal wildfire suppression cost is neglected (i.e., the minimum wildfire consequence is $0 in damages).

Proper repair of fire-damaged RC structures typically requires demolition and in-kind replacement of structurally compromised RC members (Kline, 2020).

As such, if the SSSI floodwall is exposed to any number ($n \geq 1$) of phragmites-fueled wildfires within a given year, in a worst-case scenario, the entire length of the floodwall bounding the Actionable Element site (57% of the total length of the T-wall portion) would be exposed to temperatures sufficient to compromise the structural integrity of the above-ground portions of the floodwall and require its replacement. Informed by the estimated construction costs of the T-wall portion of the SSSI floodwall, this replacement would cost be approximately $5,407,000 which accounts for approximately 57% of the total replacement cost of this section of floodwall. This potential extent of damage serves to bracket the upper bound of potential wildfire consequences to the floodwall. Given this upper bound and the generalized beta distribution parameters specified above, Figure 19 provides the resulting without-project wildfire consequence function.

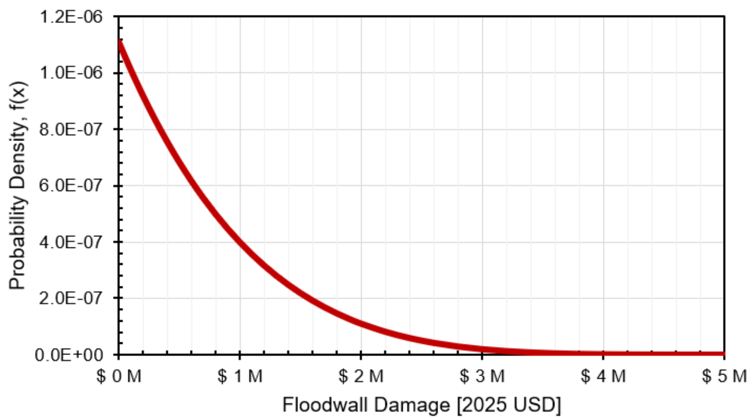


Figure 19: Without-project wildfire consequence function, considering the potential for damage to the SSSI floodwall adjacent to the Oakwood Beach Actionable Element site

3.2.4.2 With-project Wildfire Consequence Function

Under the with-project condition, while still potentially vulnerable to wildfire, the proposed spartina-dominated wetland will carry a lower fine fuel fire load. The USDA Forest Service provides a range of fire fuel models, based on the characteristics of plant species that can be used within Rothermel's surface fire spread model to understand how wildfires burn and spread (Scott & Burgan, 2005). Within this framework phragmites can be classified as fire fuel model GR8, which is expected to carry a fine fuel load of 7.8 tons per acre and a maximum flame length upwards of 50 feet. By contrast, the proposed spartina-dominated wetland, can be classified as GR3, which is expected to carry a lower fine fuel load of 1.6 tons per acre, which also translates to a much lower rate of spread and significantly shorter flame length, at most 15 feet (Scott & Burgan, 2005). Consequently, it is much less likely that a wildfire in the Actionable Element site under the future with-project condition would reach the SSSI floodwall. Further, it is even less likely that the fire would reach and sustain sufficient temperatures to damage the floodwall. Rather than assume a full reduction in the upper bound wildfire consequences, the wildfire risk reduction provided under the with-project condition is assumed to be proportional to the reduction in fine fuel load (i.e., an 80% reduction), resulting in an upper bound of $1,081,000 in wildfire damages to the SSSI floodwall. Figure 19 provides the resulting without-project wildfire consequence function.

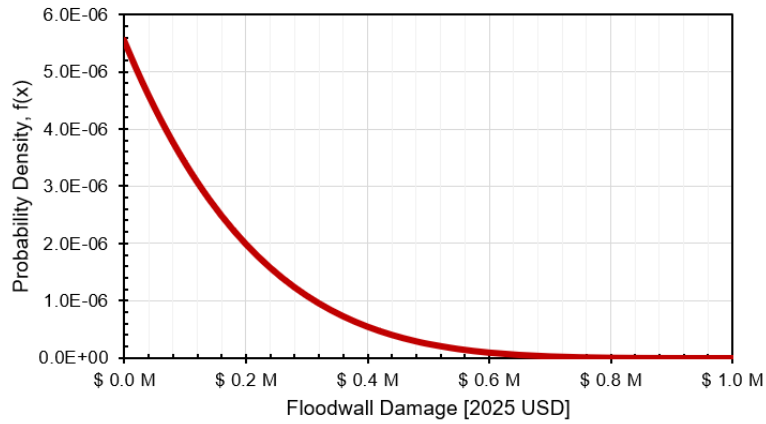


Figure 20: With-project wildfire consequence function, considering the potential for damage to the SSSI floodwall adjacent to the Oakwood Beach Actionable Element site

3.2.5 Estimated Wildfire Risk

Given the assessed wildfire hazard and the consequence functions outlined above, under current without-project conditions, there is approximately $32,000 in expected annualized wildfire risk to the SSSI floodwall. Under the with-project conditions, there is approximately $6,000 in expected annualized wildfire risk. The proposed wetland restoration is therefore expected to provide $26,000 in annualized wildfire risk management benefit. Though future wildfire risk is projected to increase in future (NYCDEP, 2012), neglecting this nonstationary (i.e., making a conservative assumption that wildfire risk will remain stationary over time), the proposed project would provide $26,000 in annualized wildfire risk management benefits. At this time, analysis of risk for Oakwood Beach does not account for uncertainty. Should Oakwood be reevaluated by a future effort, uncertainty analysis will be included as part of the economic reporting. While the actual rate of SLC would impact the beach erosion, and in turn, the vegetative cover, it is assumed that wildfire risk will be independent of future SLC for this risk assessment.

3.2.6 Results

Given these estimated without- and with-project wildfire risk estimates, the proposed actionable element is expected to provide $26,000 [FY2025 price levels] in annualized wildfire risk management benefit to the Actionable Element site. Given the estimated $55,355,000 cost of the Oakwood Beach actionable element, the actionable element has a BCR <0.1; Table 41 summarizes these results.

Table 41: Annualized wildfire risk under the without- and with-project condition and annualized wildfire risk management benefit

	Wildfire Risk (Annualized)		Coastal Storm Risk Management Benefit (Annualized)	Benefit-Cost Ratio (BCR)	Average Annual Net Benefit (AANB)
Impact Area	Without-Project	With-Project			
SSSI Floodwall	$32,000	$6,000	$26,000	<0.1	-$2,125,000
Project area	$0	$0	$0	-	
TOTAL	$32,000	$6,000	$26,000	<0.1	$26,000

FY2025 Price Levels; Federal Discount Rate = 3%; 50-year period of analysis (2037-2086)

3.3 COMPARISON OF DRAFT REPORT ALTERNATIVES

Given the risk management benefits outlined for each of the actionable element sites, Table 42 provides the national economic development (NED) average annual equivalent costs, benefits, net benefits, and benefit-cost ratios for the actionable element alternatives that were under consideration during the Draft Report phase.

Table 42: Average annual equivalent (AAEQ) economic costs, benefits, and net benefits of proposed Actionable Element alternatives

ALTERNATIVES		**Alt A: No Action**	**Alt B: NED Plan**			**Alt C: Comprehensive Benefits Plan**			**Alt D: Maximize Total Net Benefits for Study Purpose**			**Alt E: Least Environmentally Damaging**		
ACTIONABLE ELEMENTS		**-**	**East Riser**			**Harlem River, East Riser, and Oakwood Beach**			**Harlem River and East Riser**			**Oakwood Beach**		
P&G Accounts	**Metrics**	**Int. SLC**	**Low SLC**	**Int. SLC**	**High SLC**	**Low SLC**	**Int. SLC**	**High SLC**	**Low SLC**	**Int. SLC**	**High SLC**	**Low SLC**	**Int. SLC**	**High SLC**
National Economic Development	AAEQ Cost	$0	$9,683,000			$41,449,000			$39,298,000			$2,151,000		
	AAEQ NED Benefits	$0	$15,508,000			$18.00 M	$19.15 M	$24.08 M	$17.97 M	$19.12 M	$24.05 M	$26,000 wildfire risk reduction + erosion risk reduction		
	AAEQ Net Benefits	$0	$5,825,000			-$23.40 M	-$22.3 M	-$17.37 M	-$21.33 M	-$20.198 M	-$15.24 M	-$2,125,000		
	Benefit-Cost Ratio	-	1.6			0.4	0.5	0.6	0.5	0.5	0.6	< 0.1		

FY2025 Price Levels; Federal Discount Rate = 3%; 50-year period of analysis (2037-2086)

4 DRAFT REPORT ANALYSIS OF DEFERRED ACTIONABLE ELEMENT SITES - REGIONAL ECONOMIC DEVELOPMENT (RED)

This section discusses the RED analysis results calculated for the deferred Harlem River and Oakwood Beach Actionable Element Sites during Draft Report Analysis. For more information on the definition of RED, please see Chapter 3 above.

4.1 HARLEM RIVER

A 2028 year of expenditure is assumed for this site, at a cost of $762 million. The work activity for the East Harlem River Actionable Element site in New York County is Construction and Major Rehabilitation of Earth Levees and Floodways within the Flood Risk Management business line.

The expenditure associated with All Work Activities, with Ability to Customize Impact Area and Work Activity at New York (NY) are estimated to be $762,000,000. Of this total expenditure, $591,380,000 will be captured within the local impact area. The remainder of the expenditures will be captured within the state impact area and the nation. These direct expenditures generate additional economic activity, often called secondary or multiplier effects. The direct and secondary impacts are measured in output, jobs, labor income, and gross regional product (value added) as summarized in the following table. The regional economic effects are shown for the local, state, and national impact areas. In summary, the expenditure $762,000,000 supports approximately 5,724 full-time equivalent jobs, $697,112,000 in labor income, $642,845,000 in the gross regional product, and $889,385,000 in economic output in the local impact area. More broadly, these expenditures support about 11,977 full-time equivalent jobs, $1,075,000,000 in labor income, $1,264,000,000 in the gross regional product, and $2,101,000,000 in economic output in the nation. Table 43 presents the RED output for the Harlem River Actionable Element site.

Table 43: Overall Summary – Harlem River

Area	Local Capture	Output	Jobs FTE	Labor Income	Value Added
Local					
Direct Impact		$591,380,000	4,484.9	$568,450,000	$442,920,000
Secondary Impact		$298,010,000	1,239.9	$128,660,000	$199,920,000
Total Impact	$591,380,000	$889,380,000	5,724.7	$697,110,000	$642,840,000
State					
Direct Impact		$649,590,000	5,587.9	$609,500,000	$482,860,000
Secondary Impact		$627,790,000	2,810.6	$235,220,000	$395,310,000
Total Impact	$649,590,000	$1,277,380,000	8,398.5	$844,720,000	$878,170,000
U.S.					
Direct Impact		$731,490,000	6,117.9	$638,320,000	$519,610,000

Secondary Impact		$1,369,360,000	5,859.1	$437,030,000	$744,460,000
Total Impact	$731,490,000	$2,100,850,000	11,977.0	$1,075,350,000	$1,264,070,000

RED Impact Setting

Communities with relatively higher rates of poverty or unemployment stand to benefit from the multiplier effect produced by infrastructure investment in the study area. Table 44 presents the economic impact environment for East Harlem communities at the tract level. The community level data is compared to state and county to highlight the potential need for economic development within the region.

The Economic Environment table below presents the prevalence of poverty, unemployment and median income for the counties of interest. East Harlem AE site tracts have significantly higher poverty and unemployment rates than both the county and state.

Table 44: East Harlem Economic Environment

	New York State	New York County	Tract 232	Tract 234	Tract 235.02	Tract 236	Tract 243.02	Tract 259
Population	16,235,440	1,421,588	7,212	4,550	1,511	8,273	5,724	3,685
Households	7,668,956	775,376	3,484	2,446	817	4,240	2,648	1,801
Poverty	13.7%	15.8%	47.6%	30.0%	42.0%	13.8%	42.3%	16.6%
Median Income	$84,578	$104,553	$29,571	$72,423	$44,799	$42,692	$22,973	$75,406
Unemployment Rate	6.2%	7.0%	11.9%	12.3%	15.8%	18.3%	30.7%	11.2%

ACS: 2023 5-Year Estimates
Red indicates worse than both state and county; Yellow indicates worse than either state or county but not both; Green indicates better than both state and county.

4.2 OAKWOOD BEACH

A 2028 year of expenditure is assumed for the Oakwood Beach Actionable Element site in Richmond County, at a cost of $99 million. The work activity within the Flood Risk Management business line is Beach Nourishment On-Shore Sand.

The expenditures associated with All Work Activities, with Ability to Customize Impact Area and Work Activity at Richmond (NY) are estimated to be $98,565,000. Of this total expenditure, $59,990,000 will be captured within the local impact area. The remainder of the expenditures will be captured within the state impact area and the nation. These direct expenditures generate additional economic activity, often called secondary or multiplier effects. The direct and secondary impacts are measured in output, jobs, labor income, and gross regional product (value added) as summarized in the following table. The regional economic effects are shown for the local, state, and national impact areas. In summary, the expenditure $98,565,000 support approximately 625 full-time equivalent jobs, $50,868,000 in labor income, $52,096,000 in the gross regional product, and $95,388,000 in economic output in the local impact area. More broadly, these expenditures support about 1,470 full-time equivalent jobs, $119,631,000 in labor income, $156,978,000 in the gross regional product, and $290,538,000 in economic output in the nation. Table 45 presents the RED output for Oakwood Beach Actionable Element site.

Table 45: Overall Summary - Oakwood Beach

Area	Local Capture	Output	Jobs	Labor Income	Value Added
Local					
Direct Impact		$59,990,000	439.4	$39,552,000	$31,249,000
Secondary Impact		$35,398,000	185.7	$11,316,000	$20,847,000
Total Impact	$59,990,000	$95,388,000	625.1	$50,868,000	$52,096,000
State					
Direct Impact		$78,219,000	552.5	$50,849,000	$42,292,000
Secondary Impact		$74,987,000	318.5	$27,960,000	$47,732,000
Total Impact	$78,219,000	$153,207,000	871	$78,809,000	$90,024,000
U.S.					
Direct Impact		$98,258,000	669.7	$60,001,000	$53,147,000
Secondary Impact		$192,279,000	800.6	$59,630,000	$103,831,000
Total Impact	$98,258,000	$290,538,000	1470.2	$119,631,000	$156,978,000

4.3 IMPACT SETTING

Communities with relatively higher rates of poverty or unemployment stand to benefit from the multiplier effect produced by infrastructure investment in the study area. Table 46 presents the economic impact environment for Oakwood Beach at the county level. The county level data is presented because the

Table 46: Oakwood Beach Economic Environment

	New York State	Richmond County
Population	19,872,319	492,734
Households	7,668,956	170,047
Poverty	14.20%	10.90%
Median Income	84,578	98,290
Unemployment Rate	6.20%	5.50%

ACS: 2023 5-Year Estimates
Red indicates worse than both state and county; Yellow indicates worse than either state or county but not both; Green indicates better than both state and county.

5 DRAFT REPORT ANALYSIS OF DEFERRED ACTIONABLE ELEMENT SITES - OTHER SOCIAL EFFECTS (OSE)

This section discusses the OSE analysis and results calculated for the deferred Harlem River and Oakwood Beach Actionable Element Sites during Draft Report Analysis. For more information on the definition of OSE, please see Chapter 4 above.

This section is limited to identifying and summarizing characteristics of locations within the study area that have greater concentrations of socially vulnerable populations. These demographics provide an opportunity to meaningfully and comprehensively call attention to those who may have relatively more difficulty preparing for and responding to storm events. The analysis here differs slightly than was performed for East Riser however, further analysis during subsequent phases is warranted for Harlem River and Oakwood Beach.

5.1 HARLEM RIVER

Vulnerable Population

Social impacts of hazard exposure often fall disproportionately on the most vulnerable people in a society; the poor, minorities, children, the elderly, and the disabled. These groups often have the fewest resources to prepare for a flood, live in the highest-risk locations in substandard housing, and lack the knowledge or social and political connections necessary to take advantage of resources that would speed their recovery.

The Harlem River Actionable Element Site is located on the shoreline of the tidally influenced Harlem River. Table 47 summarizes vulnerable populations within the Harlem River Actionable Area floodplain. All the tracts within the site have lower rates of people over 65, and higher rates of children under 5 when compared to state and county levels. Sixty-seven percent of the tracts have higher rates of disabled persons and higher rates of poverty when compared to state and county figures. There is a clear vulnerability in populations within the area

Table 47: Vulnerable Populations – Harlem River

	Population Estimate	% Over 65	% Under 5	% Any Disability	% Poverty
New York State	20,201,249	18.6 (18.5,18.7)	5.3 (5.2,5.4)	13.0 (12.8,13.2)	14.2 (13.9,14.5)
New York County	1,694,251	18.8 (18.7,18.9)	3.9 (3.8,4.0)	12.4 (11.7,13.1)	16.5 (15.3,17.7)
Harlem River Site Tracts					
Census Tract 236	9,907	16.2 (11.4,21.0)	7.8 (3.8,11.8)	18.4 (12.7,24.1)	13.8 (6.7,20.9)
Census Tract 243.02	7,237	12.2 (8.9,15.5)	6.9 (3.3,10.5)	20.7 (14.2,27.2)	42.3 (32.2,52.4)
Census Tract 235.02	2,206	18.3 (13.0,23.6)	3.9 (0.8,7.0)	17.6 (11.9,23.3)	42.0 (30.3,53.7)
Census Tract 232	8,061	6.6 (4.9,8.3)	9.0 (5.8,12.2)	16.9 (12.5,21.3)	47.6 (34.6,60.6)
Census Tract 259	4,029	3.6 (2.1,5.1)	5.6 (2.3,8.9)	7.4 (5.0,9.8)	16.6 (10.5,22.7)
Census Tract 234	5,112	7.0 (4.8,9.2)	6.1 (3.0,9.2)	11.6 (6.1,17.1)	30.0 (21.1,38.9)

Green indicates better than state and county; red indicates worse than state and county

Figures in parentheses is the margin of error interval around the estimated percentages and are provided by US Census
Population: 2020 Decennial Census
Age demographics: DP05, S0101 | 2023 American Community Survey 5-Year Estimates
Disability: S1810 | 2023 American Community Survey 5-Year Estimates Total civilian noninstitutionalized population
Poverty: S1701 | 2023 American Community Survey 5-Year Estimates
Unemployment: DP03 | 2023 American Community Survey 5-Year Estimates

Respiratory Morbidities

Mold growth after a flood can pose serious health risks due to mold spores becoming airborne and triggering allergies or respiratory issues. According to the Environmental Protection Agency, flood water can make the air in homes unhealthy. Mold can grow on wood, drywall, carpet and furniture if they remain wet for more than 24 hours. Flood waters can also contain bacteria, chemicals or other hazards which may affect your health. Populations with pre-existing health conditions are more vulnerable to the impact of flooding, particularly those with respiratory diseases. People with asthma or Chronic Obstructive Pulmonary Disease (COPD) are likely to react badly to floods and mold conditions limiting their ability to take protective actions. CDC PLACES data on the prevalence of selected respiratory diseases within the East Riser tracts are presented in Table 48. There are significantly higher rates of asthma in every tract of the Actionable Element Site and only two tracts have lower rates of COPD as compared to the county. The population at this site would benefit from a flood risk management project.

Table 48: Respiratory Disease Prevalence –Harlem River Tracts

	Asthma	COPD
New York County	9.4	5.1
Harlem River Site Tracts		
Census Tract 236	12.4	8.1
Census Tract 243.02	13.1	9.1
Census Tract 235.02	12.2	6.9
Census Tract 232	13.5	9.0
Census Tract 259	11.0	4.7
Census Tract 234	10.7	4.2

Green indicates better than county; red indicates worse than county
Centers for Disease Control PLACES Local Data for Better Health Application updated on 08/23/2024

Displacement

Displacement refers to people that are temporarily displaced from their homes due to a disaster. Populations displaced are those where the depth of flooding above the first floor is greater than zero. An estimate of the number of people potentially displaced is derived by estimating the number of people residing in areas where flooding occurs. The structure inventory and the without-project stage-frequency results from the HEC-FDA study are used in the estimation. US Census Persons per Household from the 2019-2023 ACS 5-year estimates are 2.54 for the US and is used to determine population within the floodplain. The Harlem inventory has 221 structures (including nonresidential) yielding a population estimate of 562 people. The percentage of structures flooded is multiplied by the population estimate to determine number of displaced individuals and is presented in Table 49 for several annual chance exceedance probabilities. People in poverty tend to occupy riskier sections of a community because of financial constraints and are likely to depend on publicly provided accommodation during an event. The poverty rate in Harlem River site tracts is significantly higher than state and county (see Table 48 above). To estimate the number of people in poverty expected to be displaced during a storm event, average poverty rate for the two tracts is used. Average annual rate of displacement among people in poverty on the Harlem River Actionable Element Site is 16. This area would benefit from a flood risk reduction project.

Table 49: Displacement at Various Exceedance Probabilities –Harlem River

	Damage Frequencies						
	0.95 AEP	0.75 AEP	0.5 AEP	0.25 AEP	0.05 AEP	0.01 AEP	0.002 AEP
Percent Structures Flooded	8.20%	8.80%	8.80%	9.00%	9.40%	9.60%	9.90%
Number of People Displaced	46	49	49	51	53	54	56
Number of People in Poverty Displaced	15	16	16	16	17	17	18

Long-term Productivity

Productivity in the local area will depend on robust labor force participation. Two indicators, not in labor force and no health insurance coverage, are used here to gauge worker productivity, however there are other indicators that can be used.

Not in labor force measures the level of workforce robustness, the higher the rate of "not in labor force" the lower the workforce participation. The rate of those who are not in labor force is higher in all but two tracts in Harlem River than it is at county and state levels which indicates that current labor force participation is relatively lacking. If a damaging storm were to hit the area, rates of workers not in the labor force may increase. Another indicator of productivity is status of health insurance coverage. The higher the rate of lack of coverage the likelier it is that those people are unemployed. Most Americans get health coverage through their employers (others may rely on publicly provided social insurance). Health coverage status is also a useful indicator of a community's ability to bounce back in the face of a damaging storm. Table 50 compares economic drivers of productivity at the Harlem River site to state and county figures. There are high poverty and a general lack of health insurance coverage at this site than state and county rates. This indicates that long this community will struggle to bounce back from a damaging storm event but would benefit from a risk reduction project.

Table 50: Drivers of Economic Productivity Comparison – Harlem River

	Population 16 + Universe	Not in labor force	Noninstitutionalized Population	No health insurance coverage
New York	16,235,440	37.0 (36.9,37.1)	19,674,246	5.1 (5.0,5.2)
New York County, New York	1,421,588	33.1 (32.7,33.5)	1,619,600	4.3 (4.1,4.5)
Harlem River Tracts				
Census Tract 232; New York County; New York	7,212	43.3 (36.6,50)	9,279	8.6 (4.5,12.7)
Census Tract 234; New York County; New York	4,550	30.7 (22.8,38.6)	5,244	13.2 (4.5,12.7)
Census Tract 235.02; New York County; New York	1,511	44.2 (37.6,50.8)	1,872	13.9 (9.1,18.7)
Census Tract 236; New York County; New York	8,273	46.8 (39,54.6)	10,061	6.2 (2.8,9.6)

Census Tract 243.02; New York County; New York	5,724	45.8 (39.6,52)	7,234	7.6 (2.6,12.6)
Census Tract 259; New York County; New York	3,685	20.5 (16.1,24.9)	4,713	14.4 (8.3,20.5)

Green indicates better than state and county; red indicates worse than state and county

5.1.1 Life Safety

This section discusses the Life Safety analysis and results calculated for the differed Harlem River and Oakwood Beach Actionable Element Sites during Draft Report Analysis. For more information on the definition and calculation of Life Safety, please see Chapter 5 above.

For the draft report, a screening level analysis of life safety was done using the LSRI tool. For subsequent phases, LifeSim should be used to capture the risk framework. In the case of the Harlem River Actionable Element, the proposed floodwall will have tie-offs crossing the Harlem River Drive, which will discourage motorists from trying to use it during flood events. The closed Drive prevents a dangerous situation of motorists being stranded on flooded roads, or even worse, injured or killed in flash flooding situations. To gauge the life loss probability estimates for the Harlem River study area in the LSRI, certain assumptions about people's responsiveness to the threat are made. A scenario is modeled where the evacuation rate is generally low even though there are cues to take protective action. The study area in Community District 10 in Northern Manhattan does not have its own flood emergency evacuation planning. Instead, New York County level emergency planning is assumed for the community which is general messaging for residents to follow safety directions and is modeled in the LSRI as "All Hazards" approach to Evacuation Planning. Under this assumption, residents may not know what to do or where to go and when to take protective action. Members of the community may have complications as far as taking protective action, for example, some shelters don't allow pets, or they simply don't have the means to get out of the floodplain safely. Their response will depend on awareness of the risk of flooding. In the study area, the population at risk generally understands that the risk exists due to damages experienced throughout the city during Hurricane Sandy. Though they may be aware, they may not have the opportunity to respond to environmental cues of an event's high consequence potential, therefore, the site is assigned a score of "Medium" for Community Awareness which represents a scenario where likelihood of evacuation is fifty-fifty.

Flood warning effectiveness will also influence evacuation response. It is assumed that the community's flood warning procedures do not exist or is outdated and is therefore assigned "Low" for Flood Warning Effectiveness. These scenarios reflect the condition of a generally low evacuation rate in the LSRI, and results show that median life loss under a peak inundation scenario is low (Table 51). However, the tool only accounts for populations within the delineated boundary and not for through traffic. The Harlem River site has the major Harlem River Drive (HRD) which motorists use to go north and south in the city. The HRD at the Harlem River project area also connects to major conduits such as Interstate 87, Interstate 278 and the FDR Drive. According to state traffic records, Harlem River Drive from East 135th Street and Madison Avenue north to Routes 1 and I95 George Washington Bridge, actual average daily traffic (AADT) counts 87,420 in 2024. The highest recorded AADT was over 96,000 in 2009. At any moment, with this amount of traffic volume, the HRD can become the site of significant flooding during an event leaving sections of the road impassable and even relatively shallow flooding can lead to a vehicle being upended or swept away. Motorists will continue to be at risk and may not get the warning in time, may not have the time to respond or know how to respond in the case of a flood event. The life loss risk for motorists is an important consideration but is left unaccounted for in the modeling.

Table 51: LSRI Output Table –Harlem River

Parameter	Day	Night
PAR	3,122	3,941
Exposed Population	370	472
% of PAR Exposed	11.85%	11.96%
Median Life Loss	0	0
Fatality Rate	0.00%	0.00%
Mean Life Loss (Exposure Weighted)	0.01	
Mean Life Loss as % of PAR	0.00%	
Weighted Fatality Rate (% of Exposed PAR)	0.00%	
Property Damages	$33M	
# Structures Inundated	35	

5.2 OAKWOOD BEACH

Life loss is not considered for the Oakwood Beach site where there is zero PAR, and road access is well off site.

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