ECONOMICS
APPENDIX

NASSAU COUNTY BACK BAYS
COASTAL STORM RISK MANAGEMENT
FEASIBILITY STUDY

PHILADELPHIA, PENNSYLVANIA

Appendix F

August 2021

U.S. Army Corps of Engineers
Philadelphia District

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Table of Contents

List of Tables

List of Figures

Attachments

EXECUTIVE SUMMARY

The Nassau County Back Bays Coastal Storm Risk Management (CSRM) Feasibility Study covers a major metropolitan area across the entire southern coastline and barrier islands of Nassau County, NY. The study area encompasses over 354,000 permanent inhabitants (U.S. Census Bureau, 2019), over 100,000 inventory assets, and $60 billion in damageable value (FY2021 Price Level). This Appendix presents the Feasibility-level economic methodology, assumptions, and resulting analysis for determining Federal interest in managing coastal storm risk to the southern coastline of Nassau County over a 50-year period of analysis.

Future Without-Project (FWOP) condition average annual damages (AAD) exceed $1.01 billion (FY2021 Price Level) over the 50-year period of analysis with Intermediate SLC. Vulnerable assets include single-family residential, multi-family housing, commercial structures, industrial facilities, public facilities (recreation, religious centers), vehicles, traditional infrastructure (bridges, utilities, roadways), and critical infrastructure (wastewater treatment plants, pump stations, fire stations).

This Appendix will summarize the FWOP condition National Economic Development (NED) damages and the corresponding Future With-Project (FWP) condition reduction in damages to determine a Tentatively Selected Plan (TSP). The TSP for this study is also the NED Plan. As defined in ER 1105-2-100 *Planning Guidance Notebook,* the NED Plan is the alternative that reasonably maximizes net NED benefits consistent with protecting the Nation's environment.

The Appendix will also identify the Nonstructural Only Plan and Net Total Benefits Plan in compliance with the ASA(CW) Policy Directive *Comprehensive Documentation of Benefits in Decision Document* signed 5 January 2021. The Net Total Benefits Plan considers qualitative impacts to Regional Economic Development (RED), Other Social Effects (OSE), and Environmental Quality (EQ).

A side-by-side comparison of the NED Plan, Net Total Benefits Plan, and Nonstructural Only Plan is provided for the Intermediate Sea Level Change (SLC) curve. Though all alternatives are evaluated under each of the USACE SLC curves, current formulation and results are presented at the Intermediate SLC curve projection. A summary of the various plans is displayed in the following table.

All economic analyses and results presented are in accordance with USACE policy and guidance with specific emphasis on ER 1105-2-100 *Planning Guidance Notebook*, ER 1105-2-101 *Risk Assessment for Flood Risk Management Studies*, ER 1100-2-8162 *Incorporating Sea Level Change in Civil Works Programs*, and EM 1110-2-1619 *Risk-Based Analysis for Flood Damage Reduction Studies*. Results are presented at the FY2021 Price Level and FY2021 Project Evaluation and Formulation Rate (Discount Rate) of 2.5% in accordance with EGM 21-01 *Federal Interest Rates for Corps of Engineers Projects for Fiscal Year 2021*.

National Economic Development (NED) Plan / Tentatively Selected Plan (TSP) / Nonstructural-Only Plan	
Future Without-Project AAD	$1,011,964,000
Future With-Project AAD	$401,393,000
Total Reduced AAD	**$610,571,000**
Total Initial Construction	$3,849,693,000
Average Annual OMRR&R	$0
Average Annual Cost (AAC)	**$135,733,000**
Average Annual Net Benefits	**$474,839,000**
Benefit-Cost Ratio	**4.5**
Residual Damages	39.7%
Eligible Nonstructural	16,850

Net Total Benefits Plan (NED / RED / OSE / EQ)	
Future Without-Project AAD	$1,011,964,000
Future With-Project AAD	$389,071,000
Total Reduced AAD	**$622,893,000**
Total Initial Construction	$4,863,822,000
Average Annual OMRR&R	$4,922,000
Average Annual Cost (AAC)	**$176,411,000**
Average Annual Net Benefits	**$446,481,000**
Benefit-Cost Ratio	**3.5**
Residual Damages	38.4%
Eligible Nonstructural	16,586

The Nonstructural Only Plan reasonably maximizes net NED benefits under the Intermediate SLC curve with $475 million in AANB and a 4.5 BCR. This plan also constitutes the NED Plan and TSP. In total, 16,850 residential and non-residential structures are eligible for nonstructural retrofits (elevations and floodproofing).

The Net Total Benefits Plan is nearly identical to the NED Plan but includes perimeter measures for certain critical infrastructure facilities. These facilities, including wastewater treatment plants and power generating plants, are vital for post-storm recovery efforts and to ensure health and safety standards in the study area during and after storm events. Current analysis considers the qualitative benefits of the Net Total Benefits Plan but does not include a full quantitative assessment of those planning accounts.

A full description of both plans is provided in the Future-With Project Condition section.

INTRODUCTION

This appendix presents the economics methodology, assumptions, and resulting analysis for managing coastal storm risk within the Nassau County Back Bays system. This report will detail each step of the analytical process and describe relevant inputs and results for each reach of the study area. The assessment is conducted at a Feasibility level and covers 105 square miles within the state of New York.

The study area captures 100,900 structures with over $59.7 billion in damageable assets and critical infrastructure systems. The study area is modeled for the FY2080 0.2% Annual Exceedance Probability (AEP) event floodplain with Intermediate Sea Level Change (SLC). Economic assessment of the study area also includes modeling the Historic (Low) and High SLC rates, qualitatively assessing Regional Economic Development (RED) and Other Social Effects (OSE) impacts, highlighting critical infrastructure vulnerabilities, evaluating the focused array of alternatives, comparing proposed alternatives, identifying the National Economic Development (NED) Plan, and investigating SLC Adaptive Capacity and Project Performance of the identified NED Plan.

Figure 1 below shows the study area outline for the economic analysis. The study area covers the entire width of Nassau County and includes major population centers such as the City of Long Beach, the Village of Freeport, and the Village of East Rockaway. In total, the study area covers 350,000 persons (U.S. Census Bureau) within Nassau County.

Imagery in this Appendix pulls aerial photography and basemaps from a variety of sources including Esri ArcGIS, Google Earth Pro, and the New York State Geographic Information Systems (GIS) Clearinghouse.

Figure 1: Nassau County Back Bays Study Area

HEC-FDA MODEL DESCRIPTION

The Hydrologic Engineering Center – Flood Damage Reduction Analysis (HEC-FDA) software version 1.4.2 is used to model the Future Without-Project (FWOP) condition and a variety of alternatives for Future With-Project (FWP) conditions for which it provides relevant project performance metrics.

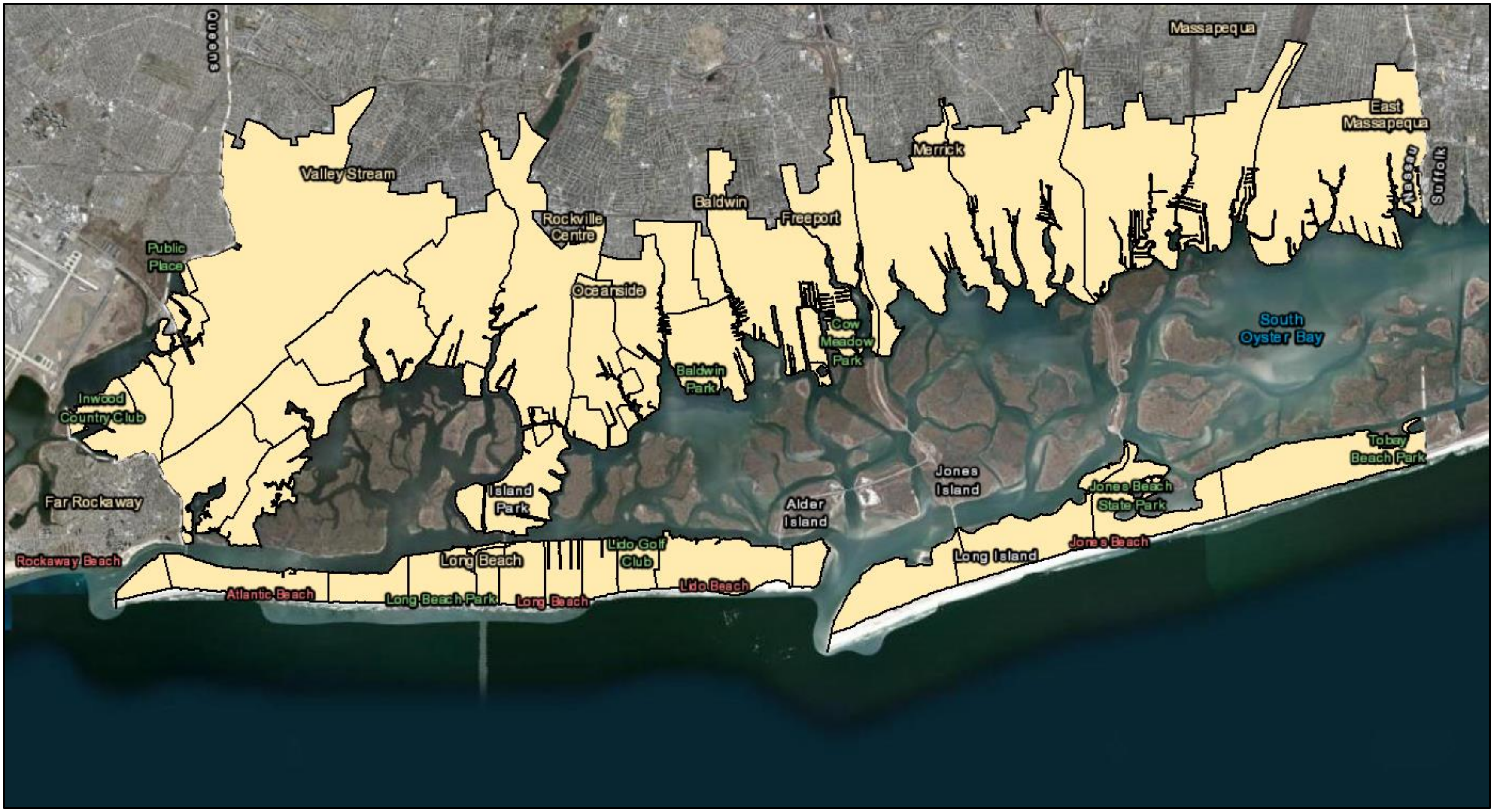
HEC-FDA ver. 1.4.2 provides integrated hydrologic engineering and economic risk analysis during the formulation and evaluation of flood damage reduction plans in compliance with policy regulations ER 1105-2-100 *Planning Guidance Notebook* and ER 1105-2-101 *Risk Analysis for Flood Damage Reduction Studies*. Uncertainty in discharge-exceedance probability, stage-discharge, and damage-stage functions are quantified and incorporated into economic and engineering performance analyses of alternatives. The process applies Monte Carlo simulation, a numerical analysis procedure that computes the expected value of damage while explicitly accounting for uncertainty in the basic parameters used to determine flood inundation damage.

Data on historic storms, water surface profiles, depth-percent damage functions, and residential, commercial, and public structures within the study area will be used as input for the HEC-FDA software. In conjunction with hydrologic modeling, HEC-FDA will also incorporate Historic (Low), Intermediate, and High SLC analysis in compliance with ER 1100-2-8162 *Incorporating Sea Level Change in Civil Works Programs* and ER 1110-2-1619 *Risk-Based Analysis for Flood Damage Reduction Studies*.

The FWOP condition is used as the base condition over the 50-year period of analysis and is compared against potential alternatives to identify potential National Economic Development (NED) benefits. The model will use the FY2021 Project Evaluation and Formulation Rate (Discount Rate) of 2.5% and values will be shown in FY2021 Price Level.

The study area is divided into 55 reaches (Figure 2). Damage reaches are specific geographical areas within a floodplain and are used to define consistent data for plan evaluation. Reaches aggregate model damage (structure, content, vehicle) information by stage of flooding to facilitate calculating Average Annual Damages in the Base Year (2030) and Future Year (2080). Reaches are drawn according to hydrologic or municipal boundaries and can be aggregated as necessary to present damages by municipality, proposed alternative, or any other required grouping. Each of the 100,900 structures fall into exactly one reach.

Figure 2: Nassau County Back Bays Reach Delineation



STRUCTURE INVENTORY DEVELOPMENT

This section covers the creation of the structure inventory for use in the HEC-FDA ver. 1.4.2 analytical model. Inventory development includes identifying, classifying, and valuating assets, estimating first floor elevations (FFE), assigning depth-percent damage functions, and highlighting critical infrastructure.

Structure Identification and Valuation

The structure inventory for the study area was created using materials supplied by the New York Department of Environmental Conservation (NYDEC), New York State Geographic Information Systems (GIS) Clearinghouse, the Nassau County Tax Assessor's Office, and the U.S. Census Bureau.

Development of the structure inventory involves surveying existing floodplain structures to collect the data necessary to determine expected coastal storm damages. The purpose of collecting this information is to determine what structures are located in the floodplain, the depreciated replacement value of the structures and their associated contents, and the zero-damage elevation at which they are initially susceptible to flooding.

Tax assessor records offer information on structure location (Northing & Easting coordinates), structure address and municipality, category type, occupancy type, parcel ID number, and county tax assessment value. A manual visual survey of the study area using recent high-resolution aerial imagery added any structures not captured by the tax assessor records methodology. County tax parcel and assessment records provide the basis for Depreciated Replacement Value (DRV) in compliance with EM 1110-2-1619 *Risk Based Analysis for Flood Damage Reduction Studies*.

Only structures within the 0.2% Annual Exceedance Probability (AEP) event floodplain (FY2080 with Intermediate SLC) are included in the HEC-FDA model inventory because structures with ground elevations above that threshold experience damages so infrequently that their exclusion does not affect the calculated Average Annual Damages for the study area.

Figure 3 on the following page shows an example subsection of inventory markers for the eastern end of the City of Long Beach. This partial inventory example shows some of the tax parcel-derived structure markers overlaid on recent high-resolution aerial imagery (provided by ArcGIS Online). The asset markers provide GPS coordinates, tax assessor values, and information on structure design and usage. Inventory markers are developed for all 100,900 assets within the structure inventory.

In total, the study area is mostly residential with 88.2% of inventory assets displaying a Residential category type. Non-residential structures include commercial, industrial, public, and multi-use buildings. Critical infrastructure assets, including fire stations, police stations, medical offices, and wastewater treatment plants, are also included in the structure inventory.

Table 1 provides a breakdown of the various category and occupancy types within the Nassau County study area. The table also provides the associated depreciated replacement values (DRV) for both structure and contents.

Figure 3: Structure Inventory – City of Long Beach (Partial) Example

Table 1: Structure Inventory Descriptive Statistics (in thousands)

		Count	Structure Value	Content Value	Total Value
RES	One-Story	40824	$10,011,000	$5,009,000	$15,020,000
	Multi-Story	48129	$14,467,000	$7,233,000	$21,700,000
	TOTAL	**88953**	**$24,477,000**	**$12,243,000**	**$36,720,000**
COM	Offices	2842	$1,839,000	$1,141,000	$2,980,000
	Retail	2408	$2,186,000	$2,665,000	$4,851,000
	Other	1004	$887,000	$600,000	$1,487,000
	TOTAL	**6254**	**$4,912,000**	**$4,406,000**	**$9,318,000**
IND	Warehouses	2376	$1,744,000	$2,669,000	$4,413,000
	Other	55	$118,000	$165,000	$283,000
	TOTAL	**2431**	**$1,862,000**	**$2,834,000**	**$4,696,000**
MULTI	One-Story	51	$151,000	$19,000	$170,000
	Multi-Story	1850	$3,353,000	$519,000	$3,872,000
	TOTAL	**1901**	**$3,504,000**	**$538,000**	**$4,042,000**
PUB	Religious	389	$376,000	$153,000	$529,000
	Recreation	136	$186,000	$65,000	$251,000
	Other	263	$447,000	$254,000	$701,000
	TOTAL	**788**	**$1,010,000**	**$472,000**	**$1,482,000**
CRIT	Medical Offices	181	$184,000	$131,000	$315,000
	Schools	148	$924,000	$256,000	$1,180,000
	Service Stations	114	$348,000	$631,000	$979,000
	Other	130	$733,000	$210,000	$943,000
	TOTAL	**573**	**$2,189,000**	**$1,228,000**	**$3,417,000**
TOTAL	**-**	**100,900**	**$37,954,000**	**$21,721,000**	**$59,675,000**

Tax assessor structure values, noted as "improvement values," provide a base for determining the depreciated replacement value (DRV) of structures and contents but need to be adjusted to account for deviations between assessed value and replacement value. Further information on this technique can be found in EM 1110-2-1619 *Risk Based Analysis for Flood Damage Reduction Studies*.

For this study, the value adjustment is completed by developing a stratified random sample of structures and independently estimating their depreciated replacement values using Marshall & Swift Residential Estimator 7 and then comparing the stated tax assessor values against Marshall & Swift-derived depreciated replacement values. Assuming the stratified random sample is representative of the entire population, the average percent difference between the two values can then be applied to the entire population of structures (within each category) to adjust the individual assessor value for each structure to a unique depreciated replacement value in compliance with USACE policy and regulations.

Content values are established using a Content-to-Structure Value Ratio (CSVR) with the implicit assumption that the content values of a structure are directly related to the value of the structure itself. The exact CSVR utilized is determined by the category type of the structure. They are pulled from EM 1110-2-1619 *Risk-Based Analysis for Flood Damage Reduction Studies,* IWR Report *Nonresidential Flood Depth-Damage Functions Derived From Expert Elicitation*, and GEC Report *Depth-Damage Relationships for Structures, Contents, and Vehicles and Content-to-Structure Value Ratios (CSVR) in Support of Donaldsville to the Gulf, Louisiana, Feasibility Study*.

Vehicles were added to the HEC-FDA model in compliance with EGM 09-04 *Generic Depth-Damage Relationships for Vehicles*. In total, the HEC-FDA inventory includes over $2 billion in damageable automobile assets. This does not represent the total depreciated replacement value of all residential and commercial vehicles in the study area, but rather only the relative percentage of value that is vulnerable to coastal storm events. EGM 09-04 estimates that 88.1% of vehicles are expected to evacuate or be moved to higher ground before or during a storm event (assuming households have at 12 hours of warning time). Only the remaining 11.9% of vehicle value is captured in HEC-FDA.

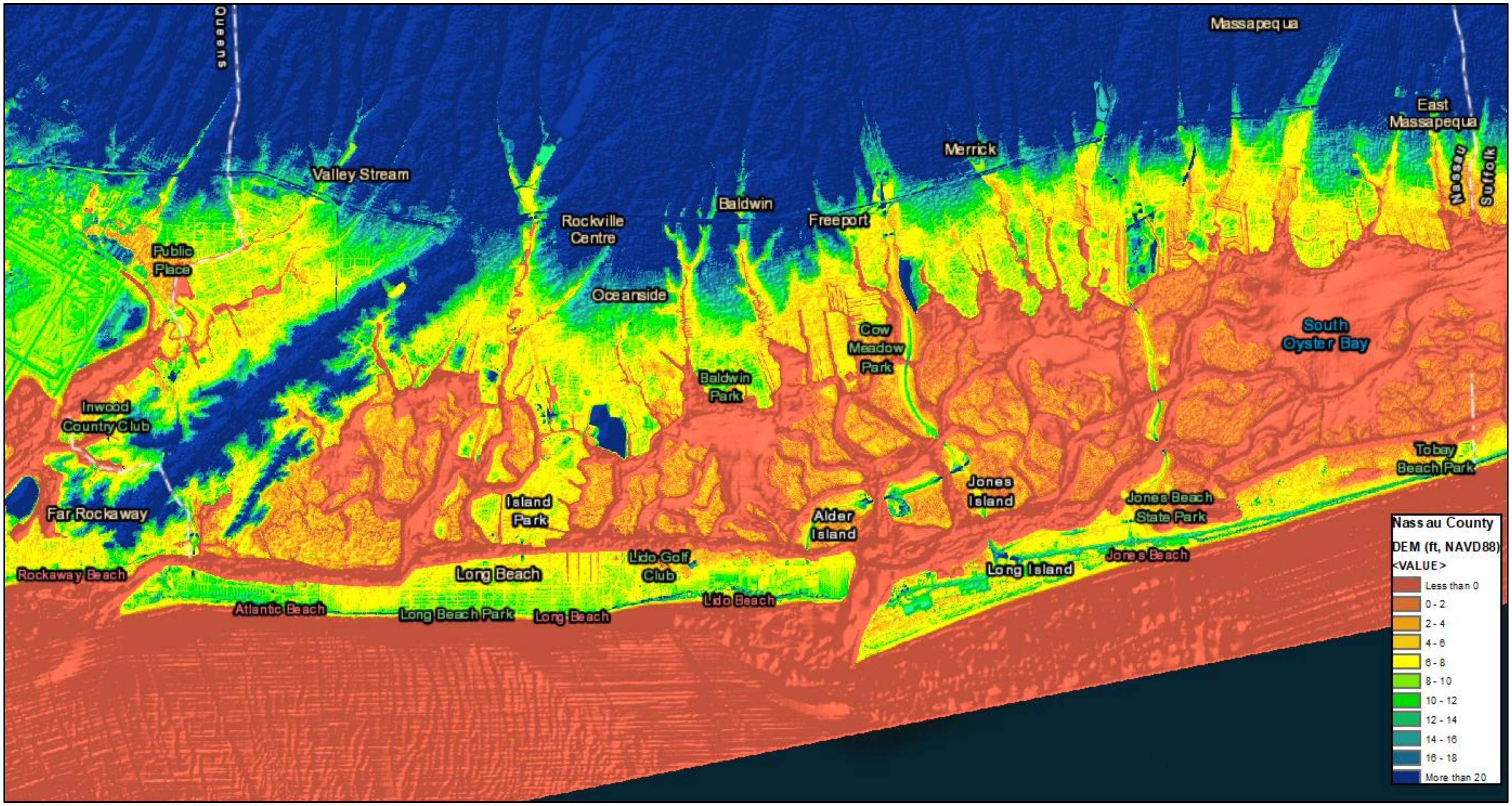
First Floor Elevation

First Floor Elevation (FFE) is the addition of Ground Elevation and Foundation Height to measure the absolute elevation of the main floor of the structure. In addition to FFE, each structure occupancy type is assigned a begin damage point to account to vulnerable entry points above (or below) the FFE. HEC-FDA will begin to assign damage to structures only when flood stage heights reach the first floor +/- the begin damage point value.

Ground elevation is the height of the land at the inventory marker location, typically at the central point of the structure. Ground elevation is calculated at a population level with the availability of a National Oceanic and Atmospheric Administration (NOAA) Digital Coast Bare Earth Light Detection and Ranging (LiDAR)-derived Digital Elevation Model (DEM). As the LiDAR-derived DEM is available for the entire study area, each individual structure is provided a unique, calculated ground elevation with a high degree of certainty.

Figure 4 on the following page shows the LiDAR-derived DEM for the study area. Shown in 2ft increments, the areas directly adjacent to the back bay have the lowest ground elevation and are most at risk for coastal storm impacts. The northern end of the City of Long Beach and the southern extent of the Village of Freeport are particularly vulnerable when only evaluating ground elevation.

Figure 4: Nassau County Back Bays DEM



Foundation height is more difficult to measure and attribute for each individual structure. While techniques such as field surveys or mobile LiDAR can theoretically calculate foundation height for every structure with a high degree of certainty, the size of the inventory makes these methods prohibitively time and resource consuming. To individually measure all 100,900 structures would require years of intense resource allocation. Additionally, population level data such as Nassau County tax records do not offer a measurement for foundation height nor can available aerial imagery provide insight on main floor height above ground elevation.

To calculate the FFE for structures within the model inventory, a stratified random sample is collected of structures within each occupancy type to assign a typical foundation height per structure type. As "typical" occupancy type characteristics can vary across the study area, location was added as an additional stratum. The average foundation height for a given occupancy type in a given region is then added to the structure's unique ground elevation to calculate final FFE. During the next study phase, foundation height estimates will be re-evaluated to increase sample size and resolution of estimates.

For residential structures, average foundation heights per occupancy type ranged from 2.1ft to 2.5ft suggesting similar foundation height characteristics among different types (e.g., number of stories) and across different locations within the study area.

For non-residential structures, average foundation heights per occupancy type ranged from 0.7ft (critical infrastructure) to 1.3ft (industrial facilities). While the range is more significant than residential structures, the difference of only 0.6ft suggests some level of homogeneity across non-residential assets.

Begin Damage Points for each structure occupancy type are also occupancy type dependent. For residential structures, assets with basements were assigned a begin damage point of -3ft to address the additional vulnerability and inundation access points. For residential structure without basements, begin damage points were set to -0.5ft. For all non-residential structures, begin damage points were also set to -0.5ft despite the likelihood that non-residential structures have basements for storage and utilities. It is assumed that non-residential structures have properly addressed inundation vulnerabilities below the First Floor Elevation.

While the described methodology of assigning average foundation height by occupancy type provides reasonable accuracy for estimating FFE across a large population and complies with SMART Planning Policy, it does not allow for knowing the true FFE for each individual structure within the inventory. This has some impact on later plan formulation and evaluation, particularly for nonstructural measures.

Nassau County, particularly in the time after Hurricane Sandy in 2012, has implemented structure elevations across the study area through both public and private programs. Elevated structures will have foundation heights significantly higher than the "typical" structure and are considerably less vulnerable to coastal storm events. While these elevations are somewhat addressed by the average foundation height (elevated structures were not screened from the sampling), the next study phase will pursue identifying individual structures in the study area that are (or will be) elevated before the Base Year in 2030. This includes tracking elevation certificates and other documentation to compile a comprehensive list of elevated structures in the asset inventory.

Depth-Percent Damage Functions

Damage functions are user-defined curves applied within the model to determine the extent of storm-induced damages attributable to inundation. Depth-percent damage curves are created for both structures and contents and for all structure occupancy types.

Damage is determined as a percentage of overall structure or content value using a triangle distribution of values: Minimum, Most Likely (ML), and Maximum. For inundation, damage is determined by the storm surge heights in excess of the FFE. While depth-percent damage curves do provide the option for quantifying damages at thresholds well below the FFE, the begin damage point for each occupancy type limits the damage estimated below the applied FFE.

The depth-percent damage functions utilized in this study are developed from the North Atlantic Coast Comprehensive Study (NACCS) - *Resilient Adaptation to Increasing Risk: Physical Depth Damage Function Summary Report,* from IWR Report *Nonresidential Flood Depth-Damage Functions Derived From Expert Elicitation*, and from GEC Report *Depth-Damage Relationships for Structures, Contents, and Vehicles and Content-to-Structure Value Ratios (CSVR) in Support of Donaldsville to the Gulf, Louisiana, Feasibility Study*.

The depth-percent damage curve for vehicles is developed from EGM 09-04 *Generic Depth-Damage Relationships for Vehicles*.

The full list of depth-percent damage functions utilized in the economic modeling is provided in Attachment A.

Critical Infrastructure Assets

The existing inventory detailed above contains critical infrastructure assets, such as schools, hospitals, fire departments, and police stations, which means it accounts for the physical losses to these structures. Non-physical losses that occur due to the impairment of critical infrastructure—for instance, the economic losses incurred when a community loses power or wastewater services—are not currently accounted for. This is due to the difficulty in tying water levels to consequences for these secondary effects. Additionally, damages to roads, ports, utilities, telecommunication lines, water supply infrastructure, and other resources that do not have rigorously defined USACE depth-percent damage curves are not currently included in HEC-FDA.

Critical Infrastructure assets are briefly covered in Table 1 and expanded in this section. Data for identifying and isolating critical infrastructure assets is developed from HSIP Gold, a unified homeland infrastructure geospatial data inventory assembled by the National Geospatial-Intelligence Agency (NGA) in partnership with the Department of Homeland Security (DHS). For this study, critical infrastructure is divided into three broad categories, only the first two of which are currently quantified in HEC-FDA. First, critical infrastructure that resembles traditional building types (e.g., medical offices, hospitals); second, large scale infrastructure that resembles an entire industrial complex (e.g., wastewater treatment plants, natural gas power station); and, third, infrastructure that does not resemble buildings in any way (e.g., evacuation routes, ports, utility lines).

Only the direct (physical) damages for the first two critical infrastructure types are quantified within HEC-FDA and currently contribute to NED damage estimates. None of the three critical infrastructure types are currently quantified for indirect (non-physical) coastal storm damages. In addition to physical and non-physical NED damages, critical infrastructure disruptions may also cause severe RED and OSE impacts due to regional business impacts and catastrophic health and safety concerns. RED and OSE impacts are currently handled qualitatively for all three infrastructure types.

Table 2 shows the types of critical infrastructure assets that are currently quantified within HEC-FDA for direct (physical) damages.

Table 2: Critical Infrastructure Types and Valuation (in thousands)

Infrastructure	**Count**	**Structure Value**	**Content Value**	**Total Value**
MEDICAL OFFICE	167	$176,000	$123,000	$299,000
SCHOOL	148	$924,000	$256,000	$1,180,000
SERVICE STATION	114	$348,000	$631,000	$979,000
EMERGENCY SERVICES[1]	72	$91,000	$108,000	$199,000
FUEL OIL / PROPANE	31	$32,000	$46,000	$78,000
NURSING HOMES	19	$130,000	$13,000	$143,000
VETERINARY	14	$7,000	$8,000	$15,000
WASTEWATER PLANT[2]	3	$39,000	$5,000	$44,000
HOSPITAL	3	$21,000	$16,000	$37,000
ELECTRIC[3]	2	$420,000	$22,000	$442,000
TOTAL	**573**	**$2,189,000**	**$1,228,000**	**$3,417,000**

[1] Police Stations, Fire Stations, EMS Stations, etc.

[2] Bay Park Water Reclamation Facility, Long Beach Wastewater Treatment, Cedar Creek Wastewater Treatment

[3] EF Barrett Generation Station, Equus Power Plant

There are approximately 573 critical infrastructure assets within the study area totaling over $3 billion in damageable value (FY2021 Price Level). While these assets are currently incorporated into HEC-FDA, additional investigation is necessary to confirm their structure and content valuation, create bespoke depth-percent damage functions for large-scale infrastructure complexes, and estimate the secondary (non-physical) NED damages that occur during and after storm events from prolonged infrastructure service disruption. That effort is expected to be completed after release of the draft Feasibility Report.

FUTURE WITHOUT-PROJECT (FWOP) CONDITION

HEC-FDA links the predictive capability of hydraulic and hydrologic modeling with project area infrastructure information, structure and content damage functions, and economic valuations to estimate the total damages under various proposed alternatives while accounting for risk and uncertainty. The model output is then used to determine the net National Economic Development (NED) benefits of each project alternative in comparison with the No-Action Plan, or Future Without-Project condition scenario.

Storm damage is defined as the monetary loss to contents and structures incurred as a direct result of inundation caused by a storm of a given magnitude and probability.

For the Future Without-Project (FWOP) conditions and Future With-Project (FWP) conditions, the structure inventory and assigned values are considered static throughout the 50-year period of analysis. Though this approach may ignore future condemnations of repeatedly damaged structures or, conversely, increases in the number or value of structures in the inventory due to future development, the variability and limitations of projecting future inventory changes over 50 years across such a wide study area are too significant to assign any reasonable level of certainty to the predicted inventory alterations.

FWOP damages are used as the base condition and potential project alternatives are measured against this base to evaluate the project effectiveness and cost efficiency. FWOP damages in this section are presented as Average Annual Damages (AAD) over a 50-year period of analysis with the current FY2021 Project Evaluation and Formulation Rate (Discount Rate) of 2.5% and the current FY2021 Price Level.

The following model results for FWOP analysis are based on estimated structure damages, content damages, and vehicle damages. Additional benefit categories such as emergency costs foregone or indirect (non-physical) damages are not currently quantified in HEC-FDA.

Model Results

The Nassau County Back Bays study area experiences a total of $1.01 billion in FWOP Average Annual Damages (AAD) over the 50-year period of analysis with Intermediate SLC. Table 3 provides the breakdown of AAD across each category type for each of the three USACE SLC curves.

Figure 6 provides a map of the study area that highlights structures with significant coastal storm risk in the FWOP condition under the Intermediate SLC curve. Markers depict structures that receive at least $195,000 in damages from the Year 2080 1% AEP event. This threshold denotes the 90th percentile of structures in terms of coastal storm damages estimated.

Table 3: FWOP Average Annual Damages (in thousands)

	Low SLC	Int SLC	High SLC
VEHICLE	$27,000	$37,000	$104,000
COMMERCIAL	$61,000	$80,000	$195,000
CRITICAL INFRASTRUCTURE	$34,000	$45,000	$119,000
INDUSTRIAL	$86,000	$113,000	$250,000
MULTI-USE	$15,000	$19,000	$53,000
PUBLIC	$12,000	$15,000	$33,000
RESIDENTIAL	$574,000	$702,000	$1,402,000
TOTAL	**$808,000**	**$1,012,000**	**$2,156,000**

Across all USACE SLC curves, residential structures provide the majority of estimated FWOP coastal storm damages.

Under the High SLC, the 1% Annual Exceedance Probability (AEP) event stage is approaching 14.9ft NAVD88 for certain parts of the study area by the end of the 50-year period of analysis. This introduces structures into the damage pool that may otherwise have not been vulnerable under the Low and Intermediate SLC rates and places them at significant risk from coastal storm events.

For context, Figure 5 provides the anticipated sea level rise for the study area across the 100-year planning horizon as calculated using the USACE Sea-Level Change Curve Calculator (Version 2021.12) and in accordance with ER 1100-2-8162 *Incorporating Sea Level Change in Civil Works Programs*. By 2080, the end of the 50-year period of analysis, relative sea level rise in this area under the High SLC curve is projected at just under 4ft. By 2130, the end of the 100-year planning horizon, High SLC projections are reaching close to 9ft.

The Low (Historic) and Intermediate SLC rates are fairly linear for this study area across both the 50-year period of analysis and 100-year planning horizon. The projections increase at a relatively uniform rate with the Intermediate SLC curve only projecting 0.8ft more sea level rise than the Low (Historic) SLC curve. This corresponds with the data in Table 3 that displays only a modest 25.3% increase in FWOP NED damages under the Intermediate SLC in comparison to the Low SLC curve.

Figure 5: Nassau County Back Bays SLC Scenarios

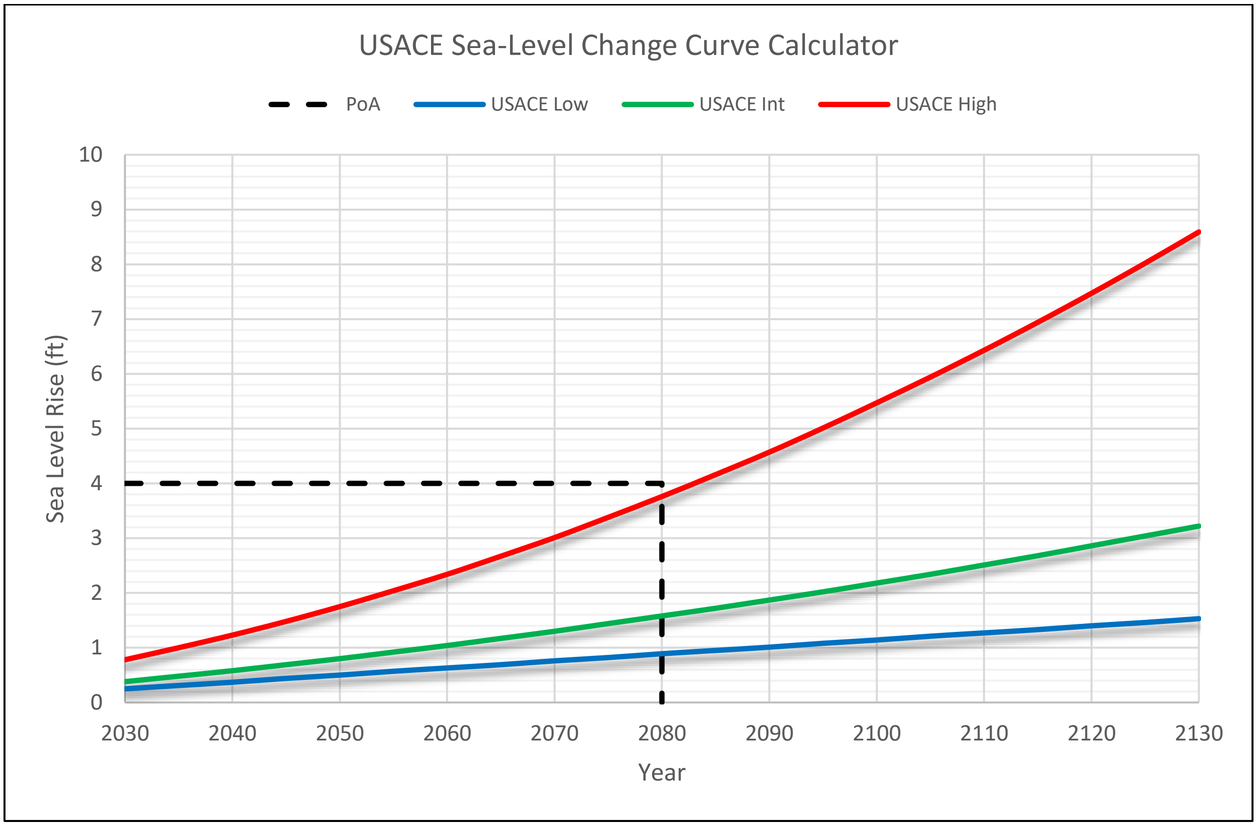
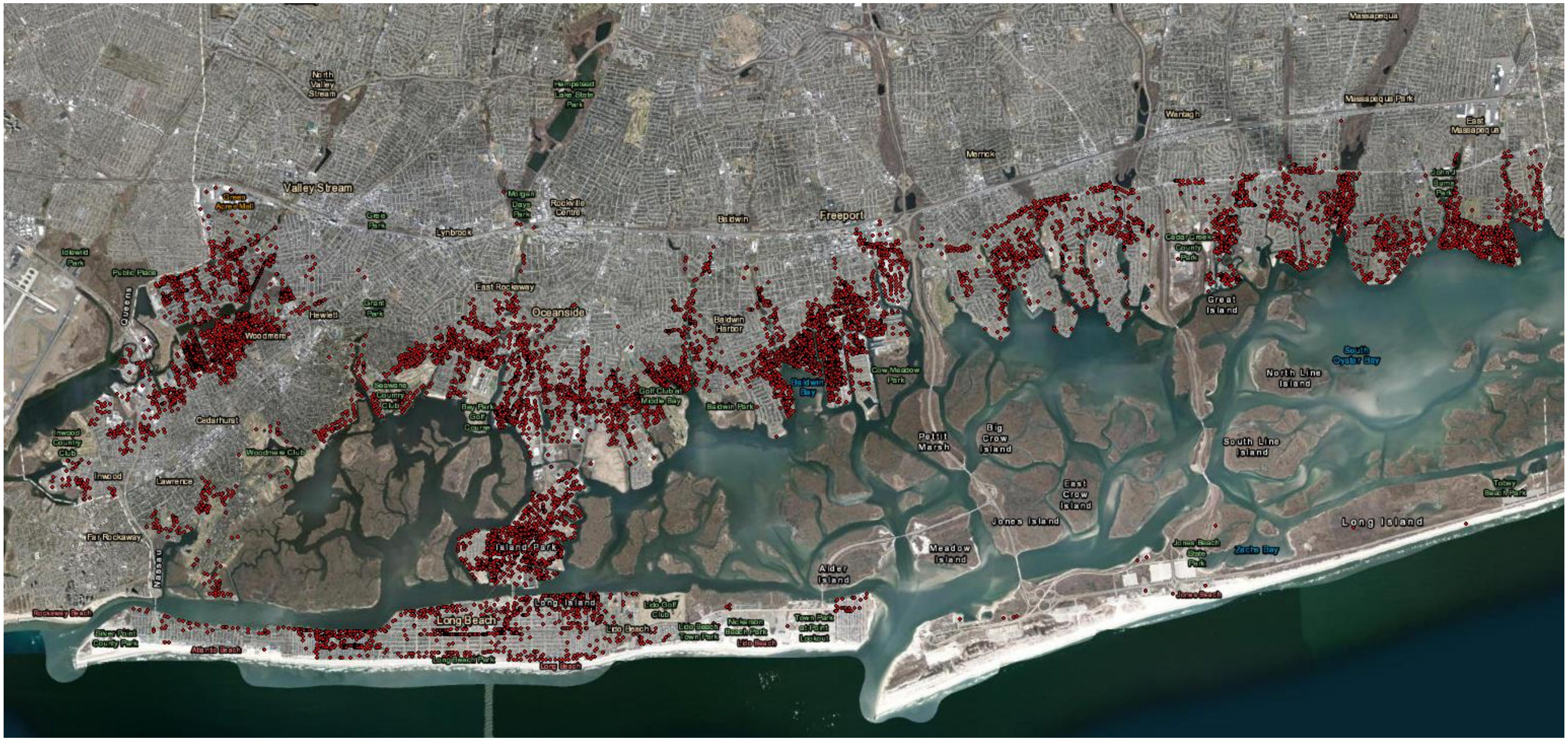


Figure 6: Nassau County Back Bays High Damage Assets



FWOP Average Annual Damages are distributed across the study area but do cluster in a few locations, particularly in the City of Long Beach, Village of Freeport, and the Village of Island Park. Smaller clusters of higher-value, high-vulnerability structures are also evident in the area north of the Village of Island Park, the far western edge of Nassau County and in East Massapequa.

This information, along with the location and vulnerability of critical infrastructure assets, was used to inform perimeter measure screening and plan formulation. More information can be found in the Main Report and Plan Formulation Appendix.

FUTURE WITH-PROJECT (FWP) CONDITION

This section details Future With-Project Condition scenario results for individual measures and for the entirety of the Focused Array of Alternatives. Performing economic analysis on proposed alternatives within the study area was an iterative process with complex interdependence between study reaches and between certain measure combinations. Additional screening details can be found in the Main Report, but economic analysis centered on two possible measure types: Perimeter (floodwalls and levees) and Nonstructural (building retrofits). Four potential perimeter locations were identified based on the density of vulnerable structures and overall risk from coastal storm impacts. Perimeter measure locations, cost estimates, and benefits (reduced damages) are detailed in this section.

Nonstructural was evaluated throughout the entire study area. Both elevations and floodproofing are potential building retrofit measures for inventory assets. This section details nonstructural costs, eligibility criteria, limitations, and benefits. More information on nonstructural can be found in the Plan Formulation Appendix and Cost Engineering Appendix.

Perimeter Measures

Potential perimeter measure locations were screened based on the density of vulnerable structures and the presence of critical infrastructure assets (e.g., wastewater treatment facilities, power plants, hospitals, police stations, utility lines). More information on perimeter screening can be found in the Main Report and Plan Formulation Appendix. Quantitative assessment of four proposed perimeter locations were completed within HEC-FDA to compute NED benefits (coastal storm damages reduced). Cost estimates were completed using Micro-Computer Aided Cost Estimating System (MCACES) Second Generation (MII). More information on perimeter construction cost estimates can be found in the Cost Engineering Appendix.

Proposed Locations

Figure 7 shows the proposed perimeter measure locations for the study area. Perimeter measures were modeled at three different elevations to assess their effectiveness and economic viability at various heights: 20% AEP event (9ft NAVD88), 5% AEP event (13ft NAVD88), and 1% AEP event (16ft NAVD88). More information on these perimeter measure designs, locations, and characteristics can be found in the Engineering Appendix.

Perimeter measures were designed and modeled for (1) Village of Freeport, (2) Village of East Rockaway to Hamlet of Oceanside, (3) Island Park and Vicinity, and (4) City of Long Beach, all of which were identified as “Highly Vulnerable Areas.”

Figure 8 through Figure 11 provide the outline of the 1% AEP perimeter design for each of the Highly Vulnerable Areas. These designs are provided in this Appendix only for contextual purposes; detailed descriptions of their characteristics (and designs for the 20% AEP and 5% AEP measures) are found in the Engineering Appendix.

Figure 7: Perimeter Measures - Screening Locations

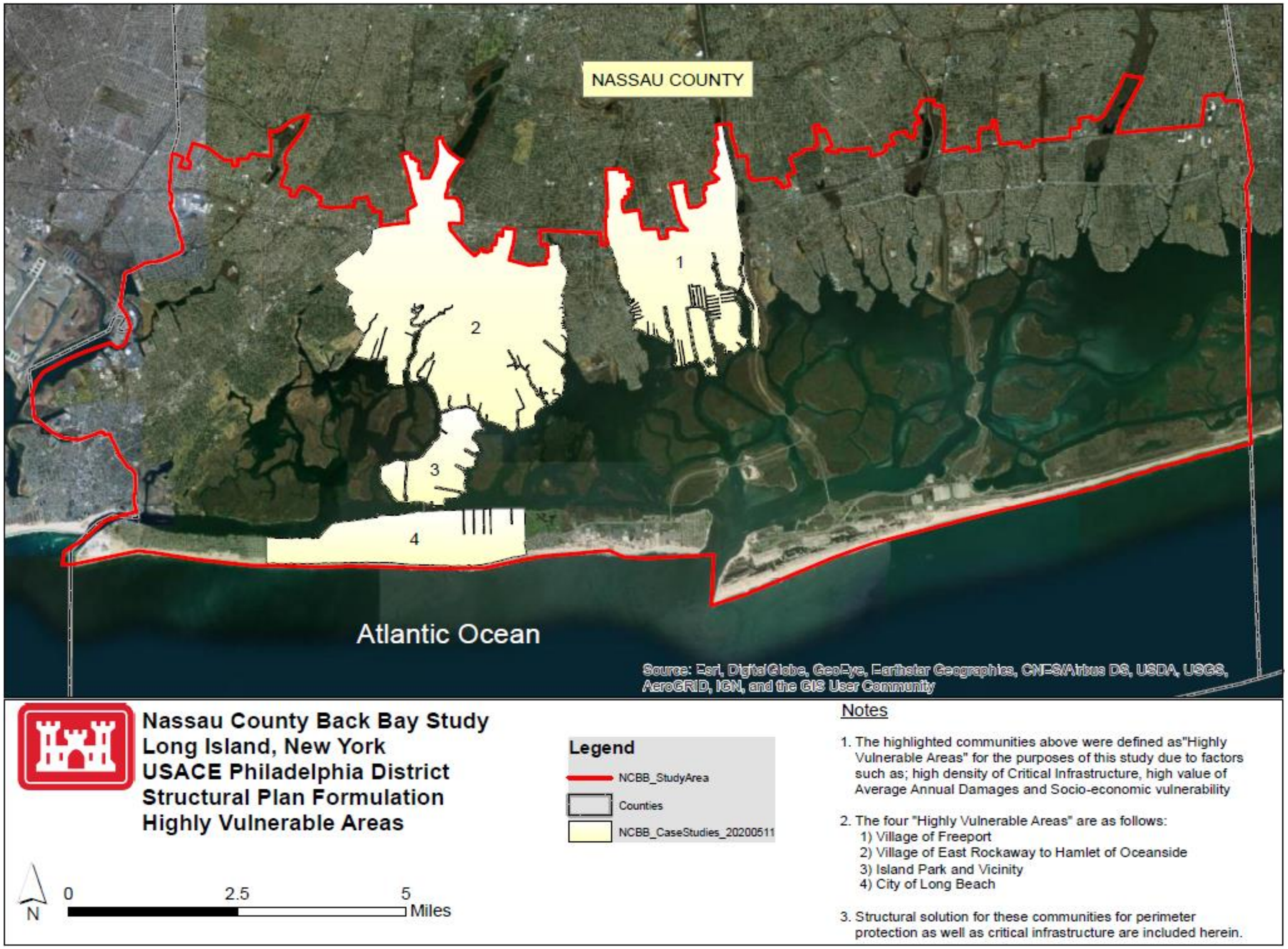


Figure 8: Perimeter Measures – Village of Freeport

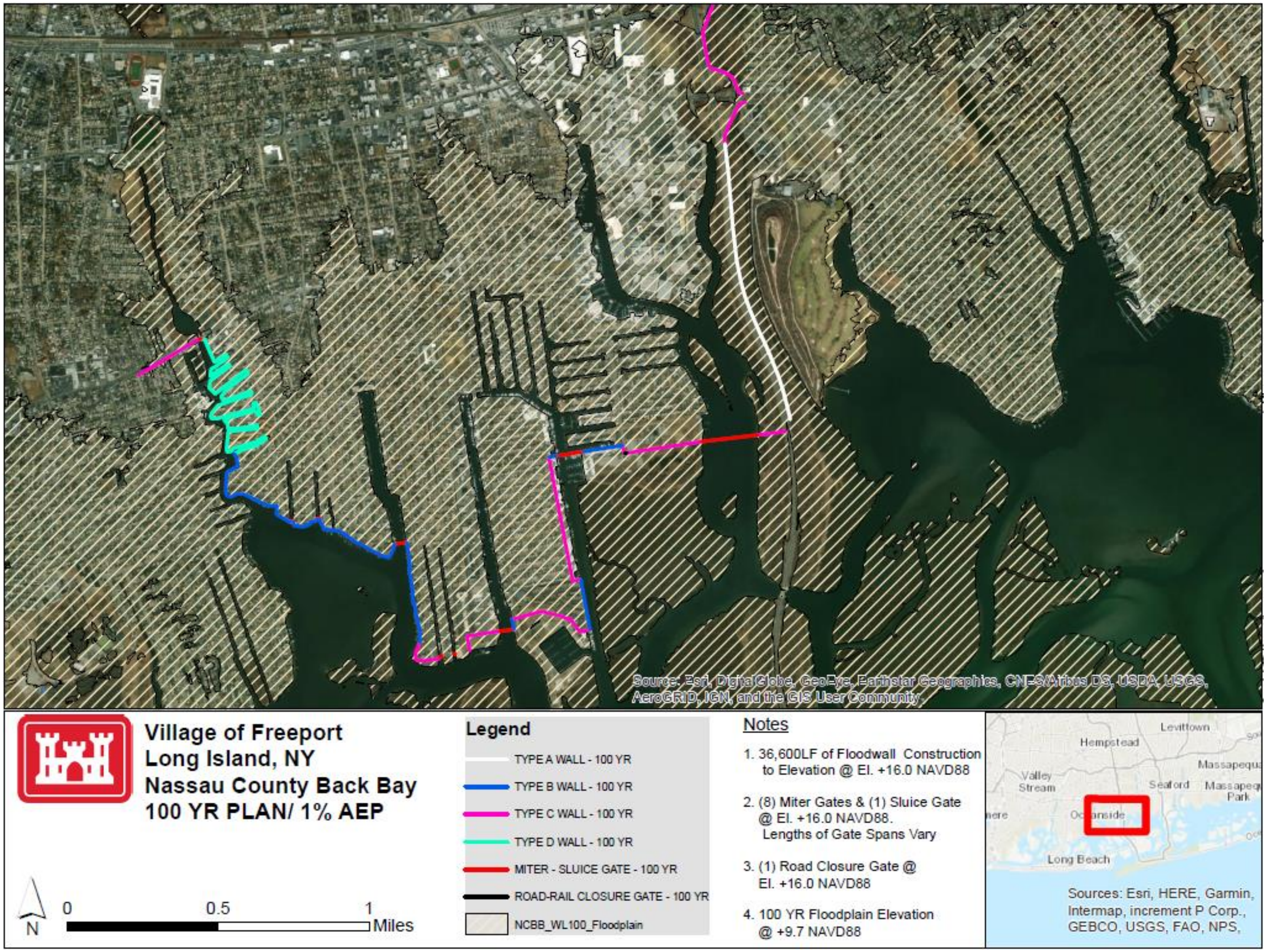


Figure 9: Perimeter Measures – East Rockaway & Vicinity

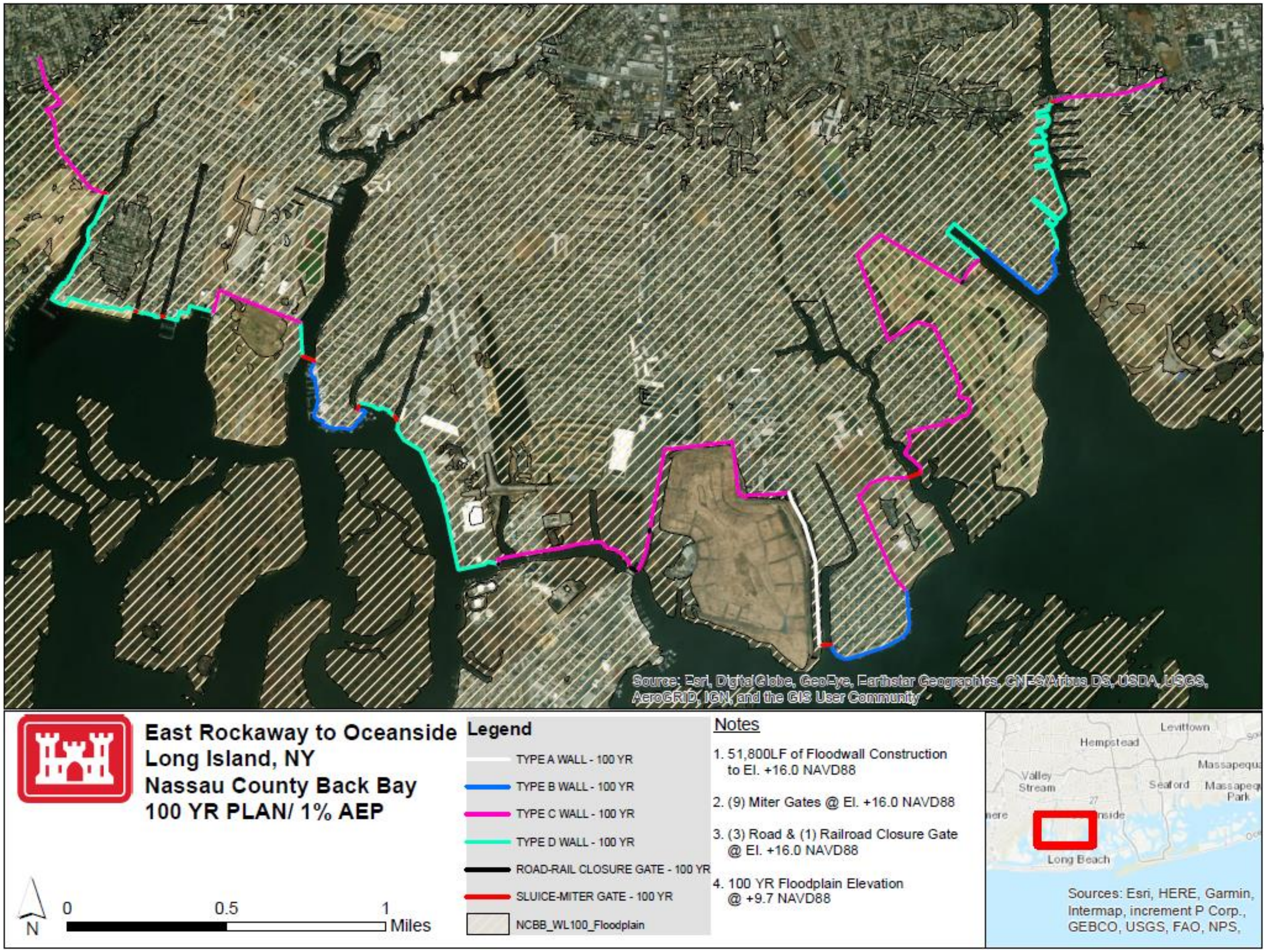
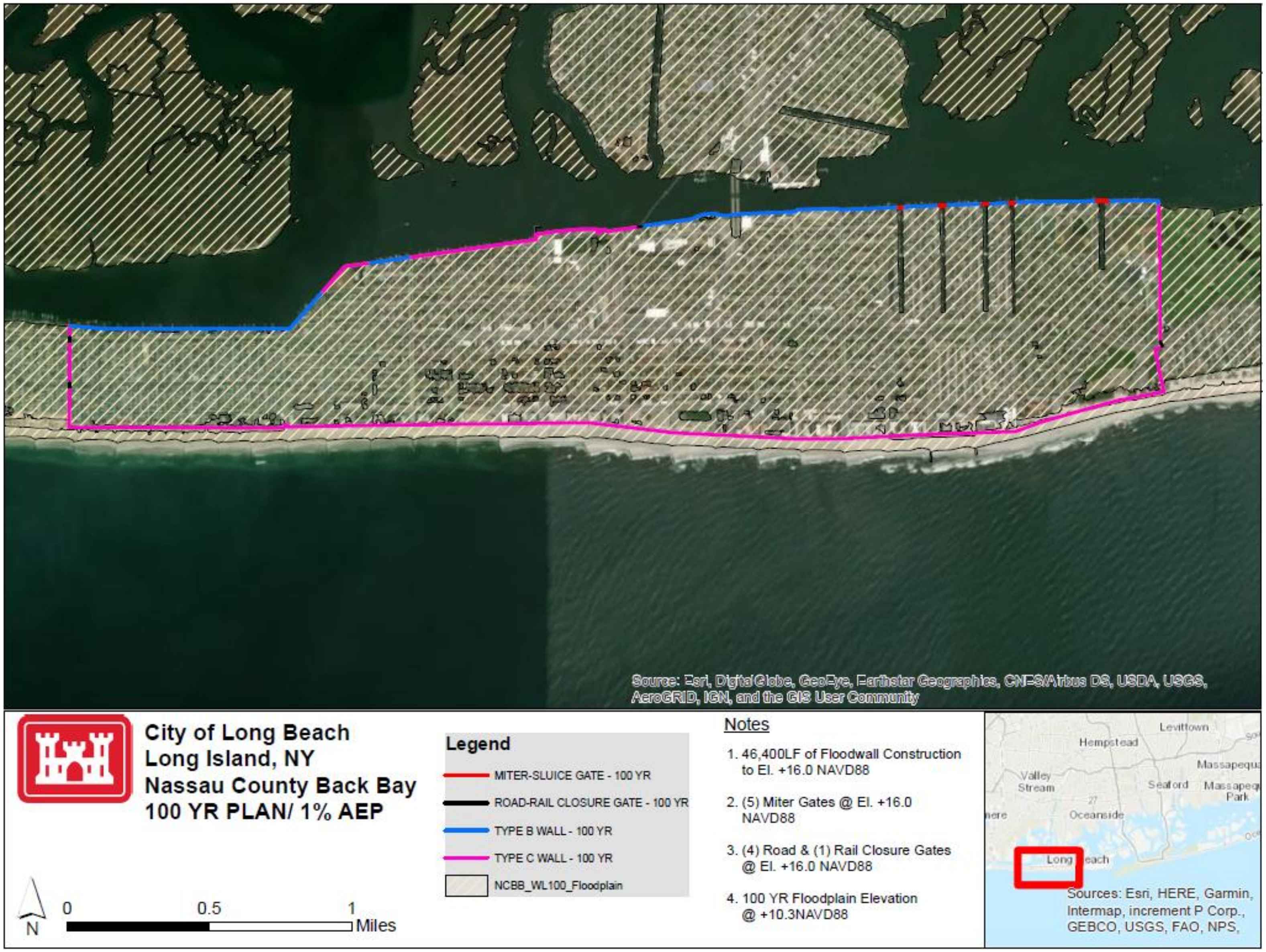


Figure 10: Perimeter Measures – Island Park & Vicinity

Figure 11: Perimeter Measures – City of Long Beach



Sea Level Change Adaptability

Perimeter measures are currently formulated and designed to maintain effectiveness under the Intermediate SLC curve scenario. The proposed floodwall measures are evaluated under each of the USACE SLC curves as required by ER 1100-2-8162 *Incorporating Sea Level Change in Civil Works Programs* but are not redesigned for each SLC curve at this stage of the analysis. In the scenario that perimeter measures are incorporated into the NED Plan or carried forward to the next stage of analysis, designs will expand to incorporate SLC resiliency and adaptability characteristics. This includes, but is not limited to, investigating anticipatory (precautionary) approaches such as "overbuilding" the floodwall in the base year and adaptive approaches such as widening the initial floodwall base to facilitate possible future retrofits. Evaluation will be conducted in compliance with ER 1105-2-100 *Planning Guidance Notebook* and EP 1100-2-1 *Procedures to Evaluate Sea Level Change: Impacts, Responses, and Adaptation*.

The definitions for precautionary, adaptive, and reactionary approaches are expanded in the Nonstructural Measures section later in the Appendix.

Critical Infrastructure

In addition to the comprehensive, large-scale perimeter measures designed for each highlighted area, alternative perimeter measures were developed for limiting coastal storm risk for essential critical infrastructure facilities such as wastewater treatment facilities and power substations. The objective for these focused perimeter alternatives is not only to mitigate direct damages to vital infrastructure systems but to reduce recovery time during and after storm events.

By mitigating or eliminating downtime for certain critical infrastructure systems, post-storm recovery time and impacts to regional economic stability are also reduced. Critical infrastructure support also significantly reduces health and safety concerns during and after storm events, particularly for socially vulnerable populations that rely on public utilities and infrastructure stability for vital health services.

Figure 12 through Figure 15 provide the location of critical infrastructure-focused perimeter measures for the study area. This includes facilities in the Village of Freeport (Equus Power), Village of Island Park (EF Barret Power Station), City of Long Beach (Long Beach Wastewater Treatment Plant), and the Hamlet of Wantagh (Cedar Creek Wastewater Treatment Plant).

Figure 12: Perimeter Measures – Critical Infrastructure – Village of Freeport

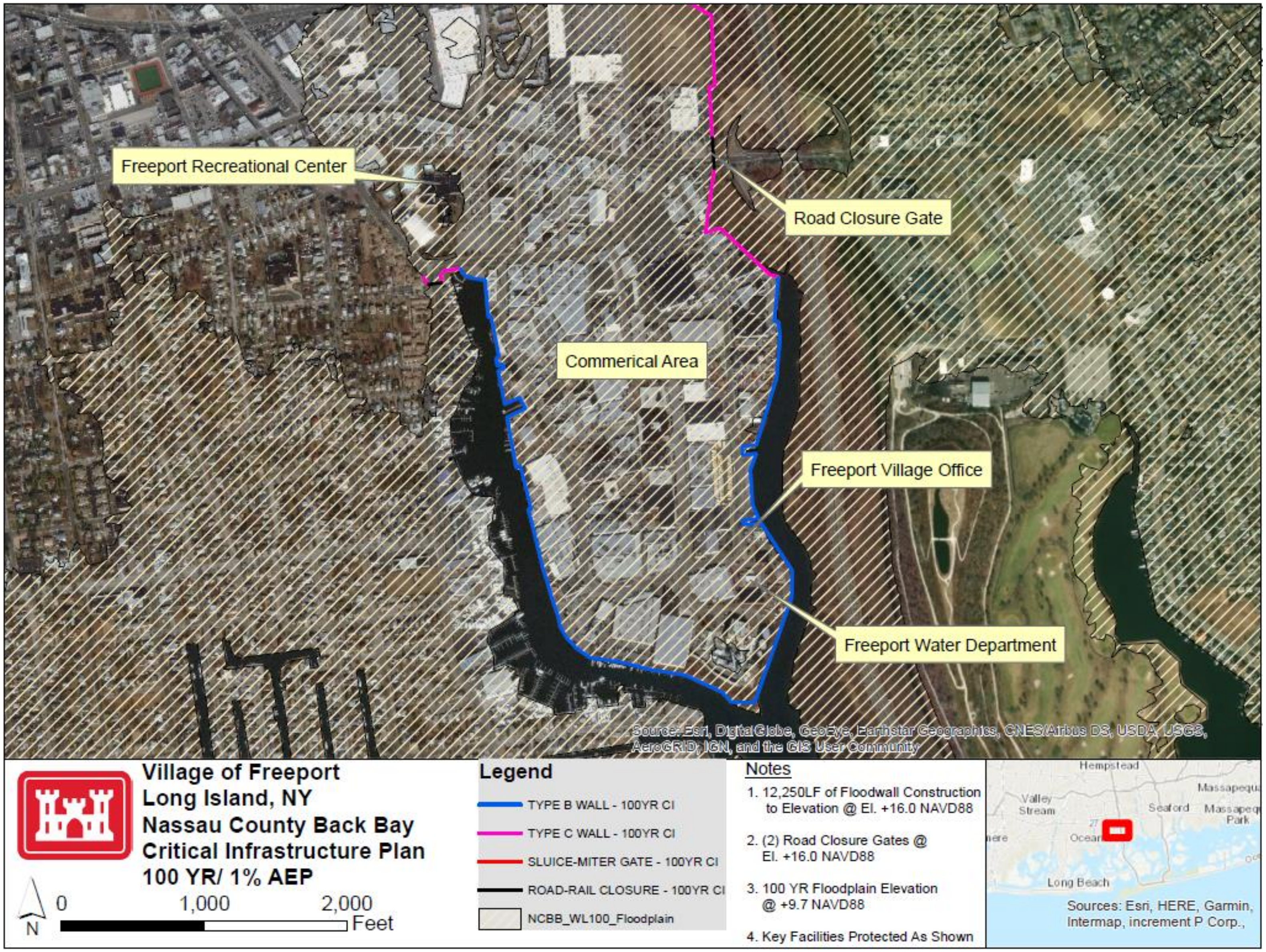


Figure 13: Perimeter Measures – Critical Infrastructure – Village of Island Park

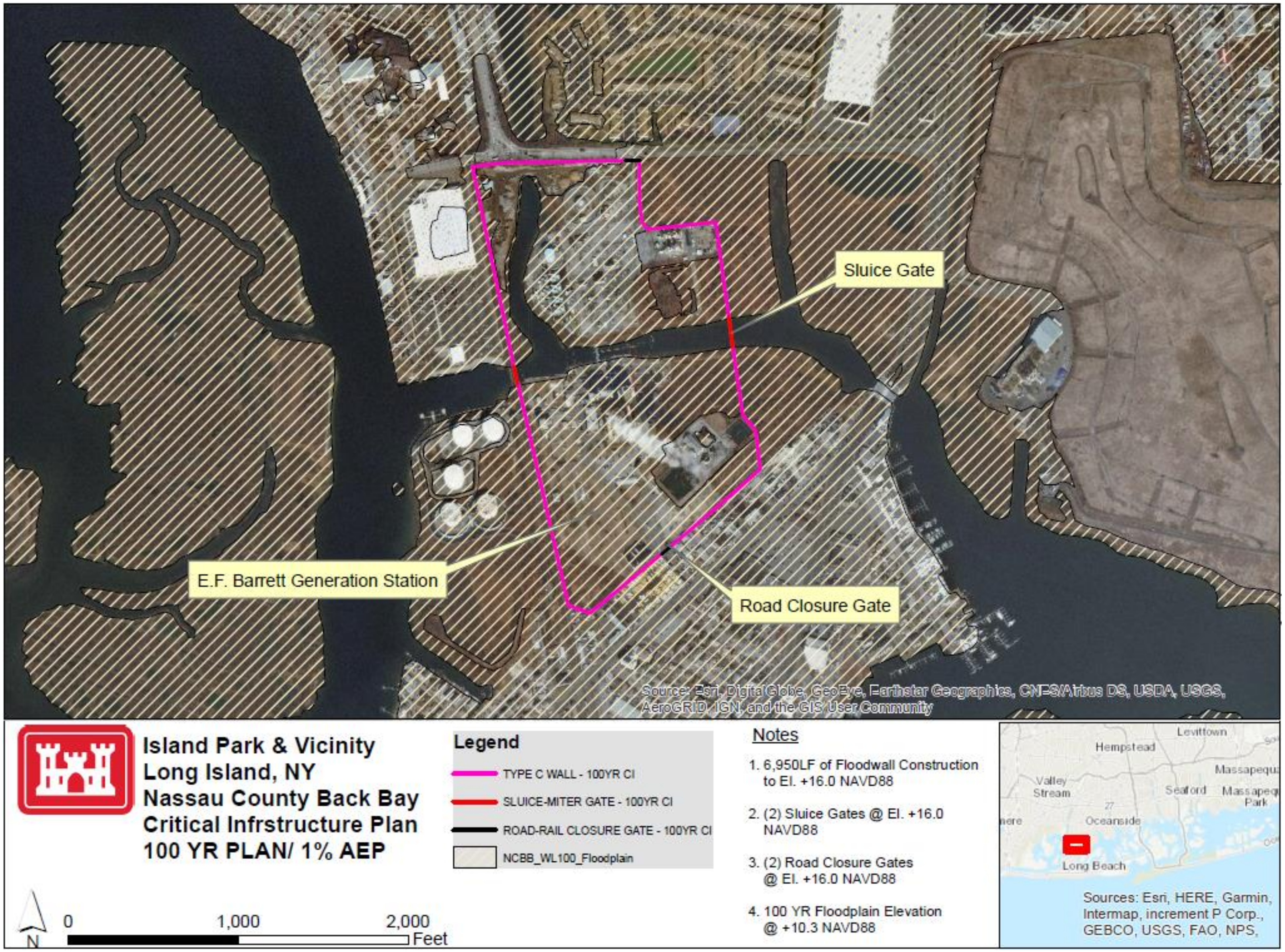


Figure 14: Perimeter Measures – Critical Infrastructure – City of Long Beach

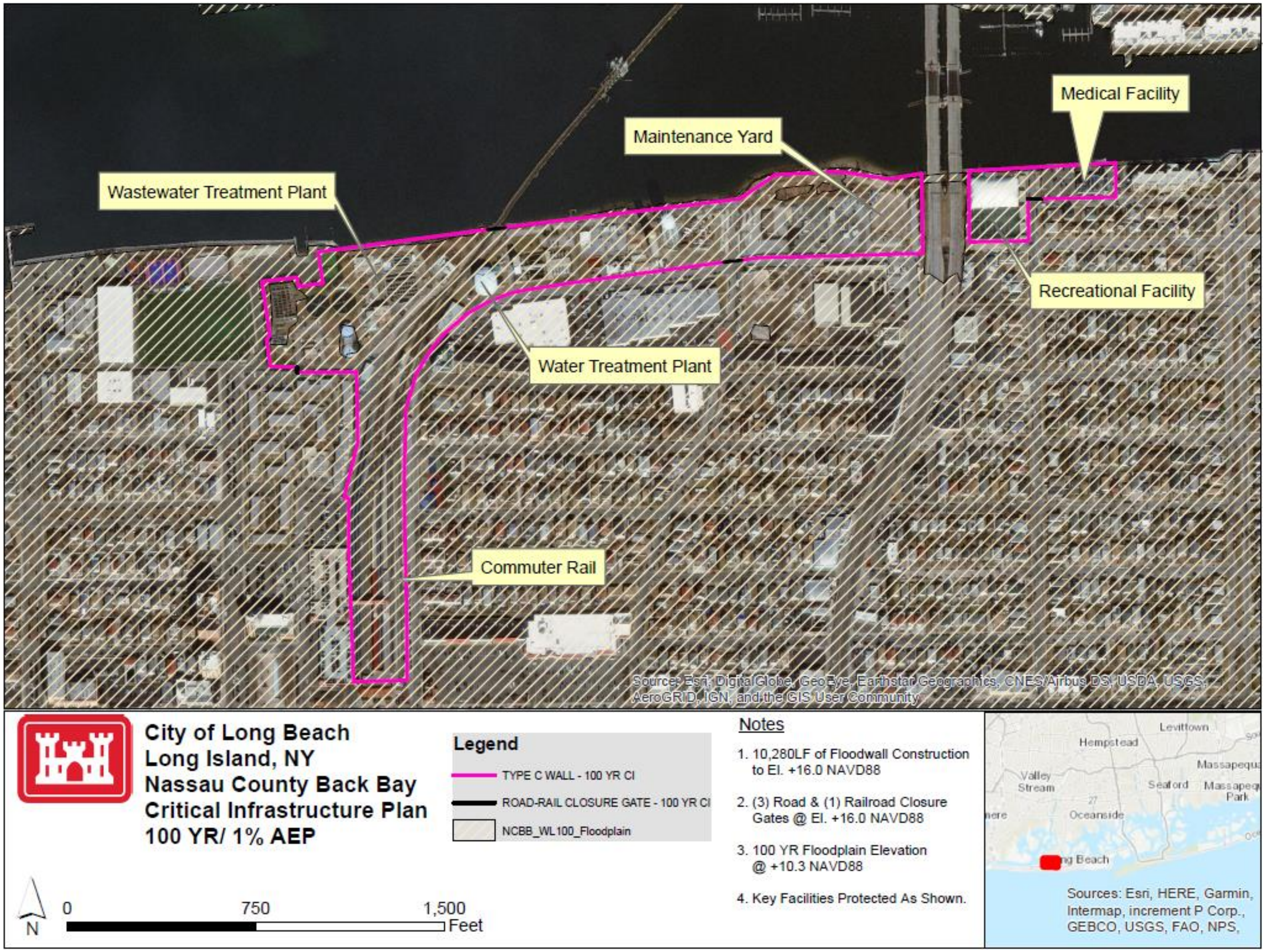
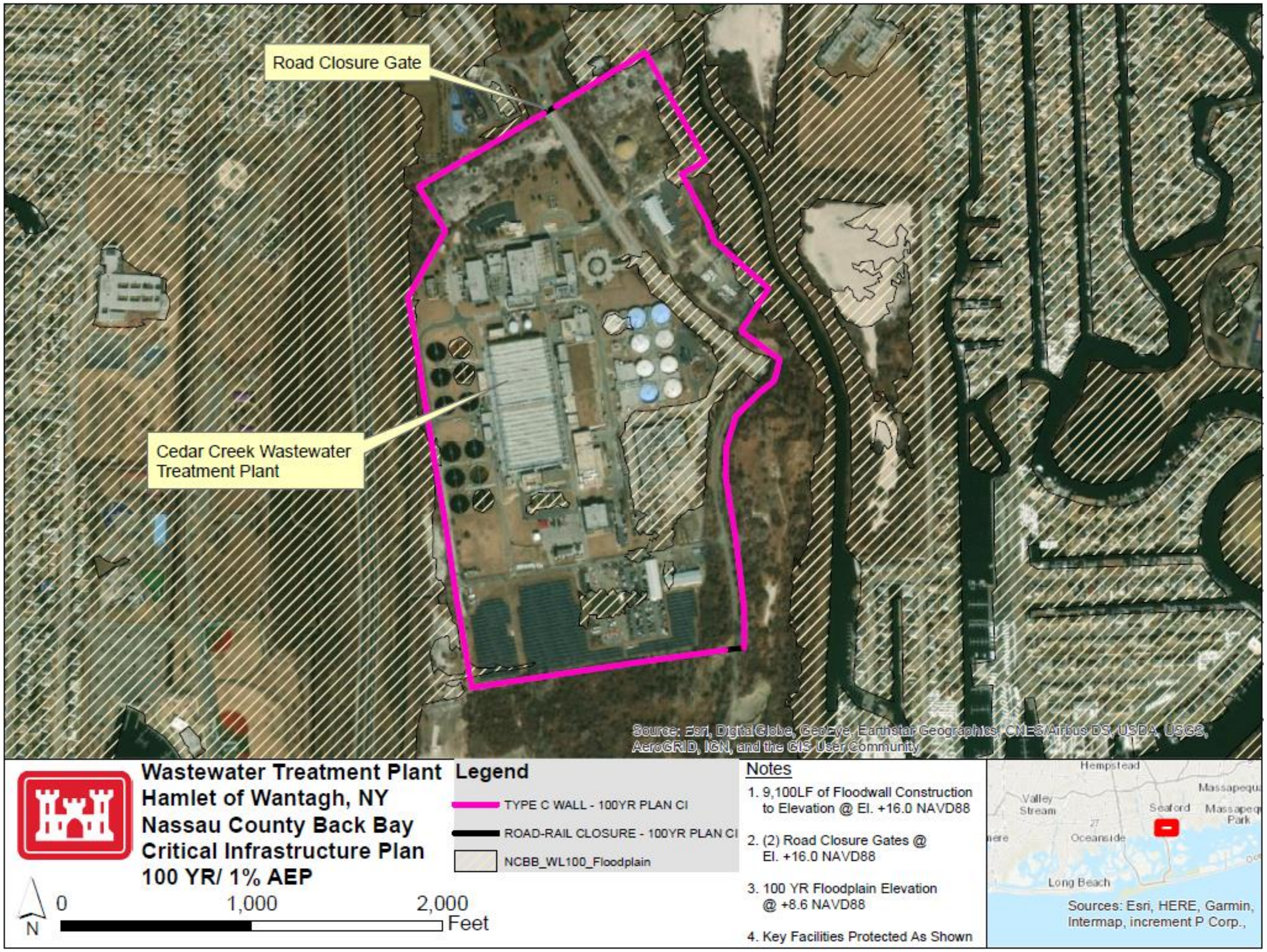


Figure 15: Perimeter Measures – Critical Infrastructure – Hamlet of Wantagh



Cost Estimates

The Total Project Cost Summary (TPCS) for each potential perimeter measure location was developed at the October 1st, 2020 (FY2021) Price Level. A TPCS provides detailed information on estimated contingencies, individual components of the proposed alternative, Planning Engineering & Design (PE&D), and Construction Management. TPCS reports are generated from MII and more information on their development can be found in the Cost Engineering Appendix.

A TPCS is provided for each perimeter measure individually to facilitate incremental economic analysis. As the measures are considered separable elements, each measure must be independently investigated for economic viability to be eligible for recommendation.

According to ER 1105-2-100 *Planning Guidance Notebook*, a separable element is any part of a project that has separately assigned benefits and costs and that can be implemented as a separate action (at a later date or as a separate project). All four potential comprehensive perimeter measures and each of the infrastructure-focused perimeter measures fall under this definition and must have clearly assigned benefits and costs for economic assessment.

Table 4 provides a summary of the potential perimeter measure cost estimates. The table includes construction costs, contingency, Interest During Construction (IDC), average annual Operations, Maintenance, Repair, Rehabilitation & Replacement (OMRR&R), and total construction cost in FY2021 Price Level.

IDC is calculated in accordance with IWR Report 88-R-2 *Urban Flood Damages.* Average annual OMRR&R is estimated as 0.5% of initial construction cost plus contingency. This estimate is based on similar perimeter projects near the study area.

Average Annual Cost (AAC) is calculated at the FY2021 Price Level using the FY2021 Project Evaluation and Formulation Rate (Discount Rate) of 2.5% in accordance with EGM 21-01 *Federal Interest Rates for Corps of Engineers Projects for Fiscal Year 2021*.

Table 5 through Table 8 provide the TPCS for each comprehensive perimeter measure alignment.

Table 9 through Table 11 provide the TPCS for each infrastructure-focused perimeter measure alignment.

Please note that the critical infrastructure-focused perimeter measure in the hamlet of Wantagh (Cedar Creek Wastewater) does not yet have a cost estimate nor has the measure yet been evaluated for economic NED benefits. Both efforts will be completed before release of the final Feasibility Report.

Table 4: TPCS – Summary Cost Table (in thousands)

Location	Initial Construction Cost	Contingency	Interest During Construction	Total First Construction Cost	Subtotal AAC	Annual OMRR&R	Total AAC
Freeport	$1,373,000	$648,000	$129,000	$2,150,000	$76,000	$10,000	**$86,000**
East Rockaway	$1,878,000	$874,000	$175,000	$2,928,000	$103,000	$14,000	**$117,000**
Island Park	$1,325,000	$575,000	$121,000	$2,021,000	$71,000	$10,000	**$81,000**
Long Beach	$1,067,000	$487,000	$99,000	$1,653,000	$58,000	$8,000	**$66,000**
CI - Freeport	$294,000	$132,000	$27,000	$453,000	$16,000	$2,000	**$18,000**
CI - Island Park	$172,000	$82,000	$16,000	$270,000	$10,000	$1,000	**$11,000**
CI - Long Beach	$209,000	$96,000	$19,000	$324,000	$11,000	$2,000	**$13,000**
CI - Wantagh	-	-	-	-	-	-	**-**

*CI = Critical Infrastructure

Table 5: TPCS – Village of Freeport – Perimeter

WBS Structure		ESTIMATED COST				PROJECT FIRST COST (Constant Dollar Basis)				TOTAL PROJECT COST (FULLY FUNDED)				
		Estimate Prepared: Estimate Price Level:			26-Feb-21 1-Oct-20	Program Year (Budget EC): Effective Price Level Date:			2022 1 -Oct-21					
				RISK BASED										
WBS NUMBER A	Civil Works Feature & Sub-Feature Description B	COST ($K) C	CNTG ($K) D	CNTG (%) E	TOTAL ($K) F	ESC (%) G	COST ($K) H	CNTG ($K) I	TOTAL ($K) J	Mid-Point Date P	ESC (%) L	COST ($K) M	CNTG ($K) N	FULL ($K) O
	Freeport Alignment													
06	FISH & WILDLIFE FACILITIES	$6,476	$1,943	30.0%	$8,419	2.9%	$6,661	$1,998	$8,659	2030Q3	27.5%	$8,495	$2,548	$11,043
11	LEVEES & FLOODWALLS	$546,517	$235,003	43.0%	$781,520	2.9%	$562,098	$241,702	$803,800	2030Q3	27.5%	$716,895	$308,265	$1,025,159
13	PUMPING PLANT	$187,227	$123,570	66.0%	$310,797	2.9%	$192,565	$127,093	$319,657	2030Q3	27.5%	$245,595	$162,093	$407,688
15	FLOODWAY CONTROL & DIVERSION STRUCTURE	$146,130	$84,756	58.0%	$230,886	2.9%	$150,296	$87,172	$237,468	2030Q3	27.5%	$191,687	$111,178	$302,865
18	CULTURAL RESOURCE PRESERVATION	$8,864	$4,698	53.0%	$13,561	2.9%	$9,116	$4,832	$13,948	2030Q3	27.5%	$11,627	$6,162	$17,789
	CONSTRUCTION ESTIMATE TOTALS:	$895,214	$449,968	50.3%	$1,345,183		$920,736	$462,797	$1,383,532			$1,174,298	$590,246	$1,764,545
01	LANDS AND DAMAGES	$271,994	$135,997	50.0%	$407,991	2.9%	$279,748	$139,874	$419,622	2027Q3	17.1%	$327,465	$163,732	$491,197
30	PLANNING, ENGINEERING & DESIGN													
1.0%	Project Management	$8,952	$2,686	30.0%	$11,638	4.0%	$9,310	$2,793	$12,103	2025Q2	12.5%	$10,478	$3,143	$13,621
1.0%	Planning & Environmental Compliance	$8,952	$2,686	30.0%	$11,638	4.0%	$9,310	$2,793	$12,103	2025Q2	12.5%	$10,478	$3,143	$13,621
4.0%	Engineering & Design	$35,809	$10,743	30.0%	$46,551	4.0%	$37,239	$11,172	$48,410	2025Q2	12.5%	$41,910	$12,573	$54,484
1.0%	Reviews, ATRs, IEPRs, VE	$8,952	$2,686	30.0%	$11,638	4.0%	$9,310	$2,793	$12,103	2025Q2	12.5%	$10,478	$3,143	$13,621
1.0%	Life Cycle Updates (cost, schedule, risl	$8,952	$2,686	30.0%	$11,638	4.0%	$9,310	$2,793	$12,103	2025Q2	12.5%	$10,478	$3,143	$13,621
1.0%	Contracting & Reprographics	$8,952	$2,686	30.0%	$11,638	4.0%	$9,310	$2,793	$12,103	2030Q3	36.6%	$12,721	$3,816	$16,537
1.0%	Engineering During Construction	$8,952	$2,686	30.0%	$11,638	4.0%	$9,310	$2,793	$12,103	2030Q3	36.6%	$12,721	$3,816	$16,537
1.0%	Planning During Construction	$8,952	$2,686	30.0%	$11,638	4.0%	$9,310	$2,793	$12,103	2025Q2	12.5%	$10,478	$3,143	$13,621
1.0%	Adaptive Management & Monitoring	$8,952	$2,686	30.0%	$11,638	4.0%	$9,310	$2,793	$12,103	2030Q3	36.6%	$12,721	$3,816	$16,537
1.0%	Project Operations	$8,952	$2,686	30.0%	$11,638	4.0%	$9,310	$2,793	$12,103	2030Q3	36.6%	$12,721	$3,816	$16,537
31	CONSTRUCTION MANAGEMENT													
8.0%	Construction Management	$71,617	$21,485	30.0%	$93,102	4.0%	$74,477	$22,343	$96,820	2030Q3	36.6%	$101,767	$30,530	$132,297
1.0%	Project Operation:	$8,952	$2,686	30.0%	$11,638	4.0%	$9,310	$2,793	$12,103	2030Q3	36.6%	$12,721	$3,816	$16,537
1.0%	Project Management	$8,952	$2,686	30.0%	$11,638	4.0%	$9,310	$2,793	$12,103	2030Q3	36.6%	$12,721	$3,816	$16,537
	CONTRACT COST TOTALS:	$1,373,108	$647,735		$2,020,843		$1,414,606	$666,907	**$2,081,513**			$1,774,154	$835,696	**$2,609,850**

Table 6: TPCS – East Rockaway & Vicinity – Perimeter

WBS Structure		ESTIMATED COST				PROJECT FIRST COST (Constant Dollar Basis)				TOTAL PROJECT COST (FULLY FUNDED)				
		Estimate Prepared:			26-Feb-21	Program Year (Budget EC):			2022					
		Estimate Price Level:			1-Oct-20	Effective Price Level Date:			1 -Oct-21					
				RISK BASED										
WBS NUMBER	Civil Works Feature & Sub-Feature Description	COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	Mid-Point Date	ESC (%)	COST ($K)	CNTG ($K)	FULL ($K)
A	*B*	*C*	*D*	*E*	*F*	*G*	*H*	*I*	*J*	*P*	*L*	*M*	*N*	*O*
	East Rockaway Alignment													
06	FISH & WILDLIFE FACILITIES	$3,660	$1,098	30.0%	$4,758	2.9%	$3,765	$1,129	$4,894	2030Q3	27.5%	$4,801	$1,440	$6,242
11	LEVEES & FLOODWALLS	$810,035	$348,315	43.0%	$1,158,350	2.9%	$833,128	$358,245	$1,191,373	2030Q3	27.5%	$1,062,564	$456,903	$1,519,467
13	PUMPING PLANT	$213,856	$141,145	66.0%	$355,002	2.9%	$219,953	$145,169	$365,122	2030Q3	27.5%	$280,528	$185,147	$465,674
15	FLOODWAY CONTROL & DIVERSION S	$174,451	$101,181	58.0%	$275,632	2.9%	$179,424	$104,066	$283,490	2030Q3	27.5%	$228,836	$132,725	$361,560
18	CULTURAL RESOURCE PRESERVATIO	$12,020	$6,371	53.0%	$18,391	2.9%	$12,363	$6,552	$18,915	2030Q3	27.5%	$15,767	$8,357	$24,124
	CONSTRUCTION ESTIMATE TOTALS:	$1,214,022	$598,110	49.3%	$1,812,133		$1,248,633	$615,162	$1,863,795			$1,592,495	$784,572	$2,377,066
01	LANDS AND DAMAGES	$384,828	$192,414	50.0%	$577,242	2.9%	$395,799	$197,899	$593,698	2027Q3	17.1%	$463,310	$231,655	$694,965
30	PLANNING, ENGINEERING & DESIGN													
1.0%	Project Management	$12,140	$3,642	30.0%	$15,782	4.0%	$12,625	$3,788	$16,413	2025Q2	12.5%	$14,209	$4,263	$18,472
1.0%	Planning & Environmental Compliance	$12,140	$3,642	30.0%	$15,782	4.0%	$12,625	$3,788	$16,413	2025Q2	12.5%	$14,209	$4,263	$18,472
4.0%	Engineering & Design	$48,561	$14,568	30.0%	$63,129	4.0%	$50,500	$15,150	$65,650	2025Q2	12.5%	$56,836	$17,051	$73,886
1.0%	Reviews, ATRs, IEPRs, VE	$12,140	$3,642	30.0%	$15,782	4.0%	$12,625	$3,788	$16,413	2025Q2	12.5%	$14,209	$4,263	$18,472
1.0%	Life Cycle Updates (cost, schedule, risks)	$12,140	$3,642	30.0%	$15,782	4.0%	$12,625	$3,788	$16,413	2025Q2	12.5%	$14,209	$4,263	$18,472
1.0%	Contracting & Reprographics	$12,140	$3,642	30.0%	$15,782	4.0%	$12,625	$3,788	$16,413	2025Q2	12.5%	$14,209	$4,263	$18,472
1.0%	Engineering During Construction	$12,140	$3,642	30.0%	$15,782	4.0%	$12,625	$3,788	$16,413	2025Q2	12.5%	$14,209	$4,263	$18,472
1.0%	Planning During Construction	$12,140	$3,642	30.0%	$15,782	4.0%	$12,625	$3,788	$16,413	2025Q2	12.5%	$14,209	$4,263	$18,472
1.0%	Adaptive Management & Monitoring	$12,140	$3,642	30.0%	$15,782	4.0%	$12,625	$3,788	$16,413	2030Q3	36.6%	$17,251	$5,175	$22,426
1.0%	Project Operations	$12,140	$3,642	30.0%	$15,782	4.0%	$12,625	$3,788	$16,413	2030Q3	36.6%	$17,251	$5,175	$22,426
31	CONSTRUCTION MANAGEMENT													
8.0%	Construction Management	$97,122	$29,137	30.0%	$126,258	4.0%	$101,000	$30,300	$131,300	2030Q3	36.6%	$138,009	$41,403	$179,412
1.0%	Project Operation:	$12,140	$3,642	30.0%	$15,782	4.0%	$12,625	$3,788	$16,413	2030Q3	36.6%	$17,251	$5,175	$22,426
1.0%	Project Management	$12,140	$3,642	30.0%	$15,782	4.0%	$12,625	$3,788	$16,413	2030Q3	36.6%	$17,251	$5,175	$22,426
	CONTRACT COST TOTALS:	$1,878,076	$874,292		$2,752,368		$1,934,807	$900,174	**$2,834,981**			$2,419,117	$1,125,220	**$3,544,337**

Table 7: TPCS – Island Park & Vicinity – Perimeter

WBS Structure		ESTIMATED COST				PROJECT FIRST COST (Constant Dollar Basis)				TOTAL PROJECT COST (FULLY FUNDED)				
		Estimate Prepared:			26-Feb-21	Program Year (Budget EC):			2022					
		Estimate Price Level:			1-Oct-20	Effective Price Level Date:			1 -Oct-21					
				RISK BASED										
WBS NUMBER	Civil Works Feature & Sub-Feature Description	COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	Mid-Point Date	ESC (%)	COST ($K)	CNTG ($K)	FULL ($K)
A	*B*	*C*	*D*	*E*	*F*	*G*	*H*	*I*	*J*	*P*	*L*	*M*	*N*	*O*
	Island Park Alignment													
06	FISH & WILDLIFE FACILITIES	$2,253	$676	30.0%	$2,928	2.9%	$2,317	$695	$3,012	2030Q3	27.5%	$2,955	$886	$3,841
11	LEVEES & FLOODWALLS	$773,603	$332,649	43.0%	$1,106,253	2.9%	$795,658	$342,133	$1,137,791	2030Q3	27.5%	$1,014,775	$436,353	$1,451,128
13	PUMPING PLANT	$12,999	$8,580	66.0%	$21,579	2.9%	$13,370	$8,824	$22,194	2030Q3	27.5%	$17,052	$11,254	$28,306
15	FLOODWAY CONTROL & DIVERSION STRUCTURE	$60,168	$34,897	58.0%	$95,065	2.9%	$61,883	$35,892	$97,775	2030Q3	27.5%	$78,925	$45,776	$124,701
18	CULTURAL RESOURCE PRESERVATIC	$8,490	$4,500	53.0%	$12,990	2.9%	$8,732	$4,628	$13,360	2030Q3	27.5%	$11,137	$5,903	$17,040
	CONSTRUCTION ESTIMATE TOTALS:	$857,513	$381,302	44.5%	$1,238,815		$881,960	$392,172	$1,274,132			$1,124,843	$500,173	$1,625,016
01	LANDS AND DAMAGES	$269,876	$134,938	50.0%	$404,814	2.9%	$277,570	$138,785	$416,355	2027Q3	17.1%	$324,915	$162,457	$487,372
30	PLANNING, ENGINEERING & DESIGN													
1.0%	Project Management	$8,575	$2,573	30.0%	$11,148	4.0%	$8,918	$2,675	$11,593	2025Q2	12.5%	$10,036	$3,011	$13,047
1.0%	Planning & Environmental Compliance	$8,575	$2,573	30.0%	$11,148	4.0%	$8,918	$2,675	$11,593	2025Q2	12.5%	$10,036	$3,011	$13,047
4.0%	Engineering & Design	$34,301	$10,290	30.0%	$44,591	4.0%	$35,670	$10,701	$46,371	2025Q2	12.5%	$40,145	$12,044	$52,189
1.0%	Reviews, ATRs, IEPRs, VE	$8,575	$2,573	30.0%	$11,148	4.0%	$8,918	$2,675	$11,593	2025Q2	12.5%	$10,036	$3,011	$13,047
1.0%	Life Cycle Updates (cost, schedule, risl	$8,575	$2,573	30.0%	$11,148	4.0%	$8,918	$2,675	$11,593	2025Q2	12.5%	$10,036	$3,011	$13,047
1.0%	Contracting & Reprographics	$8,575	$2,573	30.0%	$11,148	4.0%	$8,918	$2,675	$11,593	2025Q2	12.5%	$10,036	$3,011	$13,047
1.0%	Engineering During Construction	$8,575	$2,573	30.0%	$11,148	4.0%	$8,918	$2,675	$11,593	2025Q2	12.5%	$10,036	$3,011	$13,047
1.0%	Planning During Construction	$8,575	$2,573	30.0%	$11,148	4.0%	$8,918	$2,675	$11,593	2025Q2	12.5%	$10,036	$3,011	$13,047
1.0%	Adaptive Management & Monitoring	$8,575	$2,573	30.0%	$11,148	4.0%	$8,918	$2,675	$11,593	2030Q3	36.6%	$12,185	$3,656	$15,841
1.0%	Project Operations	$8,575	$2,573	30.0%	$11,148	4.0%	$8,918	$2,675	$11,593	2030Q3	36.6%	$12,185	$3,656	$15,841
31	CONSTRUCTION MANAGEMENT													
8.0%	Construction Management	$68,601	$20,580	30.0%	$89,181	4.0%	$71,340	$21,402	$92,743	2030Q3	36.6%	$97,481	$29,244	$126,726
1.0%	Project Operation:	$8,575	$2,573	30.0%	$11,148	4.0%	$8,918	$2,675	$11,593	2030Q3	36.6%	$12,185	$3,656	$15,841
1.0%	Project Management	$8,575	$2,573	30.0%	$11,148	4.0%	$8,918	$2,675	$11,593	2030Q3	36.6%	$12,185	$3,656	$15,841
	CONTRACT COST TOTALS:	$1,324,617	$575,408		$1,900,025		$1,364,633	$592,488	**$1,957,121**			$1,706,380	$739,617	**$2,445,996**

Table 8: TPCS – City of Long Beach – Perimeter

WBS Structure		ESTIMATED COST				PROJECT FIRST COST (Constant Dollar Basis)				TOTAL PROJECT COST (FULLY FUNDED)				
		Estimate Prepared:			26-Feb-21	Program Year (Budget EC):			2022					
		Estimate Price Level:			1-Oct-20	Effective Price Level Date:			1 -Oct-21					
				RISK BASED										
WBS NUMBER	Civil Works Feature & Sub-Feature Description	COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	Mid-Point Date	ESC (%)	COST ($K)	CNTG ($K)	FULL ($K)
A	*B*	*C*	*D*	*E*	*F*	*G*	*H*	*I*	*J*	*P*	*L*	*M*	*N*	*O*
	Long Beach Island Alignment													
06	FISH & WILDLIFE FACILITIES	$1,689	$507	30.0%	$2,196	2.9%	$1,738	$521	$2,259	2030Q3	27.5%	$2,216	$665	$2,881
11	LEVEES & FLOODWALLS	$449,167	$193,142	43.0%	$642,309	2.9%	$461,972	$198,648	$660,620	2030Q3	27.5%	$589,195	$253,354	$842,549
13	PUMPING PLANT	$28,460	$18,783	66.0%	$47,243	2.9%	$29,271	$19,319	$48,590	2030Q3	27.5%	$37,332	$24,639	$61,971
15	FLOODWAY CONTROL & DIVERSION STRUCTURE	$101,386	$58,804	58.0%	$160,190	2.9%	$104,277	$60,480	$164,757	2030Q3	27.5%	$132,994	$77,136	$210,130
18	CULTURAL RESOURCE PRESERVATION	$5,807	$3,078	53.0%	$8,885	2.9%	$5,973	$3,165	$9,138	2030Q3	27.5%	$7,617	$4,037	$11,655
	CONSTRUCTION ESTIMATE TOTALS:	$586,509	$274,314	46.8%	$860,823		$603,230	$282,134	$885,364			$769,354	$359,831	$1,129,185
01	LANDS AND DAMAGES	$345,109	$172,554	50.0%	$517,663	2.9%	$354,947	$177,474	$532,421	2027Q3	17.1%	$415,490	$207,745	$623,236
30	PLANNING, ENGINEERING & DESIGN													
1.0%	Project Management	$5,865	$1,760	30.0%	$7,625	4.0%	$6,099	$1,830	$7,929	2025Q2	12.5%	$6,865	$2,059	$8,924
1.0%	Planning & Environmental Compliance	$5,865	$1,760	30.0%	$7,625	4.0%	$6,099	$1,830	$7,929	2025Q2	12.5%	$6,865	$2,059	$8,924
4.0%	Engineering & Design	$23,460	$7,038	30.0%	$30,498	4.0%	$24,397	$7,319	$31,716	2025Q2	12.5%	$27,458	$8,237	$35,695
1.0%	Reviews, ATRs, IEPRs, VE	$5,865	$1,760	30.0%	$7,625	4.0%	$6,099	$1,830	$7,929	2025Q2	12.5%	$6,865	$2,059	$8,924
1.0%	Life Cycle Updates (cost, schedule,	$5,865	$1,760	30.0%	$7,625	4.0%	$6,099	$1,830	$7,929	2025Q2	12.5%	$6,865	$2,059	$8,924
1.0%	Contracting & Reprographics	$5,865	$1,760	30.0%	$7,625	4.0%	$6,099	$1,830	$7,929	2030Q3	36.6%	$8,334	$2,500	$10,834
1.0%	Engineering During Construction	$5,865	$1,760	30.0%	$7,625	4.0%	$6,099	$1,830	$7,929	2030Q3	36.6%	$8,334	$2,500	$10,834
1.0%	Planning During Construction	$5,865	$1,760	30.0%	$7,625	4.0%	$6,099	$1,830	$7,929	2025Q2	12.5%	$6,865	$2,059	$8,924
1.0%	Adaptive Management & Monitoring	$5,865	$1,760	30.0%	$7,625	4.0%	$6,099	$1,830	$7,929	2030Q3	36.6%	$8,334	$2,500	$10,834
1.0%	Project Operations	$5,865	$1,760	30.0%	$7,625	4.0%	$6,099	$1,830	$7,929	2030Q3	36.6%	$8,334	$2,500	$10,834
31	CONSTRUCTION MANAGEMENT													
8.0%	Construction Management	$46,921	$14,076	30.0%	$60,997	4.0%	$48,794	$14,638	$63,433	2030Q3	36.6%	$66,674	$20,002	$86,676
1.0%	Project Operation:	$5,865	$1,760	30.0%	$7,625	4.0%	$6,099	$1,830	$7,929	2030Q3	36.6%	$8,334	$2,500	$10,834
1.0%	Project Management	$5,865	$1,760	30.0%	$7,625	4.0%	$6,099	$1,830	$7,929	2030Q3	36.6%	$8,334	$2,500	$10,834
	CONTRACT COST TOTALS:	$1,066,515	$487,337		$1,553,852		$1,098,461	$501,693	**$1,600,154**			$1,363,304	$621,114	**$1,984,418**

Table 9: TPCS – Critical Infrastructure – Village of Freeport – Perimeter

WBS Structure		ESTIMATED COST				PROJECT FIRST COST (Constant Dollar Basis)				TOTAL PROJECT COST (FULLY FUNDED)				
		Estimate Prepared: Estimate Price Level:			8-Oct-20 1-Oct-20	Program Year (Budget EC): Effective Price Level Date:			2022 1 -Oct-21					
				RISK BASED										
WBS NUMBER A	Civil Works Feature & Sub-Feature Description B	COST ($K) C	CNTG ($K) D	CNTG (%) E	TOTAL ($K) F	ESC (%) G	COST ($K) H	CNTG ($K) I	TOTAL ($K) J	Mid-Point Date P	ESC (%) L	COST ($K) M	CNTG ($K) N	FULL ($K) O
	Freeport Alignment													
02	RELOCATIONS													
11	LEVEES & FLOODWALLS	$143,913	$61,883	43.0%	$205,796	2.9%	$148,016	$63,647	$211,663	2030Q3	27.5%	$188,778	$81,175	$269,953
13	PUMPING PLANT	$6,310	$4,165	66.0%	$10,475	2.9%	$6,490	$4,283	$10,773	2030Q3	27.5%	$8,277	$5,463	$13,740
15	FLOODWAY CONTROL & DIVERSION S	$12,773	$7,408	58.0%	$20,181	2.9%	$13,137	$7,620	$20,757	2030Q3	27.5%	$16,755	$9,718	$26,473
18	CULTURAL RESOURCE PRESERVATIC	$2,227	$1,180	53.0%	$3,407	2.9%	$2,290	$1,214	$3,504	2030Q3	27.5%	$2,921	$1,548	$4,470
	CONSTRUCTION ESTIMATE TOTALS:	$165,223	$74,636	45.2%	$239,859		$169,933	$76,764	$246,697			$216,731	$97,904	$314,635
01	LANDS AND DAMAGES	$90,994	$45,497	50.0%	$136,491	2.9%	$93,588	$46,794	$140,382	2027Q3	17.1%	$109,551	$54,776	$164,327
30	PLANNING, ENGINEERING & DESIGN													
1.0%	Project Management	$1,652	$496	30.0%	$2,148	4.0%	$1,718	$515	$2,234	2025Q2	12.5%	$1,934	$580	$2,514
1.0%	Planning & Environmental Compliance	$1,652	$496	30.0%	$2,148	4.0%	$1,718	$515	$2,234	2025Q2	12.5%	$1,934	$580	$2,514
4.0%	Engineering & Design	$6,609	$1,983	30.0%	$8,592	4.0%	$6,873	$2,062	$8,935	2025Q2	12.5%	$7,735	$2,321	$10,056
1.0%	Reviews, ATRs, IEPRs, VE	$1,652	$496	30.0%	$2,148	4.0%	$1,718	$515	$2,234	2025Q2	12.5%	$1,934	$580	$2,514
1.0%	Life Cycle Updates (cost, schedule, risks)	$1,652	$496	30.0%	$2,148	4.0%	$1,718	$515	$2,234	2025Q2	12.5%	$1,934	$580	$2,514
1.0%	Contracting & Reprographics	$1,652	$496	30.0%	$2,148	4.0%	$1,718	$515	$2,234	2030Q3	36.6%	$2,348	$704	$3,052
1.0%	Engineering During Construction	$1,652	$496	30.0%	$2,148	4.0%	$1,718	$515	$2,234	2030Q3	36.6%	$2,348	$704	$3,052
1.0%	Planning During Construction	$1,652	$496	30.0%	$2,148	4.0%	$1,718	$515	$2,234	2025Q2	12.5%	$1,934	$580	$2,514
1.0%	Adaptive Management & Monitoring	$1,652	$496	30.0%	$2,148	4.0%	$1,718	$515	$2,234	2030Q3	36.6%	$2,348	$704	$3,052
1.0%	Project Operations	$1,652	$496	30.0%	$2,148	4.0%	$1,718	$515	$2,234	2030Q3	36.6%	$2,348	$704	$3,052
31	CONSTRUCTION MANAGEMENT													
8.0%	Construction Management	$13,218	$3,965	30.0%	$17,183	4.0%	$13,746	$4,124	$17,869	2030Q3	36.6%	$18,782	$5,635	$24,417
1.0%	Project Operation:	$1,652	$496	30.0%	$2,148	4.0%	$1,718	$515	$2,234	2030Q3	36.6%	$2,348	$704	$3,052
1.0%	Project Management	$1,652	$496	30.0%	$2,148	4.0%	$1,718	$515	$2,234	2030Q3	36.6%	$2,348	$704	$3,052
	CONTRACT COST TOTALS:	$294,218	$131,533		$425,752		$303,040	$135,413	**$438,454**			$376,556	$167,761	**$544,317**

Table 10: TPCS – Critical Infrastructure – Island Park & Vicinity – Perimeter

WBS Structure		ESTIMATED COST				PROJECT FIRST COST (Constant Dollar Basis)				TOTAL PROJECT COST (FULLY FUNDED)				
		Estimate Prepared:			8-Oct-20	Program Year (Budget EC):			2022					
		Estimate Price Level:			1-Oct-20	Effective Price Level Date:			1 -Oct-21					
				RISK BASED										
WBS NUMBER	Civil Works Feature & Sub-Feature Description	COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	Mid-Point Date	ESC (%)	COST ($K)	CNTG ($K)	FULL ($K)
A	*B*	*C*	*D*	*E*	*F*	*G*	*H*	*I*	*J*	*P*	*L*	*M*	*N*	*O*
	Island Park Alignment													
02	RELOCATIONS													
11	LEVEES & FLOODWALLS	$56,394	$24,249	43.0%	$80,643	2.9%	$58,002	$24,941	$82,942	2030Q3	27.5%	$73,975	$31,809	$105,784
13	PUMPING PLANT	$6,310	$4,165	66.0%	$10,475	2.9%	$6,490	$4,283	$10,773	2030Q3	27.5%	$8,277	$5,463	$13,740
15	FLOODWAY CONTROL & DIVERSION S	$34,138	$19,800	58.0%	$53,938	2.9%	$35,111	$20,365	$55,476	2030Q3	27.5%	$44,781	$25,973	$70,753
18	CULTURAL RESOURCE PRESERVATIO	$1,323	$701	53.0%	$2,024	2.9%	$1,361	$721	$2,082	2030Q3	27.5%	$1,735	$920	$2,655
	CONSTRUCTION ESTIMATE TOTALS:	$98,165	$48,915	49.8%	$147,080		$100,964	$50,310	$151,273			$128,768	$64,165	$192,933
01	LANDS AND DAMAGES	$51,653	$25,827	50.0%	$77,480	2.9%	$53,126	$26,563	$79,688	2027Q3	17.1%	$62,187	$31,094	$93,281
30	PLANNING, ENGINEERING & DESIGN													
1.0%	Project Management	$982	$294	30.0%	$1,276	4.0%	$1,021	$306	$1,327	2025Q2	12.5%	$1,149	$345	$1,494
1.0%	Planning & Environmental Compliance	$982	$294	30.0%	$1,276	4.0%	$1,021	$306	$1,327	2025Q2	12.5%	$1,149	$345	$1,494
4.0%	Engineering & Design	$3,927	$1,178	30.0%	$5,105	4.0%	$4,083	$1,225	$5,308	2025Q2	12.5%	$4,596	$1,379	$5,974
1.0%	Reviews, ATRs, IEPRs, VE	$982	$294	30.0%	$1,276	4.0%	$1,021	$306	$1,327	2025Q2	12.5%	$1,149	$345	$1,494
1.0%	Life Cycle Updates (cost, schedule, risks)	$982	$294	30.0%	$1,276	4.0%	$1,021	$306	$1,327	2025Q2	12.5%	$1,149	$345	$1,494
1.0%	Contracting & Reprographics	$982	$294	30.0%	$1,276	4.0%	$1,021	$306	$1,327	2025Q2	12.5%	$1,149	$345	$1,494
1.0%	Engineering During Construction	$982	$294	30.0%	$1,276	4.0%	$1,021	$306	$1,327	2025Q2	12.5%	$1,149	$345	$1,494
1.0%	Planning During Construction	$982	$294	30.0%	$1,276	4.0%	$1,021	$306	$1,327	2025Q2	12.5%	$1,149	$345	$1,494
1.0%	Adaptive Management & Monitoring	$982	$294	30.0%	$1,276	4.0%	$1,021	$306	$1,327	2030Q3	36.6%	$1,395	$418	$1,813
1.0%	Project Operations	$982	$294	30.0%	$1,276	4.0%	$1,021	$306	$1,327	2030Q3	36.6%	$1,395	$418	$1,813
31	CONSTRUCTION MANAGEMENT													
8.0%	Construction Management	$7,853	$2,356	30.0%	$10,209	4.0%	$8,167	$2,450	$10,617	2030Q3	36.6%	$11,159	$3,348	$14,507
1.0%	Project Operation:	$982	$294	30.0%	$1,276	4.0%	$1,021	$306	$1,327	2030Q3	36.6%	$1,395	$418	$1,813
1.0%	Project Management	$982	$294	30.0%	$1,276	4.0%	$1,021	$306	$1,327	2030Q3	36.6%	$1,395	$418	$1,813
	CONTRACT COST TOTALS:	$172,396	$81,515		$253,911		$177,569	$83,916	**$261,485**			$220,332	$104,071	**$324,404**

Table 11: TPCS – Critical Infrastructure – City of Long Beach – Perimeter

WBS Structure		ESTIMATED COST				PROJECT FIRST COST (Constant Dollar Basis)				TOTAL PROJECT COST (FULLY FUNDED)				
		Estimate Prepared: Estimate Price Level:			8-Oct-20 1-Oct-20	Program Year (Budget EC): Effective Price Level Date:			2022 1 -Oct-21					
				RISK BASED										
WBS NUMBER *A*	Civil Works Feature & Sub-Feature Description *B*	COST ($K) *C*	CNTG ($K) *D*	CNTG (%) *E*	TOTAL ($K) *F*	ESC (%) *G*	COST ($K) *H*	CNTG ($K) *I*	TOTAL ($K) *J*	Mid-Point Date *P*	ESC (%) *L*	COST ($K) *M*	CNTG ($K) *N*	FULL ($K) *O*
	Long Beach Island Alignment													
02	RELOCATIONS													
11	LEVEES & FLOODWALLS	$83,324	$35,829	43.0%	$119,153	2.9%	$85,699	$36,851	$122,550	2030Q3	27.5%	$109,300	$46,999	$156,299
13	PUMPING PLANT	$6,310	$4,165	66.0%	$10,475	2.9%	$6,490	$4,283	$10,773	2030Q3	27.5%	$8,277	$5,463	$13,740
15	FLOODWAY CONTROL & DIVERSION S	$16,542	$9,594	58.0%	$26,136	2.9%	$17,014	$9,868	$26,881	2030Q3	27.5%	$21,699	$12,585	$34,284
18	CULTURAL RESOURCE PRESERVATIC	$1,451	$769	53.0%	$2,220	2.9%	$1,492	$791	$2,283	2030Q3	27.5%	$1,903	$1,009	$2,912
	CONSTRUCTION ESTIMATE TOTALS:	$107,627	$50,357	46.8%	$157,984		$110,695	$51,793	$162,488			$141,180	$66,056	$207,236
01	LANDS AND DAMAGES	$76,414	$38,207	50.0%	$114,621	2.9%	$78,592	$39,296	$117,889	2027Q3	17.1%	$91,998	$45,999	$137,997
30	PLANNING, ENGINEERING & DESIGN													
1.0%	Project Management	$1,076	$323	30.0%	$1,399	4.0%	$1,119	$336	$1,455	2025Q2	12.5%	$1,260	$378	$1,638
1.0%	Planning & Environmental Compliance	$1,076	$323	30.0%	$1,399	4.0%	$1,119	$336	$1,455	2025Q2	12.5%	$1,260	$378	$1,638
4.0%	Engineering & Design	$4,305	$1,292	30.0%	$5,597	4.0%	$4,477	$1,343	$5,820	2025Q2	12.5%	$5,039	$1,512	$6,550
1.0%	Reviews, ATRs, IEPRs, VE	$1,076	$323	30.0%	$1,399	4.0%	$1,119	$336	$1,455	2025Q2	12.5%	$1,260	$378	$1,638
1.0%	Life Cycle Updates (cost, schedule, risks)	$1,076	$323	30.0%	$1,399	4.0%	$1,119	$336	$1,455	2025Q2	12.5%	$1,260	$378	$1,638
1.0%	Contracting & Reprographics	$1,076	$323	30.0%	$1,399	4.0%	$1,119	$336	$1,455	2025Q2	12.5%	$1,260	$378	$1,638
1.0%	Engineering During Construction	$1,076	$323	30.0%	$1,399		$1,076	$323	$1,399	2025Q2	17.0%	$1,260	$378	$1,638
1.0%	Planning During Construction	$1,076	$323	30.0%	$1,399	4.0%	$1,119	$336	$1,455	2025Q2	12.5%	$1,260	$378	$1,638
1.0%	Adaptive Management & Monitoring	$1,076	$323	30.0%	$1,399	4.0%	$1,119	$336	$1,455	2030Q3	36.6%	$1,529	$459	$1,988
1.0%	Project Operations	$1,076	$323	30.0%	$1,399	4.0%	$1,119	$336	$1,455	2030Q3	36.6%	$1,529	$459	$1,988
31	CONSTRUCTION MANAGEMENT													
8.0%	Construction Management	$8,610	$2,583	30.0%	$11,193	4.0%	$8,954	$2,686	$11,640	2030Q3	36.6%	$12,235	$3,670	$15,905
1.0%	Project Operation:	$1,076	$323	30.0%	$1,399	4.0%	$1,119	$336	$1,455	2030Q3	36.6%	$1,529	$459	$1,988
1.0%	Project Management	$1,076	$323	30.0%	$1,399	4.0%	$1,119	$336	$1,455	2030Q3	36.6%	$1,529	$459	$1,988
	CONTRACT COST TOTALS:	$208,795	$95,991		$304,786		$214,988	$98,799	**$313,787**			$265,388	$121,718	**$387,104**

Nonstructural Measures

Nonstructural measures fall into four broad groups (as discussed in the Plan Formulation Appendix and Nonstructural Implementation Plan) including Acquisition / Relocation, Building Retrofit (floodproofing, elevations), Land Use Management (zoning changes, undeveloped land preservation), and Early Flood Warnings (evacuation planning, emergency response systems). Refinements to the National Flood Insurance Program (including increasing homeowner participation and increasing municipal protection in the Community Rating System) also represent a nonstructural opportunity, though they are outside the scope and authority of this assessment. Each measure type has a varying level of storm damage reduction function / adaptive capacity and a complete nonstructural alternative would include each of the four measures as necessary to optimize coastal storm risk management benefits.

At this stage of the analysis, nonstructural economic assessment incorporates elevations and wet/dry floodproofing as possible nonstructural measures. Additional analysis may include the possibility of acquisition/relocation for certain eligible structures, but no acquisitions are currently included in the focused array of alternatives.

Eligible Structures

Identifying structures eligible for building retrofits focused on isolating structures with the highest coastal storm damage risk levels. Residential and non-residential structures with high vulnerability to coastal storm damage, whether due to geographic conditions or first floor elevation, are considered prime candidates for building retrofits.

Nonstructural analysis was focused on treating structures within the 5% AEP event floodplain. As this floodplain threshold is dependent upon the SLC rate, nonstructural alternatives were formulated for Low (Historic), Intermediate, and High SLC scenarios in accordance with ER 1100-2-8162 *Incorporating Sea Level Change in Civil Works Programs*. As the eligibility threshold stage for each SLC scenario is different, the number of structures (both residential and non-residential) eligible under each SLC scenario is also different. Nonstructural measures can be applied as either reactive, precautionary (anticipatory), or adaptive approaches.

As stated in EP 1100-2-1 *Procedures to Evaluate Sea Level Change: Impacts, Responses, and Adaptation*, the definitions for the different approaches are listed below:

1. Anticipatory strategy implements features and design parameters that decrease the vulnerability to future SLC and/or enhance the project adaptability before impacts are incurred. This strategy can either implement features now or facilitate the next adaptive management strategy should it be needed in the future. For nonstructural, this involves identifying all structures that would be vulnerable to coastal storm events over the 50-year period of analysis and then retrofitting those structures by the base year. This includes structures that are not currently vulnerable but may become vulnerable later in the period of analysis.

   The major risk of large anticipatory investments is that their future costs and benefits are functions of uncertain future sea levels: they may either provide less performance for less time than anticipated, or they may be constructed long before they are ultimately needed, leading to costs out of balance with performance.

2. The reactive strategy may be planned or ad-hoc and is not implemented until required by the impacts of SLC. The major risks of this strategy are that impacts will already be occurring by the time SLC becomes apparent, and it may be more difficult to take the action at the time of the response due to lack of preparation. Because the occurrence of impacts drives the investment decisions when using a reactive strategy, some impacts are guaranteed, and investments do not provide as much return as if they had been made earlier. Furthermore, reactive strategies may be wasteful and repetitive if they are independent projects rather than part of a larger plan.

3. The adaptive management strategy uses sequential decisions and implementation based on learning new knowledge and adapting to a changing environment. Multiple managed adaptive actions are taken over the 50-year period of analysis to maintain project effectiveness over an uncertain future SLC rate. For this strategy, implementation of the adaptive measure occurs prior to SLC impacts and requires advance planning to maintain the ability to adapt to SLC. Identifying thresholds and tipping points, monitoring environmental changes, and outlining actionable processes to implement changes over the 50-year period of analysis and/or 100-year planning horizon.

   While the adaptive strategy allows flexibility compared to the anticipatory and reactive approaches as we monitor and learn, it implies trust in future managers to actually implement required adaptations. If future engineers, planners, and politicians fail to execute adaptive management successfully, the strategy becomes a de-facto reactive strategy with the resultant incurred impacts.

The current nonstructural economic analysis outlines a precautionary (anticipatory) approach to SLC risk management. Using the Year 2080 5% AEP event stage (for each USACE SLC curve), vulnerable structures are identified and elevated/floodproofed by the base year. All nonstructural costs are incurred by the base year and benefits start accruing in the base year for all retrofitted structures (depending on their relative vulnerability over the period of analysis).

Additionally, critical infrastructure assets are eligible based on their vulnerability to the 1% AEP flood event by the Year 2080. Nonstructural measures are applicable for the majority of critical infrastructure assets such as hospitals, police stations, and medical offices. For large-scale infrastructure facilities such as wastewater treatment plants and electric power plants, it is uncertain whether nonstructural measures alone are effective in mitigating coastal storm risk. At this stage of the analysis, nonstructural measures are not applied to those facility types in the future with-project condition. The analysis to confirm whether nonstructural measures are effective for large-scale critical infrastructure will occur prior to release of the final Feasibility Report.

The HEC-FDA results for nonstructural measures in the focused array of alternatives are presented in FY2021 dollars using the FY2021 Discount Rate of 2.5%.

This Appendix also covers the possibility for a nonstructural managed approach to SLC, but the costs and benefits of that approach are not currently quantified. The SLC Adaptive Capacity and Resiliency section later in the Appendix graphs a possible managed adaptive approach and outlines the future analysis to be conducted before release of the final Feasibility Report.

Low (Historic) Sea Level Change Scenario

Under the Low (Historic) SLC curve, 11,449 structures are vulnerable to the 5% AEP event by the Year 2080 based on their respective first floor elevations and begin damage points. This constitutes 10.5% of the total asset inventory. Of the vulnerable structures, 9,431 are residential and eligible for elevation while 2,018 are non-residential and eligible for floodproofing. A further 184 critical infrastructure assets are vulnerable to 1% AEP event by the Year 2080 under the Low (Historic) SLC rate.

Intermediate Sea Level Change Scenario

Under the Intermediate SLC curve, 16,650 structures are vulnerable to the 5% AEP event by the Year 2080 based on their respective first floor elevations and begin damage points. This constitutes 15.3% of the total asset inventory. Of the vulnerable structures, 14,183 are residential and eligible for elevation while 2,467 are non-residential and eligible for floodproofing. A further 200 critical infrastructure assets are vulnerable to 1% AEP event by the Year 2080 under the Intermediate SLC rate.

High Sea Level Change Scenario

Under the High SLC curve, 39,107 structures are vulnerable to the 5% AEP event by the Year 2080 based on their respective first floor elevations and begin damage points. This constitutes 35.9% of the total asset inventory. Of the vulnerable structures, 35,452 are residential and eligible for elevation while 3,655 are non-residential and eligible for floodproofing. A further 243 critical infrastructure assets are vulnerable to 1% AEP event by the Year 2080 under the High SLC rate.

It is important to note that due to structure inventory limitations in collected primary data, it is not possible to confidently identify any individual structure as eligible for nonstructural retrofitting, but rather only possible to estimate the given number of structures of a given type in a given location that may be eligible. As a complete survey of all 100,900 structures in the asset inventory is not feasible for this economic analysis, the exact location of eligible structures will not be available during the Feasibility phase, but rather only an estimated number of structures of a particular type that may be eligible for nonstructural. This methodology allows for the formulation, evaluation, and comparison of nonstructural alternatives while maintain the tenets of SMART Planning.

During the next study phase, implementation guidance will allow for identifying individual structures that are eligible for nonstructural retrofitting. More information can be found in the Nonstructural Implementation Guide.

Cost Estimates

Elevation and floodproofing cost estimates are derived from MII and presented as TPCS reports in FY2021 Price Level. Cost estimates are prepared for "typical" structures in each of the four Highly Vulnerable Areas as defined in the previous section. A composite cost estimate is also developed for the remaining structures by averaging the four per-unit cost estimates.

As nonstructural is applied on a house-by-house basis, a true building retrofit cost would also be developed for each structure individually based on their characteristics such as foundation type, wall type, size, condition, and available workspace. Individually surveying each structure to capture this data, however, is prohibitively time and resource intensive. In compliance with Planning Bulletin 2019-03 *Further Clarification of Existing Policy for USACE Participation in Nonstructural FRM and CSRM Measures*, "nonstructural analyses will formulate and then evaluate measures and plans using a logical aggregation method."

Given the size of the study area, building retrofit costs are developed for a "typical" structure in each of the Highly Vulnerable Areas and rest of county locations. Both a "typical" residential structure and "typical" non-residential structure are identified for each location using a stratified random sample. A per-unit cost is then developed based on the dimensions and characteristics of those "typical" structures. More information on nonstructural cost estimation can be found in the Plan Formulation Appendix and Cost Engineering Appendix.

Table 12 provides the per-unit cost summary for each of the five study areas. Table 13 through Table 15 provide the aggregated cost estimate for each area under each of the three USACE SLC curves. Both estimates are provided in FY2021 Price Level with the FY2021 Federal Discount Rate of 2.5%.

For aggregated cost summaries, current analysis assumes a 100% participation rate in the nonstructural alternative. In compliance with National Nonstructural Committee (NNC) Best Practice Guide (BPG) 2020-02 *Considerations for Estimating Participation Rates in Voluntary Nonstructural Measures*, further analysis will be conducted to estimate the participation rate of the study area.

Interest During Construction is calculated in accordance with NNC BPG 2020-01 *Calculating Interest During Construction for Nonstructural Alternatives*. Nonstructural measures are not expected to require any annual OMRR&R over the period of analysis.

Floodproofing totals include both non-residential and critical infrastructure assets.

Table 12: Nonstructural Per Unit Cost (in dollars)

Location	Elevation Cost (per structure)	Floodproofing Cost (per structure)
Village of Freeport	$218,000	$117,000
City of Long Beach	$264,000	$182,000
Village of Island Park & Vicinity	$233,000	$178,000
Village East Rockaway & Vicinity	$258,000	$106,000
Rest of County Composite	$243,000	$146,000

Table 16 through Table 23 provide the "Per Unit" TPCS reports for the four Highly Vulnerable Areas.

Table 13: Nonstructural Aggregation Cost – 5% AEP – Low SLC

Location	Elevations	Elevation Cost ($K)	Floodproofings	Floodproofing Cost ($K)	Initial Construction Cost ($K)	IDC ($K)	Total First Construction Cost ($K)	Total AAC ($K)
Freeport	1,908	$416,000	429	$50,000	$466,000	$1,000	$468,000	$16,000
Long Beach	1,083	$286,000	394	$72,000	$358,000	$1,000	$359,000	$13,000
Island Park	1,037	$242,000	349	$62,000	$304,000	$1,000	$305,000	$11,000
East Rockaway	1,630	$421,000	459	$49,000	$469,000	$1,000	$471,000	$17,000
Rest of County	3,773	$918,000	571	$83,000	$1,001,000	$3,000	$1,004,000	$35,000
TOTAL	**9,431**	**$2,282,000**	**2,202**	**$315,900**	**$2,598,000**	**$8,000**	**$2,606,000**	**$92,000**

Table 14: Nonstructural Aggregation Cost – 5% AEP – Int SLC

Location	Elevations	Elevation Cost ($K)	Floodproofings	Floodproofing Cost ($K)	Initial Construction Cost ($K)	IDC ($K)	Total First Construction Cost ($K)	Total AAC ($K)
Freeport	2,360	$514,000	496	$58,000	$573,000	$2,000	$574,000	$20,000
Long Beach	1,932	$510,000	527	$96,000	$606,000	$2,000	$608,000	$21,000
Island Park	1,383	$322,000	365	$65,000	$387,000	$1,000	$388,000	$14,000
East Rockaway	2,532	$653,000	533	$56,000	$710,000	$2,000	$712,000	$25,000
Rest of County	5,976	$1,454,000	746	$109,000	$1,562,000	$5,000	$1,567,000	$55,000
TOTAL	**14,183**	**$3,454,000**	**2,667**	**$384,000**	**$3,838,000**	**$12,000**	**$3,850,000**	**$136,000**

Table 15: Nonstructural Aggregation Cost – 5% AEP – High SLC

Location	Elevations	Elevation Cost ($K)	Floodproofings	Floodproofing Cost ($K)	Initial Construction Cost ($K)	IDC ($K)	Total First Construction Cost ($K)	Total AAC ($K)
Freeport	3,221	$702,000	583	$68,000	$770,000	$2,000	$773,000	$27,000
Long Beach	5,528	$1,459,000	857	$156,000	$1,615,000	$5,000	$1,620,000	$57,000
Island Park	2,130	$496,000	384	$68,000	$565,000	$2,000	$566,000	$20,000
East Rockaway	6,119	$1,579,000	794	$84,000	$1,663,000	$5,000	$1,668,000	$59,000
Rest of County	18,454	$4,489,000	1,280	$187,000	$4,675,000	$14,000	$4,690,000	$165,000
TOTAL	**35,452**	**$8,725,000**	**3,898**	**$563,000**	**$9,289,000**	**$29,000**	**$9,317,000**	**$329,000**

Table 16: TPCS – Village of Freeport – Per Unit Cost – Elevation (in thousands)

WBS Structure		ESTIMATED COST				PROJECT FIRST COST (Constant Dollar Basis)				TOTAL PROJECT COST (FULLY FUNDED)				
		Estimate Prepared: Estimate Price Level:			30-Nov-20 1-Oct-20	Program Year (Budget EC): Effective Price Level Date:			2022 1 -Oct-21					
				RISK BASED										
WBS NUMBER A	Civil Works Feature & Sub-Feature Description B	COST ($K) C	CNTG ($K) D	CNTG (%) E	TOTAL ($K) F	ESC (%) G	COST ($K) H	CNTG ($K) I	TOTAL ($K) J	Mid-Point Date P	ESC (%) L	COST ($K) M	CNTG ($K) N	FULL ($K) O
	Elevations													
	#N/A													
19	BUILDINGS, GROUNDS & UTILITIES	$141	$35	25.0%	$176	2.9%	$145	$36	$181	2030Q3	27.5%	$184	$46	$231
	#N/A													
	#N/A													
	#N/A													
	CONSTRUCTION ESTIMATE TOTALS:	$141	$35	25.0%	$176		$145	$36	$181			$184	$46	$231
01	LANDS AND DAMAGES													
30	PLANNING, ENGINEERING & DESIGN													
1.0%	Project Management	$1	$0	30.0%	$2	4.0%	$1	$0	$2	2025Q2	12.5%	$2	$0	$2
1.0%	Planning & Environmental Compliance	$1	$0	30.0%	$2	4.0%	$1	$0	$2	2025Q2	12.5%	$2	$0	$2
4.0%	Engineering & Design	$6	$2	30.0%	$7	4.0%	$6	$2	$8	2025Q2	12.5%	$7	$2	$9
1.0%	Reviews, ATRs, IEPRs, VE	$1	$0	30.0%	$2	4.0%	$1	$0	$2	2025Q2	12.5%	$2	$0	$2
1.0%	Life Cycle Updates (cost, schedule, risks)	$1	$0	30.0%	$2	4.0%	$1	$0	$2	2025Q2	12.5%	$2	$0	$2
1.0%	Contracting & Reprographics	$1	$0	30.0%	$2	4.0%	$1	$0	$2	2030Q3	36.6%	$2	$1	$3
1.0%	Engineering During Construction	$1	$0	30.0%	$2	4.0%	$1	$0	$2	2030Q3	36.6%	$2	$1	$3
1.0%	Planning During Construction	$1	$0	30.0%	$2	4.0%	$1	$0	$2	2025Q2	12.5%	$2	$0	$2
1.0%	Adaptive Management & Monitoring	$1	$0	30.0%	$2	4.0%	$1	$0	$2	2030Q3	36.6%	$2	$1	$3
1.0%	Project Operations	$1	$0	30.0%	$2	4.0%	$1	$0	$2	2030Q3	36.6%	$2	$1	$3
31	CONSTRUCTION MANAGEMENT													
8.0%	Construction Management	$11	$3	30.0%	$15	4.0%	$12	$4	$15	2030Q3	36.6%	$16	$5	$21
1.0%	Project Operation:	$1	$0	30.0%	$2	4.0%	$1	$0	$2	2030Q3	36.6%	$2	$1	$3
1.0%	Project Management	$1	$0	30.0%	$2	4.0%	$1	$0	$2	2030Q3	36.6%	$2	$1	$3
	CONTRACT COST TOTALS:	$173	$45		$218		$178	$46	$225			$227	$59	$286

Table 17: TPCS – Village of Freeport – Per Unit Cost – Floodproofing (in thousands)

WBS Structure		ESTIMATED COST				PROJECT FIRST COST (Constant Dollar Basis)				TOTAL PROJECT COST (FULLY FUNDED)				
		Estimate Prepared:			8-Oct-20	Program Year (Budget EC):			2022					
		Estimate Price Level:			1-Oct-20	Effective Price Level Date:			1 -Oct-21					
				RISK BASED										
WBS NUMBER	Civil Works Feature & Sub-Feature Description	COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	Mid-Point Date	ESC (%)	COST ($K)	CNTG ($K)	FULL ($K)
A	*B*	*C*	*D*	*E*	*F*	*G*	*H*	*I*	*J*	*P*	*L*	*M*	*N*	*O*
	FloodProofing													
	#N/A													
19	BUILDINGS, GROUNDS & UTILITIES	$72	$24	33.0%	$96	2.9%	$74	$24	$98	2030Q3	27.5%	$94	$31	$126
	#N/A													
	#N/A													
	#N/A													
	CONSTRUCTION ESTIMATE TOTALS:	$72	$24	33.0%	$96		$74	$24	$98			$94	$31	$126
01	LANDS AND DAMAGES													
30	PLANNING, ENGINEERING & DESIGN													
1.0%	Project Management	$1	$0	30.0%	$1	4.0%	$1	$0	$1	2025Q2	12.5%	$1	$0	$1
1.0%	Planning & Environmental Compliance	$1	$0	30.0%	$1	4.0%	$1	$0	$1	2025Q2	12.5%	$1	$0	$1
4.0%	Engineering & Design	$3	$1	30.0%	$4	4.0%	$3	$1	$4	2025Q2	12.5%	$3	$1	$4
1.0%	Reviews, ATRs, IEPRs, VE	$1	$0	30.0%	$1	4.0%	$1	$0	$1	2025Q2	12.5%	$1	$0	$1
1.0%	Life Cycle Updates (cost, schedule, risks)	$1	$0	30.0%	$1	4.0%	$1	$0	$1	2025Q2	12.5%	$1	$0	$1
1.0%	Contracting & Reprographics	$1	$0	30.0%	$1	4.0%	$1	$0	$1	2025Q2	12.5%	$1	$0	$1
1.0%	Engineering During Construction	$1	$0	30.0%	$1		$1	$0	$1	2025Q2	17.0%	$1	$0	$1
1.0%	Planning During Construction	$1	$0	30.0%	$1	4.0%	$1	$0	$1	2025Q2	12.5%	$1	$0	$1
1.0%	Adaptive Management & Monitoring	$1	$0	30.0%	$1	4.0%	$1	$0	$1	2030Q3	36.6%	$1	$0	$1
1.0%	Project Operations	$1	$0	30.0%	$1	4.0%	$1	$0	$1	2030Q3	36.6%	$1	$0	$1
31	CONSTRUCTION MANAGEMENT													
8.0%	Construction Management	$6	$2	30.0%	$7	4.0%	$6	$2	$8	2030Q3	36.6%	$8	$2	$11
1.0%	Project Operation:	$1	$0	30.0%	$1	4.0%	$1	$0	$1	2030Q3	36.6%	$1	$0	$1
1.0%	Project Management	$1	$0	30.0%	$1	4.0%	$1	$0	$1	2030Q3	36.6%	$1	$0	$1
	CONTRACT COST TOTALS:	$89	$29		$117		$91	$30	$121			$116	$38	$154

Table 18: TPCS – City of Long Beach – Per Unit Cost – Elevation (in thousands)

WBS Structure		ESTIMATED COST				PROJECT FIRST COST (Constant Dollar Basis)				TOTAL PROJECT COST (FULLY FUNDED)				
		Estimate Prepared: / Estimate Price Level:			30-Nov-20 / 1-Oct-20	Program Year (Budget EC): / Effective Price Level Date:			2022 / 1-Oct-21					
				RISK BASED										
WBS NUMBER A	Civil Works Feature & Sub-Feature Description B	COST ($K) C	CNTG ($K) D	CNTG (%) E	TOTAL ($K) F	ESC (%) G	COST ($K) H	CNTG ($K) I	TOTAL ($K) J	Mid-Point Date P	ESC (%) L	COST ($K) M	CNTG ($K) N	FULL ($K) O
	Elevations													
	#N/A													
19	BUILDINGS, GROUNDS & UTILITIES	$171	$43	25.0%	$213	2.9%	$175	$44	$219	2030Q3	27.5%	$224	$56	$280
	#N/A													
	#N/A													
	#N/A													
	CONSTRUCTION ESTIMATE TOTALS:	$171	$43	25.0%	$213		$175	$44	$219			$224	$56	$280
01	LANDS AND DAMAGES													
30	PLANNING, ENGINEERING & DESIGN													
1.0%	Project Management	$2	$1	30.0%	$2	4.0%	$2	$1	$2	2025Q2	12.5%	$2	$1	$3
1.0%	Planning & Environmental Compliance	$2	$1	30.0%	$2	4.0%	$2	$1	$2	2025Q2	12.5%	$2	$1	$3
4.0%	Engineering & Design	$7	$2	30.0%	$9	4.0%	$7	$2	$9	2025Q2	12.5%	$8	$2	$10
1.0%	Reviews, ATRs, IEPRs, VE	$2	$1	30.0%	$2	4.0%	$2	$1	$2	2025Q2	12.5%	$2	$1	$3
1.0%	Life Cycle Updates (cost, schedule, risks)	$2	$1	30.0%	$2	4.0%	$2	$1	$2	2025Q2	12.5%	$2	$1	$3
1.0%	Contracting & Reprographics	$2	$1	30.0%	$2	4.0%	$2	$1	$2	2030Q3	36.6%	$2	$1	$3
1.0%	Engineering During Construction	$2	$1	30.0%	$2	4.0%	$2	$1	$2	2030Q3	36.6%	$2	$1	$3
1.0%	Planning During Construction	$2	$1	30.0%	$2	4.0%	$2	$1	$2	2025Q2	12.5%	$2	$1	$3
1.0%	Adaptive Management & Monitoring	$2	$1	30.0%	$2	4.0%	$2	$1	$2	2030Q3	36.6%	$2	$1	$3
1.0%	Project Operations	$2	$1	30.0%	$2	4.0%	$2	$1	$2	2030Q3	36.6%	$2	$1	$3
31	CONSTRUCTION MANAGEMENT													
8.0%	Construction Management	$14	$4	30.0%	$18	4.0%	$14	$4	$18	2030Q3	36.6%	$19	$6	$25
1.0%	Project Operation:	$2	$1	30.0%	$2	4.0%	$2	$1	$2	2030Q3	36.6%	$2	$1	$3
1.0%	Project Management	$2	$1	30.0%	$2	4.0%	$2	$1	$2	2030Q3	36.6%	$2	$1	$3
	CONTRACT COST TOTALS:	$210	$54		$264		$216	$56	**$272**			$276	$71	**$347**

Table 19: TPCS – City of Long Beach – Per Unit Cost – Floodproofing (in thousands)

WBS Structure		ESTIMATED COST				PROJECT FIRST COST (Constant Dollar Basis)				TOTAL PROJECT COST (FULLY FUNDED)				
		Estimate Prepared:			8-Oct-20	Program Year (Budget EC):			2022					
		Estimate Price Level:			1-Oct-20	Effective Price Level Date:			1-Oct-21					
				RISK BASED										
WBS NUMBER A	Civil Works Feature & Sub-Feature Description B	COST ($K) C	CNTG ($K) D	CNTG (%) E	TOTAL ($K) F	ESC (%) G	COST ($K) H	CNTG ($K) I	TOTAL ($K) J	Mid-Point Date P	ESC (%) L	COST ($K) M	CNTG ($K) N	FULL ($K) O
	FloodProofing													
	#N/A													
19	BUILDINGS, GROUNDS & UTILITIES	$112	$37	33.0%	$149	2.9%	$115	$38	$153	2030Q3	27.5%	$147	$48	$195
	#N/A													
	#N/A													
	#N/A													
	CONSTRUCTION ESTIMATE TOTALS:	$112	$37	33.0%	$149		$115	$38	$153			$147	$48	$195
01	LANDS AND DAMAGES													
30	PLANNING, ENGINEERING & DESIGN													
1.0%	Project Management	$1	$0	30.0%	$1	4.0%	$1	$0	$2	2025Q2	12.5%	$1	$0	$2
1.0%	Planning & Environmental Compliance	$1	$0	30.0%	$1	4.0%	$1	$0	$2	2025Q2	12.5%	$1	$0	$2
4.0%	Engineering & Design	$4	$1	30.0%	$6	4.0%	$5	$1	$6	2025Q2	12.5%	$5	$2	$7
1.0%	Reviews, ATRs, IEPRs, VE	$1	$0	30.0%	$1	4.0%	$1	$0	$2	2025Q2	12.5%	$1	$0	$2
1.0%	Life Cycle Updates (cost, schedule, risks)	$1	$0	30.0%	$1	4.0%	$1	$0	$2	2025Q2	12.5%	$1	$0	$2
1.0%	Contracting & Reprographics	$1	$0	30.0%	$1	4.0%	$1	$0	$2	2025Q2	12.5%	$1	$0	$2
1.0%	Engineering During Construction	$1	$0	30.0%	$1		$1	$0	$1	2025Q2	17.0%	$1	$0	$2
1.0%	Planning During Construction	$1	$0	30.0%	$1	4.0%	$1	$0	$2	2025Q2	12.5%	$1	$0	$2
1.0%	Adaptive Management & Monitoring	$1	$0	30.0%	$1	4.0%	$1	$0	$2	2030Q3	36.6%	$2	$0	$2
1.0%	Project Operations	$1	$0	30.0%	$1	4.0%	$1	$0	$2	2030Q3	36.6%	$2	$0	$2
31	CONSTRUCTION MANAGEMENT													
8.0%	Construction Management	$9	$3	30.0%	$12	4.0%	$9	$3	$12	2030Q3	36.6%	$13	$4	$17
1.0%	Project Operation:	$1	$0	30.0%	$1	4.0%	$1	$0	$2	2030Q3	36.6%	$2	$0	$2
1.0%	Project Management	$1	$0	30.0%	$1	4.0%	$1	$0	$2	2030Q3	36.6%	$2	$0	$2
	CONTRACT COST TOTALS:	$138	$45		$182		$142	$46	$188			$180	$59	$239

Table 20: TPCS – Island Park & Vicinity – Per Unit Cost – Elevation (in thousands)

WBS Structure		ESTIMATED COST				PROJECT FIRST COST (Constant Dollar Basis)				TOTAL PROJECT COST (FULLY FUNDED)				
		Estimate Prepared: Estimate Price Level:		30-Nov-20 1-Oct-20		Program Year (Budget EC): Effective Price Level Date:		2022 1 -Oct-21						
WBS NUMBER A	Civil Works Feature & Sub-Feature Description B	COST ($K) C	CNTG ($K) D	RISK BASED CNTG (%) E	TOTAL ($K) F	ESC (%) G	COST ($K) H	CNTG ($K) I	TOTAL ($K) J	Mid-Point Date P	ESC (%) L	COST ($K) M	CNTG ($K) N	FULL ($K) O
	Elevations													
	#N/A													
19	BUILDINGS, GROUNDS & UTILITIES	$150	$38	25.0%	$188	2.9%	$155	$39	$193	2030Q3	27.5%	$197	$49	$247
	#N/A													
	#N/A													
	#N/A													
	CONSTRUCTION ESTIMATE TOTALS:	$150	$38	25.0%	$188		$155	$39	$193			$197	$49	$247
01	LANDS AND DAMAGES													
30	PLANNING, ENGINEERING & DESIGN													
1.0%	Project Management	$2	$0	30.0%	$2	4.0%	$2	$0	$2	2025Q2	12.5%	$2	$1	$2
1.0%	Planning & Environmental Compliance	$2	$0	30.0%	$2	4.0%	$2	$0	$2	2025Q2	12.5%	$2	$1	$2
4.0%	Engineering & Design	$6	$2	30.0%	$8	4.0%	$6	$2	$8	2025Q2	12.5%	$7	$2	$9
1.0%	Reviews, ATRs, IEPRs, VE	$2	$0	30.0%	$2	4.0%	$2	$0	$2	2025Q2	12.5%	$2	$1	$2
1.0%	Life Cycle Updates (cost, schedule, risks)	$2	$0	30.0%	$2	4.0%	$2	$0	$2	2025Q2	12.5%	$2	$1	$2
1.0%	Contracting & Reprographics	$2	$0	30.0%	$2	4.0%	$2	$0	$2	2030Q3	36.6%	$2	$1	$3
1.0%	Engineering During Construction	$2	$0	30.0%	$2	4.0%	$2	$0	$2	2030Q3	36.6%	$2	$1	$3
1.0%	Planning During Construction	$2	$0	30.0%	$2	4.0%	$2	$0	$2	2025Q2	12.5%	$2	$1	$2
1.0%	Adaptive Management & Monitoring	$2	$0	30.0%	$2	4.0%	$2	$0	$2	2030Q3	36.6%	$2	$1	$3
1.0%	Project Operations	$2	$0	30.0%	$2	4.0%	$2	$0	$2	2030Q3	36.6%	$2	$1	$3
31	CONSTRUCTION MANAGEMENT													
8.0%	Construction Management	$12	$4	30.0%	$16	4.0%	$13	$4	$16	2030Q3	36.6%	$17	$5	$22
1.0%	Project Operation:	$2	$0	30.0%	$2	4.0%	$2	$0	$2	2030Q3	36.6%	$2	$1	$3
1.0%	Project Management	$2	$0	30.0%	$2	4.0%	$2	$0	$2	2030Q3	36.6%	$2	$1	$3
	CONTRACT COST TOTALS:	$185	$48		$233		$191	$49	$240			$243	$63	$306

Table 21: TPCS – Island Park & Vicinity – Per Unit Cost – Floodproofing (in thousands)

WBS Structure		ESTIMATED COST				PROJECT FIRST COST (Constant Dollar Basis)				TOTAL PROJECT COST (FULLY FUNDED)				
		Estimate Prepared: / Estimate Price Level:			8-Oct-20 / 1-Oct-20	Program Year (Budget EC): / Effective Price Level Date:			2022 / 1 -Oct-21					
WBS NUMBER A	Civil Works Feature & Sub-Feature Description B	COST ($K) C	CNTG ($K) D	RISK BASED CNTG (%) E	TOTAL ($K) F	ESC (%) G	COST ($K) H	CNTG ($K) I	TOTAL ($K) J	Mid-Point Date P	ESC (%) L	COST ($K) M	CNTG ($K) N	FULL ($K) O
	FloodProofing													
	#N/A													
19	BUILDINGS, GROUNDS & UTILITIES	$109	$36	33.0%	$145	2.9%	$112	$37	$149	2030Q3	27.5%	$143	$47	$190
	#N/A													
	#N/A													
	#N/A													
	CONSTRUCTION ESTIMATE TOTALS:	$109	$36	33.0%	$145		$112	$37	$149			$143	$47	$190
01	LANDS AND DAMAGES													
30	PLANNING, ENGINEERING & DESIGN													
1.0%	Project Management	$1	$0	30.0%	$1	4.0%	$1	$0	$1	2025Q2	12.5%	$1	$0	$2
1.0%	Planning & Environmental Compliance	$1	$0	30.0%	$1	4.0%	$1	$0	$1	2025Q2	12.5%	$1	$0	$2
4.0%	Engineering & Design	$4	$1	30.0%	$6	4.0%	$5	$1	$6	2025Q2	12.5%	$5	$2	$7
1.0%	Reviews, ATRs, IEPRs, VE	$1	$0	30.0%	$1	4.0%	$1	$0	$1	2025Q2	12.5%	$1	$0	$2
1.0%	Life Cycle Updates (cost, schedule, risks)	$1	$0	30.0%	$1	4.0%	$1	$0	$1	2025Q2	12.5%	$1	$0	$2
1.0%	Contracting & Reprographics	$1	$0	30.0%	$1	4.0%	$1	$0	$1	2025Q2	12.5%	$1	$0	$2
1.0%	Engineering During Construction	$1	$0	30.0%	$1		$1	$0	$1	2025Q2	17.0%	$1	$0	$2
1.0%	Planning During Construction	$1	$0	30.0%	$1	4.0%	$1	$0	$1	2025Q2	12.5%	$1	$0	$2
1.0%	Adaptive Management & Monitoring	$1	$0	30.0%	$1	4.0%	$1	$0	$1	2030Q3	36.6%	$2	$0	$2
1.0%	Project Operations	$1	$0	30.0%	$1	4.0%	$1	$0	$1	2030Q3	36.6%	$2	$0	$2
31	CONSTRUCTION MANAGEMENT													
8.0%	Construction Management	$9	$3	30.0%	$11	4.0%	$9	$3	$12	2030Q3	36.6%	$12	$4	$16
1.0%	Project Operation:	$1	$0	30.0%	$1	4.0%	$1	$0	$1	2030Q3	36.6%	$2	$0	$2
1.0%	Project Management	$1	$0	30.0%	$1	4.0%	$1	$0	$1	2030Q3	36.6%	$2	$0	$2
	CONTRACT COST TOTALS:	$134	$43		$178		$138	$45	$183			$176	$57	$233

Table 22: TPCS – East Rockaway & Vicinity – Per Unit Cost – Elevation (in thousands)

WBS Structure		ESTIMATED COST				PROJECT FIRST COST (Constant Dollar Basis)				TOTAL PROJECT COST (FULLY FUNDED)				
		Estimate Prepared: 30-Nov-20 Estimate Price Level: 1-Oct-20				Program Year (Budget EC): 2022 Effective Price Level Date: 1 -Oct-21								
				RISK BASED										
WBS NUMBER A	Civil Works Feature & Sub-Feature Description B	COST ($K) C	CNTG ($K) D	CNTG (%) E	TOTAL ($K) F	ESC (%) G	COST ($K) H	CNTG ($K) I	TOTAL ($K) J	Mid-Point Date P	ESC (%) L	COST ($K) M	CNTG ($K) N	FULL ($K) O
	Elevations													
	#N/A													
19	BUILDINGS, GROUNDS & UTILITIES	$166	$42	25.0%	$208	2.9%	$171	$43	$214	2030Q3	27.5%	$218	$55	$273
	#N/A													
	#N/A													
	#N/A													
	CONSTRUCTION ESTIMATE TOTALS:	$166	$42	25.0%	$208		$171	$43	$214			$218	$55	$273
01	LANDS AND DAMAGES													
30	PLANNING, ENGINEERING & DESIGN													
1.0%	Project Management	$2	$0	30.0%	$2	4.0%	$2	$1	$2	2025Q2	12.5%	$2	$1	$3
1.0%	Planning & Environmental Compliance	$2	$0	30.0%	$2	4.0%	$2	$1	$2	2025Q2	12.5%	$2	$1	$3
4.0%	Engineering & Design	$7	$2	30.0%	$9	4.0%	$7	$2	$9	2025Q2	12.5%	$8	$2	$10
1.0%	Reviews, ATRs, IEPRs, VE	$2	$0	30.0%	$2	4.0%	$2	$1	$2	2025Q2	12.5%	$2	$1	$3
1.0%	Life Cycle Updates (cost, schedule, risks)	$2	$0	30.0%	$2	4.0%	$2	$1	$2	2025Q2	12.5%	$2	$1	$3
1.0%	Contracting & Reprographics	$2	$0	30.0%	$2	4.0%	$2	$1	$2	2030Q3	36.6%	$2	$1	$3
1.0%	Engineering During Construction	$2	$0	30.0%	$2	4.0%	$2	$1	$2	2030Q3	36.6%	$2	$1	$3
1.0%	Planning During Construction	$2	$0	30.0%	$2	4.0%	$2	$1	$2	2025Q2	12.5%	$2	$1	$3
1.0%	Adaptive Management & Monitoring	$2	$0	30.0%	$2	4.0%	$2	$1	$2	2030Q3	36.6%	$2	$1	$3
1.0%	Project Operations	$2	$0	30.0%	$2	4.0%	$2	$1	$2	2030Q3	36.6%	$2	$1	$3
31	CONSTRUCTION MANAGEMENT													
8.0%	Construction Management	$13	$4	30.0%	$17	4.0%	$14	$4	$18	2030Q3	36.6%	$19	$6	$25
1.0%	Project Operation:	$2	$0	30.0%	$2	4.0%	$2	$1	$2	2030Q3	36.6%	$2	$1	$3
1.0%	Project Management	$2	$0	30.0%	$2	4.0%	$2	$1	$2	2030Q3	36.6%	$2	$1	$3
	CONTRACT COST TOTALS:	$205	$53		$258		$211	$55	$266			$269	$70	$339

Table 23: TPCS – East Rockaway & Vicinity – Per Unit Cost – Floodproofing (in thousands)

WBS Structure		ESTIMATED COST				PROJECT FIRST COST (Constant Dollar Basis)				TOTAL PROJECT COST (FULLY FUNDED)				
		Estimate Prepared: 8-Oct-20 Estimate Price Level: 1-Oct-20				Program Year (Budget EC): 2022 Effective Price Level Date: 1 -Oct-21								
				RISK BASED										
WBS NUMBER	Civil Works Feature & Sub-Feature Description	COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	Mid-Point Date	ESC (%)	COST ($K)	CNTG ($K)	FULL ($K)
A	*B*	*C*	*D*	*E*	*F*	*G*	*H*	*I*	*J*	*P*	*L*	*M*	*N*	*O*
	FloodProofing													
	#N/A													
19	BUILDINGS, GROUNDS & UTILITIES	$65	$21	33.0%	$86	2.9%	$67	$22	$89	2030Q3	27.5%	$85	$28	$113
	#N/A													
	#N/A													
	#N/A													
	CONSTRUCTION ESTIMATE TOTALS:	$65	$21	33.0%	$86		$67	$22	$89			$85	$28	$113
01	LANDS AND DAMAGES													
30	PLANNING, ENGINEERING & DESIGN													
1.0%	Project Management	$1	$0	30.0%	$1	4.0%	$1	$0	$1	2025Q2	12.5%	$1	$0	$1
1.0%	Planning & Environmental Compliance	$1	$0	30.0%	$1	4.0%	$1	$0	$1	2025Q2	12.5%	$1	$0	$1
4.0%	Engineering & Design	$3	$1	30.0%	$3	4.0%	$3	$1	$4	2025Q2	12.5%	$3	$1	$4
1.0%	Reviews, ATRs, IEPRs, VE	$1	$0	30.0%	$1	4.0%	$1	$0	$1	2025Q2	12.5%	$1	$0	$1
1.0%	Life Cycle Updates (cost, schedule, risks)	$1	$0	30.0%	$1	4.0%	$1	$0	$1	2025Q2	12.5%	$1	$0	$1
1.0%	Contracting & Reprographics	$1	$0	30.0%	$1	4.0%	$1	$0	$1	2025Q2	12.5%	$1	$0	$1
1.0%	Engineering During Construction	$1	$0	30.0%	$1		$1	$0	$1	2025Q2	17.0%	$1	$0	$1
1.0%	Planning During Construction	$1	$0	30.0%	$1	4.0%	$1	$0	$1	2025Q2	12.5%	$1	$0	$1
1.0%	Adaptive Management & Monitoring	$1	$0	30.0%	$1	4.0%	$1	$0	$1	2030Q3	36.6%	$1	$0	$1
1.0%	Project Operations	$1	$0	30.0%	$1	4.0%	$1	$0	$1	2030Q3	36.6%	$1	$0	$1
31	CONSTRUCTION MANAGEMENT													
8.0%	Construction Management	$5	$2	30.0%	$7	4.0%	$5	$2	$7	2030Q3	36.6%	$7	$2	$10
1.0%	Project Operation:	$1	$0	30.0%	$1	4.0%	$1	$0	$1	2030Q3	36.6%	$1	$0	$1
1.0%	Project Management	$1	$0	30.0%	$1	4.0%	$1	$0	$1	2030Q3	36.6%	$1	$0	$1
	CONTRACT COST TOTALS:	$80	$26		$106		$82	$27	$109			$105	$34	$139

EVALUATION AND COMPARISON OF ALTERNATIVES

Following the formulation and cost estimation of each potential measure type, alternatives were modeled in HEC-FDA to estimate their NED damages reduced (benefits). HEC-FDA quantitative outputs were then used to evaluate and compare the alternatives in terms of maximizing net NED benefits. Alternatives were also qualitatively evaluated and compared under the RED, OSE, and EQ accounts in accordance with ER 1105-2-100 *Planning Guidance Notebook* and the ASA(CW) Policy Directive *Comprehensive Documentation of Benefits in Decision Document* signed 5 January 2021.

Quantitative results are provided in the FY2021 Price Level using the FY2021 Federal Discount Rate of 2.5%. HEC-FDA results are provided for each of the USACE SLC curves.

Low (Historic) SLC Results

Table 24: HEC-FDA Results – Low SLC (in thousands)

Location	FWOP AAD	FWP AAD	Reduced AAD	AAC	BCR	AANB	Residual Risk
Comprehensive Perimeter							
Freeport	$127,000	$9,000	$118,000	$86,000	1.4	$32,000	7.5%
Long Beach	$96,000	$13,000	$83,000	$66,000	1.3	$17,000	14.1%
Island Park	$71,000	$6,000	$65,000	$81,000	0.8	-$15,000	8.0%
East Rockaway	$156,000	$16,000	$140,000	$117,000	1.2	$23,000	10.5%
Critical Infrastructure Perimeter							
Freeport	$31,000	$2,000	$29,000	$18,000	1.6	$10,000	7.9%
Long Beach	$1,000	$0	$1,000	$13,000	0.1	-$12,000	8.3%
Island Park	$5,000	$1,000	$4,000	$11,000	0.4	-$7,000	13.6%
Wantagh	-	-	-	-	-	-	-
Nonstructural Only							
Freeport	$127,000	$36,000	$91,000	$16,000	5.5	$75,000	28.6%
Long Beach	$96,000	$56,000	$40,000	$13,000	3.2	$28,000	58.3%
Island Park	$71,000	$25,000	$46,000	$11,000	4.3	$35,000	35.4%
East Rockaway	$156,000	$74,000	$82,000	$17,000	4.9	$66,000	47.5%
Rest of County	$357,000	$207,000	$150,000	$35,000	4.2	$115,000	58.0%
Nonstructural with Critical Infrastructure Perimeter							
Freeport	$127,000	$31,000	$96,000	$33,000	2.9	$63,000	24.1%
Long Beach	$96,000	$56,000	$40,000	$26,000	1.6	$15,000	57.8%
Island Park	$71,000	$21,000	$50,000	$22,000	2.3	$29,000	29.5%
Wantagh	-	-	-	-	-	-	-

= NED maximizing alternative

Across all the quantified measures, the Nonstructural Only alternative maximizes net NED benefits across all study area regions. Critical infrastructure perimeter in the Village of Freeport has a BCR above 1.0 but does not maximize net NED benefits in comparison to the nonstructural only measure.

The NED Plan has $317,000,000 AANB with a BCR of 4.5 at the Low SLC scenario.

Intermediate SLC Results

Table 25: HEC-FDA Results – Intermediate SLC (in thousands)

Location	FWOP AAD	FWP AAD	Reduced AAD	AAC	BCR	AANB	Residual Risk
Comprehensive Perimeter							
Freeport	$158,000	$12,000	$146,000	$86,000	1.7	$60,000	7.6%
Long Beach	$122,000	$17,000	$105,000	$66,000	1.6	$39,000	14.1%
Island Park	$89,000	$7,000	$82,000	$81,000	1.0	$1,000	8.0%
East Rockaway	$196,000	$21,000	$175,000	$117,000	1.5	$58,000	10.5%
Critical Infrastructure Perimeter							
Freeport	$40,000	$3,000	$37,000	$18,000	2.1	$19,000	7.2%
Long Beach	$2,000	$0	$2,000	$13,000	0.1	-$11,000	7.8%
Island Park	$7,000	$1,000	$6,000	$11,000	0.5	-$5,000	12.4%
Wantagh	-	-	-	-	-	-	-
Nonstructural Only							
Freeport	$158,000	$31,000	$127,000	$20,000	6.2	$106,000	19.8%
Long Beach	$122,000	$56,000	$66,000	$21,000	3.1	$44,000	46.1%
Island Park	$89,000	$25,000	$64,000	$14,000	4.7	$50,000	28.2%
East Rockaway	$196,000	$74,000	$122,000	$25,000	4.9	$97,000	37.9%
Rest of County	$447,000	$215,000	$232,000	$55,000	4.2	$177,000	48.0%
Nonstructural with Critical Infrastructure Perimeter							
Freeport	$158,000	$25,000	$133,000	$37,000	3.5	$95,000	16.1%
Long Beach	$122,000	$56,000	$66,000	$34,000	1.9	$32,000	45.6%
Island Park	$89,000	$19,000	$70,000	$24,000	2.9	$46,000	21.6%
Wantagh	-	-	-	-	-	-	-

(shaded) = NED maximizing alternative

Across all the quantified measures, nonstructural only maximizes net NED benefits across all study area regions. Critical infrastructure perimeter in the Village of Freeport has a BCR above 1.0 but does not maximize net NED benefits in comparison to the nonstructural-only measure.

The NED Plan has $475,000,000 AANB with a BCR of 4.5 at the Intermediate SLC scenario.

High SLC Results

Table 26: HEC-FDA Results – High SLC (in thousands)

Location	FWOP AAD	FWP AAD	Reduced AAD	AAC	BCR	AANB	Residual Risk
Comprehensive Perimeter							
Freeport	$307,000	$29,000	$278,000	$86,000	3.2	$191,000	9.6%
Long Beach	$284,000	$41,000	$243,000	$66,000	3.7	$176,000	14.6%
Island Park	$181,000	$17,000	$164,000	$81,000	2.0	$83,000	9.4%
East Rockaway	$407,000	$48,000	$359,000	$117,000	3.1	$242,000	11.9%
Critical Infrastructure Perimeter							
Freeport	$97,000	$7,000	$90,000	$18,000	5.0	$72,000	7.0%
Long Beach	$4,000	$0	$4,000	$13,000	0.2	-$10,000	8.3%
Island Park	$19,000	$2,000	$17,000	$11,000	1.6	$7,000	10.1%
Wantagh	-	-	-	-	-	-	-
Nonstructural Only							
Freeport	$307,000	$52,000	$255,000	$27,000	9.3	$227,000	17.0%
Long Beach	$284,000	$66,000	$218,000	$57,000	3.8	$161,000	23.3%
Island Park	$181,000	$46,000	$135,000	$20,000	6.7	$115,000	25.6%
East Rockaway	$407,000	$85,000	$322,000	$59,000	5.5	$263,000	20.8%
Rest of County	$978,000	$217,000	$761,000	$165,000	4.6	$596,000	22.2%
Nonstructural with Critical Infrastructure Perimeter							
Freeport	$307,000	$30,000	$277,000	$44,000	6.3	$233,000	9.7%
Long Beach	$284,000	$64,000	$220,000	$70,000	3.1	$149,000	22.6%
Island Park	$181,000	$29,000	$152,000	$31,000	5.0	$121,000	15.9%
Wantagh	-	-	-	-	-	-	-

= NED maximizing alternative

Across all the quantified measures, nonstructural only maximizes net NED benefits in the Village of East Rockaway & Vicinity and Rest of County areas. The comprehensive perimeter measure maximizes net NED benefits in the City of Long Beach. A combination of Nonstructural and Critical Infrastructure perimeter maximizes net NED benefits in the Village of Freeport and Village of Island Park & Vicinity.

As the SLC rate increases, nonstructural requires elevating/floodproofing more and more structures to maintain project effectiveness. In areas of sufficient density (City of Long Beach, Village of Freeport), perimeter measures will become more efficient measures to achieving coastal storm risk mitigation.

Current NED costs, particularly for perimeter measures, only capture the engineering design and materials costs as shown in the MCACES TPCS reports. Other potential issues, such as acceptability, implementation, or legal issues, are not captured but are still relevant to the plan formulation and plan selection process. More information can be found in the Main Report.

The NED Plan has $1,389,000,000 AANB with a BCR of 4.8 at the High SLC scenario.

Summary Results

In compliance with the ASA(CW) Policy Directive *Comprehensive Documentation of Benefits in Decision Document* signed 5 January 2021, the final array of alternatives will include the "No Action" alternative, "Net Total Benefits" Plan, "Net NED CSRM Benefits" Plan (or NED Plan), "Nonstructural Only" Plan, and, if requested, a Locally Preferred Plan (LPP). At this time, an LPP has not been requested by the non-Federal partner.

The Net Total Benefits Plan is intended to maximize total benefits across all four planning accounts. Current summary results do not include quantitative assessments for RED, OSE, or EQ accounts. These accounts are qualitatively assessed in the following section. For this feasibility study, the Net Total Benefits Plan includes Nonstructural with critical infrastructure perimeter measures to facilitate post-storm recovery and minimize health and safety concerns.

Table 27 through Table 29 provides the summary NED results for the five plans under each SLC scenario.

Table 27: Final Array Results – Low SLC (in thousands)

Plan	**AAB**	**AAC**	**AANB**	**BCR**	**Residual Risk**	**Structures Retrofitted**	**Annual OMRR&R**
No Action	$0	$0	$0	1.0	100%	0	$0
Net NED CSRM	$409,000	$92,000	$317,000	4.5	49.4%	11,633	$0
Net Total Benefits	$419,000	$133,000	$287,000	3.2	48.1%	11,369	$5,000
Nonstructural Only	$409,000	$92,000	$317,000	4.5	49.4%	11,633	$0
LPP	-	-	-	-	-	-	-

Under the Low (Historic) SLC scenario, the Nonstructural Only Plan is also the NED Plan with $317 million AANB and a BCR of 4.5.

Table 28: Final Array Results – Intermediate SLC (in thousands)

Plan	**AAB**	**AAC**	**AANB**	**BCR**	**Residual Risk**	**Structures Retrofitted**	**Annual OMRR&R**
No Action	$0	$0	$0	1.0	100%	0	$0
Net NED CSRM	$611,000	$136,000	$475,000	4.5	39.7%	16,850	$0
Net Total Benefits	$622,893	$176,000	$447,000	3.5	38.4%	16,586	$5,000
Nonstructural Only	$611,000	$136,000	$475,000	4.5	39.7%	16,850	$0
LPP	-	-	-	-	-	-	-

Under the Intermediate SLC scenario, the Nonstructural Only Plan is also the NED Plan with $475 million AANB and a BCR of 4.5.

Table 29: Final Array Results – High SLC (in thousands)

Plan	AAB	AAC	AANB	BCR	Residual Risk	Structures Retrofitted	Annual OMRR&R
No Action	$0	$0	$0	1.0	100%	0	$0
Net NED CSRM	$1,755,000	$365,000	$1,389,000	4.8	18.6%	32,709	$11,000
Net Total Benefits	$1,732,000	$369,000	$1,362,525	4.7	19.7%	39,086	$5,000
Nonstructural Only	$1,690,000	$329,000	$1,362,000	5.1	21.6%	39,350	$0
LPP	-	-	-	-	-	-	-

Under the High SLC scenario, the NED Plan is mostly nonstructural with critical infrastructure perimeter in the Village of Freeport and in the Village of Island Park & Vicinity. The NED Plan also includes a comprehensive perimeter measure in the City of Long Beach with a total of $1.39 billion in AANB and a 4.9 BCR.

RED, OSE, AND EQ ACCOUNTS

In compliance with ER 1105-2-100 *Planning Guidance Notebook* and the ASA(CW) Policy Directive *Comprehensive Documentation of Benefits in Decision Document* signed 5 January 2021, Regional Economic Development (RED), Other Social Effects (OSE), and Environmental Quality (EQ) planning accounts are incorporated during measure evaluation. At this phase of the study, RED and OSE are covered qualitatively and described in the following section. For a full description of the EQ planning account, more information can be found in the Main Report and Environmental Appendix.

Regional Economic Development

The RED planning account covers a broad spectrum of potential coastal storm damages and possible benefit streams. At this stage of the analysis, RED includes (1) benefits from construction and (2) benefits from avoiding business interruption during and after storm events.

Benefits from Construction

Per IWR 2011-RPT-01 *Regional Economic Development (RED) Procedures Handbook* (March 2011), RED impacts are defined as the transfers of economic activity within a region or between regions in the FWOP and for each alternative plan. Spending in an area can spur economic activity, leading to increases in employment, income, and output of the regional economy, while chronic or catastrophic flooding can lead to regional losses of employment and income. This section will first quantify RED benefit multipliers from construction spending and afterwards qualitatively discuss RED losses in the FWOP due to flooding.

IWR 2011-RPT 01 defines three types of RED impacts: direct, indirect, and induced.

• *Direct effects* are the impacts direct federal expenditure have on industries that directly support the new project. Labor and construction materials are considered the direct components of a project.

• *Indirect effects* represent changes to secondary industries that support the direct industry. For example, rock quarries used in making cement could be considered indirect pieces of a project.

• *Induced effects* are changes in consumer spending patterns caused by changes in employment and income within the direct and indirect industries. The additional income earned by workers may be spent in numerous different ways within the region.

These impacts associated with construction spending are calculated using the USACE Regional Economic System (RECONS) certified regional economic model. The RECONS model uses IMPLAN modeling system software to trace the economic ripple, or multiplier, effects of project spending in the study area. The model is based on data collected by the U.S. Department of Commerce, the U.S. Bureau of Labor Statistics, and other federal and state government agencies. Nationally developed input-output tables represent the relationships between the many different sectors of the economy to allow an estimate of changes in economic activity on the larger economy brought about by spending in the project area. Estimates are provided for three levels of geographic impact area: local, state, and national.

Within RECONS, the direct effects are equal to “local capture.” Local capture measures what percentage of federal spending is captured within the impact area. It is calculated by applying the level-specific (local, state, or national) Local Purchase Coefficients (LPCs) to the expenditures for each industry and aggregating the local capture across all industries. For example, labor costs may be entirely captured at the local level (if the laborers all live locally), while something like cement manufacturing may be only be captured at the state or national level (meaning federal spending on cement manufacturing is not a direct effect for the locality). Both the LPCs and the spending profile (the proportions of construction dollars spent in different sectors) are preset within RECONS; the LPCs vary by location, while the spending profiles vary based on the type of project. More information on LPCs, spending profiles, and the different types of effects measured within RECONS can be found in the RECONS 2.0 *User Guide (April 2019).*

Table 30: RECONS Purchase Coefficients

Area	Direct	Indirect	Total
Local	0.79	0.73	1.52
NY State	0.87	0.85	1.72
Nationwide	0.95	1.78	2.73

Federal funding spent in Nassau County represents a benefit when it is captured locally. Referring to Table 30, 79.2% of federal spending in Nassau County is captured within the local area. The local capture rate is one benefit of federal spending.

Secondary impacts include indirect and induced benefits. These benefits are additive with the direct effects and stem from the multiplier effect. Indirect impacts include payments to industries that support the directly affected industries, while induced effects occur when workers associated with the direct and indirect industries spend their salaries in the impact area, creating additional jobs and income.

The direct and indirect benefits are both represented on Table 30. For example, the local area has a total regional economic benefits capture of 1.52. This implies that for every dollar spent on this project, $1.52 in value is created at the local level, and due to these expenses helping industries throughout the U.S., the same dollar contributes a total of $2.73 to the nation split between direct and indirect benefits according to this RED analysis. In other words, this analysis suggests that each dollar spent creates $1.52 in local benefit, an additional 20 cents in benefits to the state, and an additional $1.01 in national benefit.

Spending in the study area will also spur job growth. On average, each $1 million spent in the study area will directly create 7.5 jobs and indirectly create 4 jobs. On the national level, the same spending creates a total of 17.6 jobs. That means 11.5 jobs are created locally, and an additional 6.1 jobs are created elsewhere throughout the nation. This implies that this study would create thousands of jobs locally, regionally, and nationally.

Benefits from Avoiding Business Interruption

The above discusses the direct and secondary benefits of federal spending in the NCBB study area, but a USACE project could also potentially prevent regional economic losses—a separate benefit stream. Back bay flooding can cause physical damages to commercial and industrial structures in the study area, which can in turn lead to business interruption. Some of the major sectors that may be impacted include healthcare and tourism. Preventing the physical damage can prevent the business interruption.

These business interruption losses are often transferrable, as spending that is prevented due to flooding may simply be spent elsewhere or deferred to a later time. Still, these losses are acutely felt by the local communities that bear them.

During the next study phase, these RED impacts will be quantitatively assessed by tying RED losses to individual commercial and industrial structures within the asset inventory. RED depth-percent damage curves will be developed for each asset based on HAZUS data that tie length of business interruptions to flood depths (relative to first floor elevation). These business interruptions will then be linked to a dollar loss, which will be determined by the size and type of the commercial structure. These new “RED loss” assets will be put into HEC-FDA to determine the expected RED losses over the 50-year study timeframe.

Successfully quantifying RED losses will give a more complete picture of the vulnerability of the study area. To do this work, the commercial structures in the inventory will have to be surveyed to determine their type (e.g., office, retail, restaurant) so that accurate RED loss depth-percent damage curves can be assigned. The parameters for the curves will have to be developed and new HEC-FDA import files will need to be created to actuate new model runs. The quantified RED losses will help inform the selection of the Net Total Benefits Plan (the plan that maximizes benefits across all benefit categories).

Other Social Effects

In compliance with ER 1105-2-100 *Planning Guidance Notebook* and ER 1105-2-101 *Risk Assessment For Flood Risk Management Studies*, the necessity for a comprehensive life safety risk assessment of the Tentatively Selected Plan and Net Total Benefits Plan will be investigated during the next phase of the study. Though both plans are heavily nonstructural and unlikely to induce life safety risk after implementation, a full accounting of life safety hazards can improve risk communication and inform future risk mitigation efforts.

An abbreviated qualitative life safety risk assessment is detailed in this section. This risk assessment includes a description of the various types of safety risks, a qualitative assessment of key life safety metrics, and an outline of the Tolerable Risk Guidelines (TRGs) as recommended by USACE Planning Bulletin (PB) 2019-04 *Incorporating Life Safety into Flood and Coastal Storm Risk Management Studies*.

Life safety risk assessments are a systematic approach for describing the nature of coastal storm risk including the likelihood and severity of occurrence while explicitly acknowledging the uncertainty in the analysis. Life loss consequences are the determination of the population at risk and the estimated statistical life loss in a given area. An assessment of the various types of risk, including residual risk, transferred risk, transformed risk, and incremental risk, can help inform whether the Recommended Plan provides a tolerable level of safety for the study area in the future with-project condition.

Residual risk is the coastal storm risk that remains in the floodplain even after a proposed coastal storm risk management project is constructed and implemented. Physical damages, as well as potential life loss consequences, can remain even after the project is implemented due to a variety of causes.

Population at Risk (PAR) provides a brief overview of the vulnerable population within the study area. Demographics information, including the percentage of population older than 65 years (17.5%), older than 75 (7.9%), below the poverty line (5.6%), or living with a disability (8.4%) is derived from the U.S. Census Bureau (Population Estimates Program, V2019). These demographics are highlighted as these populations are particularly vulnerable to coastal storm events. Though the study area hosts a considerable volume of seasonal tourists, the PAR information provided is only for the permanent population.

Table 31: Population at Risk and Demographics Information

Category	**NCBB**
Population at Risk	354,000

Population Characteristics	**U.S.**	**NCBB**
Age 65+	15.6%	17.5%
Age 75+	6.5%	7.9%
Age Under 18	22.6%	21.7%
Age Under 5	6.1%	5.5%
Percentage in Poverty	13.4%	5.6%
Percentage with Disability	12.6%	8.4%

Race and Ethnicity	U.S.	NCBB
White	72.5%	68.0%
Black or African American	12.7%	11.7%
American Indian or Native	0.8%	0.3%
Asian	5.5%	9.7%
Pacific Islander	0.2%	0.0%
Some other race	4.9%	7.3%
2 or more races	3.4%	3.0%

As mentioned earlier, the next study phase will investigate the necessity for a comprehensive life safety risk assessment based on the proposed measures of the Recommended Plan. The comprehensive life safety risk assessment would investigate estimated statistical life loss in the FWOP and the effectiveness of the various alternatives in reducing this life loss. The comprehensive life safety risk assessment would fully cover the four TRGs detailed in USACE PB 2019-04 *Incorporating Life Safety into Flood and Coastal Storm Risk Management Studies*. An outline and qualitative assessment of the TRGs is completed below. Like all planning objectives, the extent to which the TRGs objectives can be met will vary based on the conditions in the study area and the efficiency and effectiveness of measures that contribute towards meeting the objectives.

TRG 1 – Understanding the Risk. The first tolerable risk guideline involves considering whether society is willing to live with the risk associated with the costal protective system to secure the benefits of living and working in that area. To properly understand the risk, an assessment of life safety risk will cover both societal and individual life risks. Societal risk is the risk of widespread or large-scale catastrophes from the inundation of a vulnerable area that would result in a negative societal response. Conversely, individual risk the risk represented by the probability of life loss for the identifiable person or group by location that is most at risk of loss of life due to a structural failure. Individual life risk is influenced by location, exposure, and vulnerability within an area. Life Safety risk encompasses understanding the societal, individual, economic, and environmental risks associated with the construction of a project in the study area.

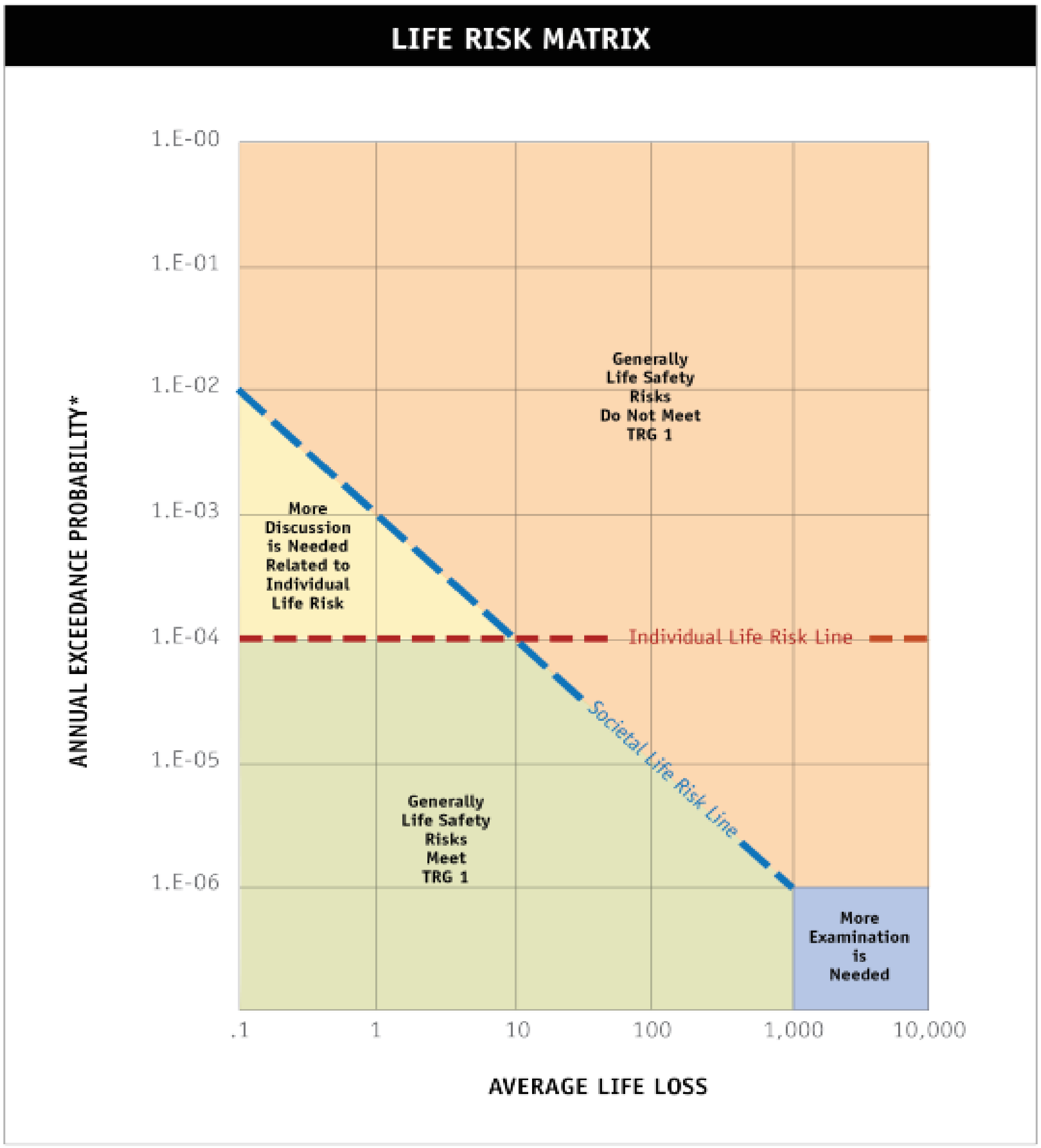
The Life Safety Risk Matrix in Figure 16 below shows the framework for quantitatively determining whether the life safety risk is tolerable for the study area. The full quantitative effort will be completed during the comprehensive life safety risk assessment in the next study phase.

TRG 2 – Building Risk Awareness. The second tolerable risk guideline involves determining that there is a continuation of recognition and communication of the floodwall risk. A proper EAP is required to ensure risk awareness within the vulnerable population as well as to maintain risk communication such as public engagement activities, media stories, and a current community website. The comprehensive life safety risk assessment will include recommendations for the EAP and floodplain management plan.

TRG 3 – Fulfilling Daily Responsibilities. The third tolerable risk guideline involves determining that the risks associated with the floodwall system are being properly monitored and managed by those responsible for managing the risk. This responsibility is met by demonstrating monitoring and risk management activities such as documented regular inspections, updated and tested emergency plans, instrumentation programs, and interim risk reduction measures plans. Proper Operations, Maintenance, Repair, Rehabilitation, and Replacement (OMRR&R) mitigates the risk of failure and corresponding life safety consequences.

TRG 4 – Actions to Reduce Risk. The fourth guideline is determining if there are cost effective, socially acceptable, or environmentally acceptable ways to reduce risks from an individual or societal risk perspective. The comprehensive life safety risk assessment will investigate whether complementary risk reduction measures are feasible or appropriate for the study area.

Figure 16: Life Safety Risk Matrix



*OR ANNUAL PROBABILITY OF INCREMENTAL LIFE LOSS

Environmental Quality (EQ)

The Environmental Quality (EQ) section provided here is not intended as a comprehensive representation of the environmental constraints, impacts, or benefits associated with each potential measure. A complete investigation of the environmental impacts and analyses is found in the Main Report and various Environmental Appendices. Direct environmental costs associated with each measure are already included in the TPCS estimates and incorporated into the provided BCRs and AANB estimates. The EQ section detailed here is meant only to convey the ongoing investigation of environmental quality as it relates to plan formulation and plan selection. As EQ is one of the four planning accounts, it must be presented equally alongside NED, RED, and OSE impacts to provide a complete description of the FWOP and FWP conditions.

At this stage, similar to RED and OSE benefits, potential EQ benefits are handled qualitatively. The opportunity to improve EQ benefits for each measure with supplemental Natural and Nature-Based Features (NNBF) is an area of investigation for the next study phase. Potential design improvements to advance EQ benefits (without sacrificing performance) is also an area of future study. This is particularly true for structural measures.

Plan formulation for NCBB followed strict guidance on environmental risks and abided to a set of constraints including the avoidance of construction within Coastal Barrier Resources Act (CBRA) zones, avoidance of impacts to threatened and endangered species, and the minimization of effects on cultural resources and historic structures.

Under the TSP / NED plan, there is no anticipated change in sedimentation. On-land construction will follow all erosion and sediment control guidelines to accommodate any necessary mitigation efforts. There are no impacts anticipated on water quality. Construction will comply with all applicable regulatory requirements. There are water quality changes over the course of the plan’s effective life, but these changes stem from sea level rise and not from the plan. Air quality may be temporarily adversely affected from construction, but all construction would comply with all applicable regulatory requirements. Air quality impacts would be present under each of the considered alternatives.

Impacts on threatened and endangered species are expected to be minimal. Impacts on threatened and endangered species related with sea level rise would continue as described in the environmental analysis of No Action or FWOP. There are no anticipated impacts to fisheries or on any aquatic life. There are no anticipated impacts to wetlands, aquatic habitats, or terrestrial habitats.

Executive Order 12898, “Federal Actions to Address Environmental Justice in Minority Populations and Low- Income Populations” (1994), directs Federal agencies, “to the greatest extent practicable and permitted by law, to make achieving environmental justice part of its mission by identifying and addressing, as appropriate, disproportionately high and adverse human health or environmental effects of its programs, policies, and activities on minority populations and low-income populations in the United States and its territories and possessions…” USACE continues to strive toward a more just future and the PDT considered all at-risk populations that may be detrimentally affected by any changes to the environment. At this time, there are no concerns within the study area related to changes in the environment.

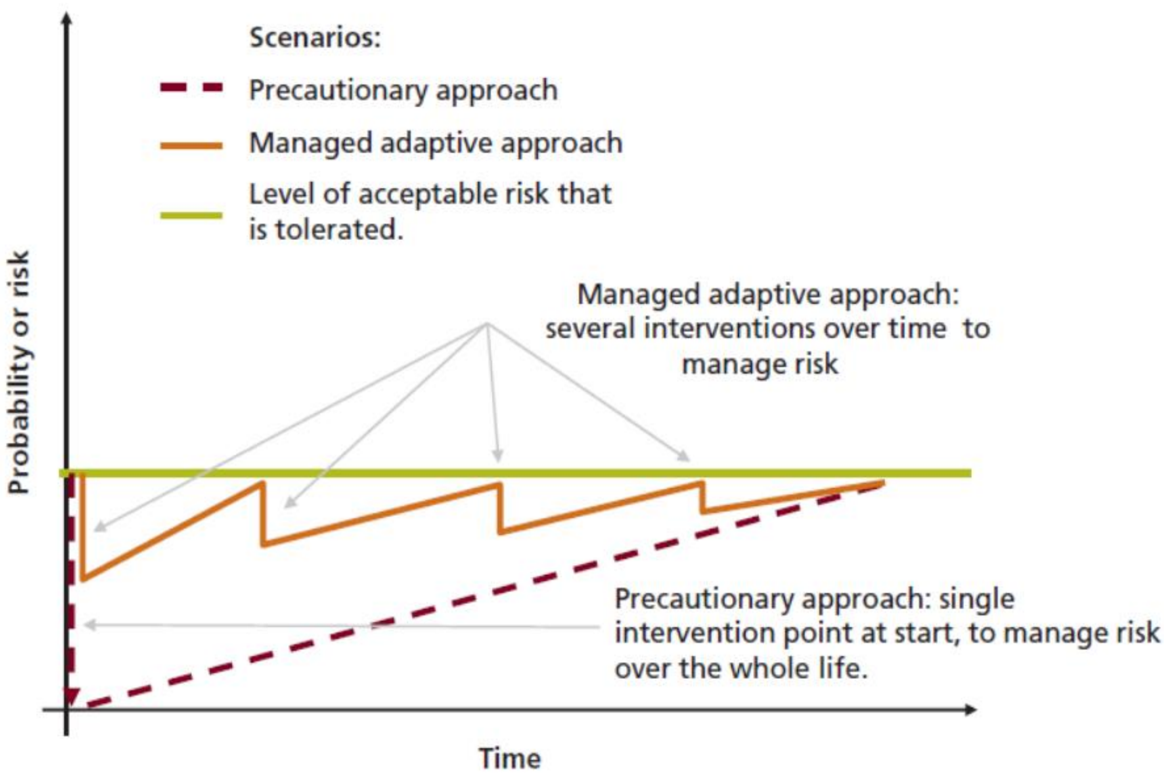
SEA LEVEL CHANGE – ADAPTIVE CAPACITY AND RESILIENCY

Sea level change is incorporated into the formulation, evaluation, comparison, and selection of alternatives in accordance with ER 1105-2-100 *Planning Guidance Notebook,* ER 1100-2-8162 *Incorporating Sea Level Change in Civil Works Programs*, and EP 1100-2-1 *Procedures to Evaluate Sea Level Change: Impacts, Responses, and Adaptation*. Sea level change is integrally included in the economic and engineering analyses. This includes assessment of the impacts of sea level change on forecasted Future Without-Project Conditions and understanding of the robustness, resiliency, and potential adaptability of proposed coastal storm risk management alternatives.

As economic modeling results indicate, the study area is sensitive to changes in sea level rise. As required by ER 1100-2-8162, the PDT pursued comparing all alternatives against each of the three USACE SLC curves. This allows assessment of the economic performance, structural performance, and system performance of each proposed measure under each SLC curve. This approach also allows the possibility for reformulating plans to improve overall life-cycle performance over the 50-year period of analysis and 100-year planning horizon.

Sea level change analysis investigates the resiliency of proposed alternatives in terms of project performance and possible decision-timing strategies. As first mentioned in the Nonstructural section earlier in the Appendix, decision-timing strategies are different approaches in managing sea level change risk over the period of analysis (or over the planning horizon). Figure 17 shows the overview for Anticipatory (i.e., Precautionary), Managed Adaptive, and Reactive project strategies.

Figure 17: Conceptual Comparison of Project Decision-Timing Strategies



Anticipatory strategy implements features and design parameters that decrease the vulnerability to future SLC and/or enhance the project adaptability before impacts are incurred. An example of this strategy is the design of hard structures for initial construction with a design crest height that also reduces risk for expected increases in sea level change in the future. Another example of an anticipatory action is the acquisition of additional lands for wetland migration or future structure construction and/or expansion.

Adaptive management strategy uses sequential decisions and implementations based on evaluating new data as it becomes available during the period of analysis. Implementation of the alternative measures occurs prior to sea level change impacts and requires advance planning to maintain the ability to adapt to sea level change. An example of adaptive management is designing berms, seawalls, or barriers to accommodate future additional height, with design and construction tied to a threshold prior to the time that the future impact is expected to occur. Another example is periodically re-evaluating and implementing nonstructural measures based on the experienced sea level change rate and impact to eligibility thresholds.

Reactive strategy may be planned or ad-hoc and is not implemented until required by the impacts of sea level change. The probability of sea level change risk in the study area will continue to surpass tolerable risk levels until additional planning and action is taken. The major risks of this strategy are that impacts will already be occurring by the time sea level change becomes apparent and it may be more difficult to take the action at the time of the response due to lack of preparation.

Nonstructural

Current formulation strategies vary for different measure types due to unique SLC adaptive capacity characteristics. For nonstructural, current formulation uses an Anticipatory approach with all eligible structures (using the Year 2080 5% AEP stage height with SLC) retrofitted prior to the Base Year. Figure 18 shows the structure retrofits (elevation and floodproofing) per SLC scenario. These figures match the nonstructural results provided in Table 13 through Table 15. Future SLC rates are uncertain and, according to current USACE guidance ER 1110-2-8162, have an equal probability of occurring at any rate between the Low (Historic) and High SLC rates. The main disadvantage of an Anticipatory approach is the potential to either unnecessarily overspend on project implementation (if SLC is less than expected) or the potential to leave significant residual risk in the study area (if SLC is higher than expected).

Figure 19 shows the nonstructural alternatives using a potential Managed Adaptive strategy. This strategy is not quantified in HEC-FDA but would include periodically returning to the study area and retrofitting structures that become vulnerable to coastal storm hazards based on the experienced SLC curve. This strategy requires active management over the 50-year period of analysis but offers numerous advantages in terms of cost efficiency and improving plan resiliency. With a Managed Adaptive approach, plan formulation no longer needs to predict SLC rates and then attempt to fit nonstructural implementation to an uncertain curve. Rather, implementation of nonstructural retrofits can be accomplished incrementally to optimize measure resiliency.

Figure 18: Anticipatory (Precautionary) Nonstructural Strategy

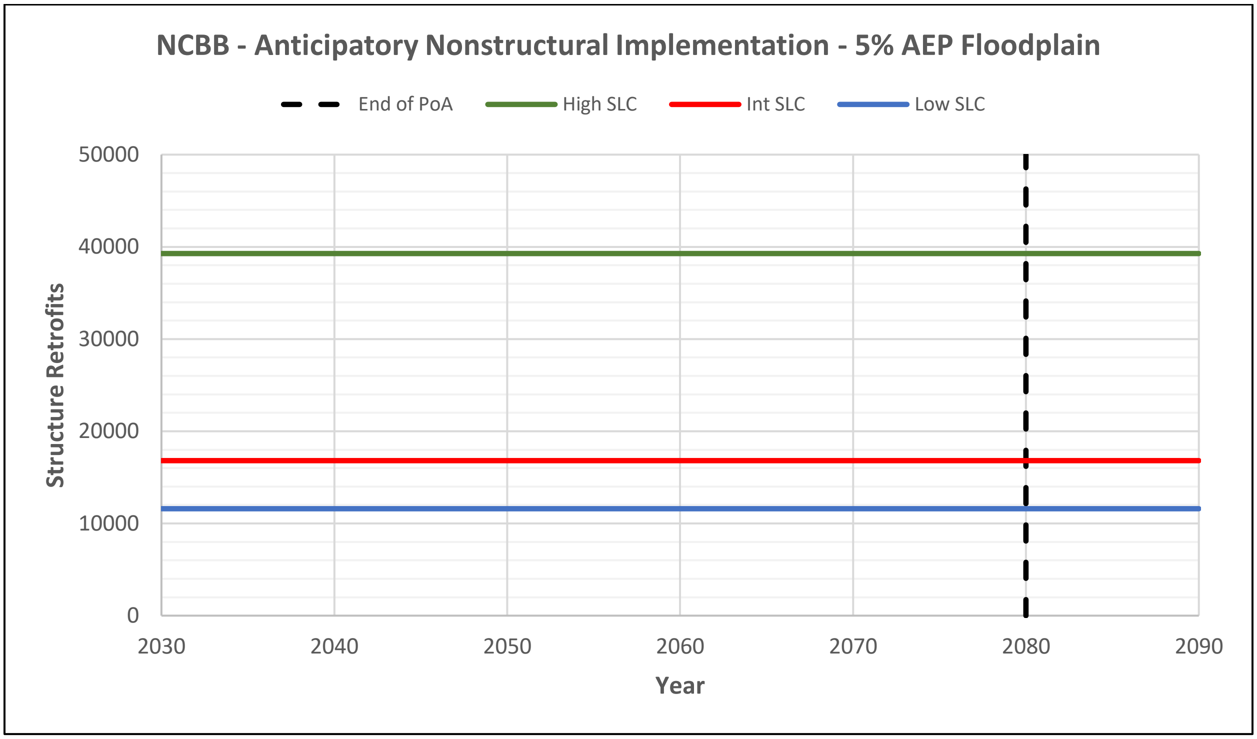
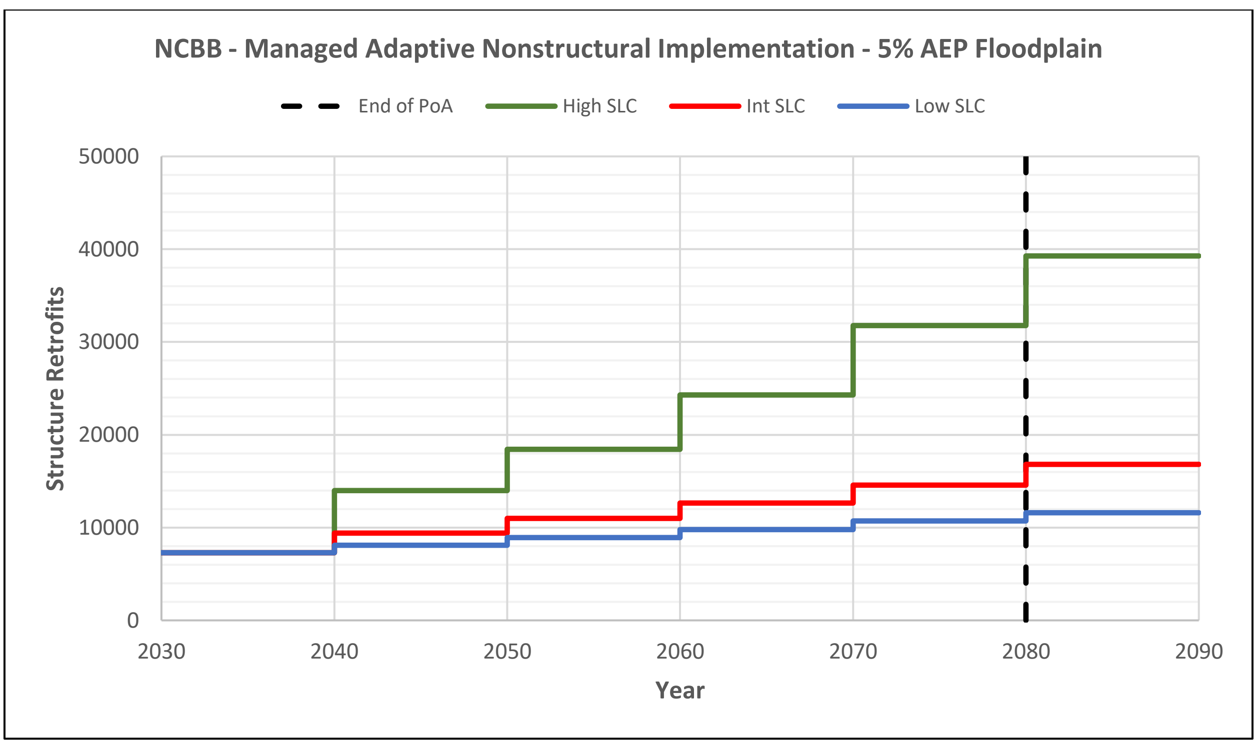


Figure 19: Managed Adaptive Nonstructural Strategy



For the example in Figure 19, all structures vulnerable to the 5% AEP stage height in Year 2030 (Base Year) are eligible for retrofits. This is approximately 7,300 residential and non-residential structures. In ten-year increments, the study area asset inventory is revisited and, depending on the measured SLC rate, additional structures are retrofitted to maintain project performance. For example, in Year 2040, as few as 800 structures may become eligible (Low SLC) or as many as 6,700 structures may become eligible (High SLC). With a Managed Adaptive approach, it is no longer necessary to predict the number of structures and thus threaten cost inefficiency risk or project performance risk. Measurements taken in Year 2040 are used to identify the additional vulnerable structures and only those structures are elevated or floodproofed (as appropriate for their occupancy type). This procedure repeats every ten years until the end of the period of analysis, maximizing net NED benefits and mitigating coastal storm risk.

A Reactive strategy for nonstructural is also possible, but not recommended for this study area. The approach would include elevating or floodproofing the 7,300 vulnerable structures by the Base Year without including any plans or procedures for re-evaluating coastal storm risk over the period of analysis. While this approach is the least expensive, the risk of significant residual damages is very high and the proposed measure is neither resilient nor robust for addressing SLC. As nonstructural is inherently adaptable to SLC due to the flexibility in assigning eligibility, there are few benefits to a nonstructural Reactive strategy for this study area.

Perimeter

For perimeter measures, current formulation also uses an Anticipatory approach though current design characteristics are optimized for the Intermediate SLC curve. Perimeter measures, including both levees and floodwalls, can be adaptable to SLC, but require significant upfront costs (prior to the Base Year) to allow for potential future modifications of the structure in response to uncertain SLC rates.

Current perimeter measure design, which is detailed in the Engineering Appendix, is intended to mitigate coastal storm risk for the 1% AEP storm event in Year 2080 with Intermediate SLC. In terms of robustness, the proposed measure is highly effective in mitigating damages under both the Intermediate and Low SLC curves. However, the current design is not optimal for mitigating damages at the High SLC curve and would be overtopped by the 1% AEP storm in the Year 2080 with High SLC

In terms of cost efficiency, the proposed perimeter measure is optimized for the Intermediate SLC curve, with a single construction phase, and ensures project performance over the entire Intermediate SLC 50-year period of analysis. However, the same measure design is overbuilt for the Low SLC scenario (unnecessarily high and costly) while also underbuilt for the High SLC scenario (project performance falls below 1% AEP event). Under the High SLC scenario, maintaining project performance and CSRM benefits would necessitate an expensive deconstruction and rebuild of the entire perimeter system.

A potential managed adaptive approach, however, would include constructing the initial perimeter measure at the Low SLC scenario height, but overbuilding the base to facilitate future height increases if SLC increases at a faster rate. As the perimeter base is widened to accommodate a design feature that would maintain system performance even under the High SLC scenario, future modification efforts would be significantly faster, easier to implement, and less expensive. The trade-off to this approach is the more expensive perimeter design (wider base) without any immediately increased coastal storm damage reduction benefits (lower initial height).

A Reactive strategy for perimeter measures is also not recommended for this study area. This strategy would include constructing the Low SLC scenario design without constructing a wider base or acquiring additional real estate to facilitate future modifications. While this strategy is the least expensive, the probability of increased economic residual damages and life safety risk is significant. It is unlikely that the Reactive design would maintain project performance over the entire 50-year period of analysis.

Perimeter measures implemented with a managed adaptive approach are not yet cost estimated nor modeled in HEC-FDA for NED benefits. If perimeter measures are not screened from consideration prior to the next phase of analysis, those costs and benefits will be compiled and compared against corresponding nonstructural alternatives.

Summary

Table 32 on the following page provides a summary outline of the pros and cons of each decision-timing strategy for perimeter (floodwalls and levees) and nonstructural (elevation and floodproofing). As the remaining alternatives under consideration are optimized in the next study phase to allow for identification of the eventual Recommended Plan (as currently quantified in Table 24 through Table 26), incorporating SLC resiliency and adaptive capacity will remain an integral part of the analysis.

This optimization effort will include trade-off analysis incorporating net NED benefits, RED impacts, OSE impacts, EQ benefits, life safety risk, economic residual damages, project performance, and SLC resiliency.

Table 32: Measures Strategy Comparison: Anticipatory, Managed Adaptive, Reactive

	Anticipatory	Managed Adaptive	Reactive
Perimeter	**Pros** (1) No future actions necessary to preserve project effectiveness and performance (2) Minimizes residual risk (3) Maximizes RED/OSE benefits by keeping inundation out of study area	**Pros** (1) More easily adaptable to future SLC scenarios. Wider base can accommodate taller floodwall heights to maintain effectiveness and performance. Resilient. (2) Lower initial wall height commensurate with current study area vulnerabilities (3) Potentially more societally implementable	**Pros** (1) Less expensive than Anticipatory (Precautionary) or Adaptive approaches. No risk of unnecessary construction or real estate expenses (2) No future expenses planned to elevate or modify floodwall (3) Project is robust in dealing with Low/Int SLC potential impacts
	Cons (1) Requires larger initial investment in real estate, environmental mitigation (larger footprint), and construction materials (2) Potential efficiency loss. Benefits for larger wall height may only be realized late in the period of analysis (or not at all) depending on uncertain SLC future (3) Potential societal implementation issues due to taller wall height	**Cons** (1) Significant initial cost investment for over-building wider base. Benefits may not be realized if wall height is not elevated in the future. (2) Requires a second (or third) expensive future investment to construct a taller floodwall on the pre-built wider base (3) Requires future actions to maintain robustness and performance across Int and High SLC curves. Risk that future decision-makers will not be able to act in time to mitigate future SLC impacts (4) Initial performance less than floodwall optimized for High SLC (residual risk/life safety)	**Cons** (1) Project is not resilient to changes in future SLC scenarios. High SLC rates would dramatically reduce performance and effectiveness. Significant risk of residual damages and life safety under High SLC curve (2) Project is not easily adaptable for future scenarios. Project would need to be effectively rebuilt (significant construction and real estate burdens) to maintain performance and effectiveness. (3) Initial performance less than floodwall optimized for High SLC (residual risk/life safety)

	Anticipatory	Managed Adaptive	Reactive
Nonstructural	**Pros** (1) No future actions necessary to preserve project effectiveness and performance. Robust across all 3 SLC scenarios. (2) No future expenses or incremental implementation schedules	**Pros** (1) Efficiency improvement. Structures can be elevated/floodproofed/removed over time only when they become vulnerable. Investments only incurred if warranted. (2) Incremental implementation allows costs for complementary measures to be spread out over the period of analysis (3) Measure is robust to current SLC impacts and resilient to future SLC impacts with periodic re-investments	**Pros** (1) Less expensive than Anticipatory (Precautionary) or Adaptive approaches. No risk of unnecessary nonstructural construction costs (2) No future expenses for additional measures
	Cons (1) Potential efficiency loss. Significant initial investment to elevate/floodproof all possibly vulnerable structures by Base Year. (2) Benefits for some structures may not be realized until late in the period of analysis or not at all. (3) Increased residual risk due to inundation waters still entering study area. Limited RED and OSE benefits.	**Cons** (1) Requires future investments in elevating/floodproofing/removing structures to maintain project performance and effectiveness (2) Requires future actions to maintain robustness and performance across Int and High SLC curves. Risk that future decision-makers will not be able to act in time to mitigate future SLC impacts (3) Initial performance less than more comprehensive nonstructural measure optimized for High SLC (4) Increased residual risk due to inundation waters still entering study area. Limited RED and OSE benefits.	**Cons** (1) Study area receives significant residual damages under all 3 SLC curves (2) Project is neither robust nor resilient to potential SLC futures

CONCLUSION

The Tentatively Selected Plan (TSP) / NED Plan is the net NED benefits maximizing alternative consistent with protecting the Nation's environment. A nonstructural only alternative, the TSP boasts $475 million in AANB with a 4.5 BCR. In total, 16,850 structures are eligible for nonstructural retrofits (elevation and floodproofing) within the 5% AEP event floodplain under the Intermediate SLC scenario.

Table 33: Selected Plan Summary

National Economic Development (NED) Plan / Tentatively Selected Plan (TSP) / Nonstructural-Only Plan		Net Total Benefits Plan (NED / RED / OSE / EQ)	
Future Without-Project AAD	$1,011,964,000	Future Without-Project AAD	$1,011,964,000
Future With-Project AAD	$401,393,000	Future With-Project AAD	$389,071,000
Total Reduced AAD	**$610,571,000**	**Total Reduced AAD**	**$622,893,000**
Total Initial Construction	$3,849,693,000	Total Initial Construction	$4,863,822,000
Average Annual OMRR&R	$0	Average Annual OMRR&R	$4,922,000
Average Annual Cost (AAC)	**$135,733,000**	**Average Annual Cost (AAC)**	**$176,411,000**
Average Annual Net Benefits	**$474,839,000**	**Average Annual Net Benefits**	**$446,481,000**
Benefit-Cost Ratio	**4.5**	**Benefit-Cost Ratio**	**3.5**
Residual Damages	39.7%	Residual Damages	38.4%
Eligible Nonstructural	16,850	Eligible Nonstructural	16,586

During the next phase of analysis, both plans will be optimized and investigated for their SLC resiliency, adaptive capacity, contributions to RED / OSE / EQ, structural performance, and system project performance (in compliance with ER 1105-2-101). Additionally, further investigation is planned to identify any supplemental NED benefit streams and to identify any areas of risk and uncertainty within the economic methodology and modeling.

Attachment A

Depth-Percent Damage Functions

Single-Family Residential One-Story (SFR1) No Basement - NACCS							
Stage	S	STL	STU	Stage	C	CTL	CTU
-1	0	0	0	-1	0	0	0
-0.5	0	0	5	-0.5	0	0	0
0	1	0	10	0	0	0	5
0.5	10	6	20	0.5	20	5	30
1	18	10	30	1	40	18	60
2	28	16	40	2	60	34	84
3	33	20	45	3	80	60	100
5	42	30	60	5	90	80	100
7	55	42	94	7	100	100	100
10	65	55	100	10	100	100	100

Single-Family Residential One-Story (SFR1) With Basement - NACCS							
Stage	S	STL	STU	Stage	C	CTL	CTU
-9	0	0	0	-9	0	0	0
-8	1	0	2	-8	0	0	5
-5	3	0	10	-5	3	3	14
-3	5	1	15	-3	5	5	25
-1	10	3	18	-1	15	5	30
-0.5	12	4	21	-0.5	15	5	40
0	18	5	30	0	15	10	48
0.5	30	10	35	0.5	30	15	60
1	30	15	43	1	45	30	80
2	35	25	50	2	64	52	90
3	40	30	55	3	80	66	97
5	70	50	84	5	100	80	100
7	90	64	94	7	100	100	100
10	95	85	100	10	100	100	100

Single-Family Residential Multi-Story (SFRM) No Basement - NACCS							
Stage	S	STL	STU	Stage	C	CTL	CTU
-2	0	0	0	-2	0	0	0
-1	0	0	2	-1	0	0	0
-0.5	1	0	3	-0.5	0	0	3
0	5	0	8	0	5	0	8
0.5	10	5	10	0.5	12	5	20
1	15	9	20	1	25	15	30
2	20	15	25	2	35	25	40
3	25	20	30	3	45	32	60
5	30	25	40	5	55	40	80
7	50	40	55	7	70	50	100
10	60	50	70	10	80	60	100

Single-Family Residential Multi-Story (SFRM) With Basement - NACCS							
Stage	S	STL	STU	Stage	C	CTL	CTU
-9	0	0	0	-9	0	0	0
-8	0	0	3	-8	0	0	2
-5	3	0	8	-5	3	2	10
-3	7	1	10	-3	5	5	25
-1	10	3	15	-1	15	5	25
-0.5	12	4	17	-0.5	15	5	28
0	15	5	20	0	20	10	34
0.5	20	7	30	0.5	30	15	40
1	25	15	30	1	35	20	50
2	30	17	35	2	40	30	60
3	35	27	40	3	50	40	70
5	50	40	55	5	60	50	72
7	60	50	65	7	70	60	90
10	70	62	80	10	90	72	100

Apartment One-Story No Basement - NACCS							
Stage	S	STL	STU	Stage	C	CTL	CTU
-1	0	0	0	-1	0	0	0
-0.5	0	0	0	-0.5	0	0	0
0	10	3	14	0	4	1	10
0.5	16	10	22	0.5	14	5	23
1	25	16	38	1	28	11	34
2	35	23	45	2	45	29	58
3	43	39	60	3	60	45	73
5	60	52	75	5	81	62	90
7	68	59	85	7	100	96	100

Apartment Multi-Story No Basement - NACCS							
Stage	S	STL	STU	Stage	C	CTL	CTU
-1	0	0	0	-1	0	0	0
-0.5	0	0	0	-0.5	0	0	0
0	5	0	8	0	2	1	8
0.5	8	5	12	0.5	10	5	15
1	20	7	25	1	15	8	20
2	28	10	29	2	20	15	25
3	28	18	30	3	25	20	30
5	38	20	44	5	30	25	32
7	46	35	50	7	35	30	40
10	50	35	60	10	45	37	50

Vehicles – EGM 09-04							
Stage	S	STL	STU	Stage	C	CTL	CTU
-1	0	0	0	-1	0	0	0
-0.5	0	0	0	-0.5	0	0	0
0	0	0	0	0	0	0	0
0.5	7.6	7.6	7.6	0.5	0	0	0
1	28	28	28	1	0	0	0
2	46.2	46.2	46.2	2	0	0	0
3	62.2	62.2	62.2	3	0	0	0
5	87.6	87.6	87.6	5	0	0	0
7	100	100	100	7	0	0	0
10	100	100	100	10	0	0	0

Engineered Building (Perishable Contents) - NACCS							
Stage	S	STL	STU	Stage	C	CTL	CTU
-1	0	0	0	-1	0	0	0
-0.5	0	0	0	-0.5	0	0	0
0	5	0	9	0	5	0	8
0.5	10	5	17	0.5	18	5	28
1	20	12	27	1	35	17	50
2	30	18	36	2	39	28	58
3	35	28	43	3	43	37	65
5	40	33	48	5	47	43	65
7	53	43	60	7	70	50	90
10	58	48	69	10	75	50	90

Engineered Building (Nonperishable Contents) - NACCS							
Stage	S	STL	STU	Stage	C	CTL	CTU
-1	0	0	0	-1	0	0	0
-0.5	0	0	0	-0.5	0	0	0
0	5	0	9	0	2	0	5
0.5	10	5	17	0.5	10	4	15
1	20	12	27	1	13	10	22
2	30	18	36	2	28	22	35
3	35	28	43	3	37	27	44
5	40	33	48	5	44	33	50
7	53	43	60	7	50	44	55
10	58	48	69	10	55	48	70

Non / Pre-Engineered Building - NACCS							
Stage	S	STL	STU	Stage	C	CTL	CTU
-1	0	0	0	-1	0	0	0
-0.5	0	0	10	-0.5	0	0	0
0	5	0	15	0	1	0	4
0.5	12	5	20	0.5	8	3	18
1	20	10	30	1	12	7	28
2	28	15	42	2	18	13	38
3	35	20	55	3	25	20	49
5	45	28	65	5	39	30	64
7	55	35	75	7	50	40	72
10	60	40	78	10	60	45	90

Urban High-Rises (NACCS)							
Stage	S	STL	STU	Stage	C	CTL	CTU
-8	0	0	0	-8	0	0	0
-5	6.5	0.5	10	-5	0.25	0	0.5
-3	9	1.75	12.5	-3	0.25	0	1.25
-1	13	3.5	16	-1	0.5	0	2.5
-0.5	13.25	3.5	17.75	-0.5	1.5	0	3.5
0	13.75	5.5	18.5	0	4	0	5
0.5	14.25	6.75	19.25	0.5	5	1.5	6
1	15.5	8	20	1	5	2.6	8
2	17.5	8.75	22.5	2	7	4	11
3	19	9.5	24	3	7.5	5.5	13.5
5	21.5	10.25	25	5	10	6.5	16
7	22.5	11.5	25.5	7	11	8	20
10	23.5	12.5	26.5	10	12	9	20

Mobile Home – GEC Report							
Stage	S	STL	STU	Stage	C	CTL	CTU
-1.1	0	0	0	-1.1	0	0	0
-1	6.4	6.1	7.7	-1	0	0	0
-0.5	7.3	6.9	8.8	-0.5	0	0	0
0	9.9	9.4	11.9	0	0	0	0
0.5	43.4	41.2	52.1	0.5	95	90	100
1	44.7	42.5	53.6	1	96	92	100
2	45.9	43.6	55.1	2	97	94	100
3	46.6	44.3	55.9	3	98	96	100
4	46.8	44.5	56.2	4	99	98	100
5	51	48.5	61.2	5	100	100	100
6	66.9	63.5	80.2	6	100	100	100
7	66.9	63.5	80.2	7	100	100	100
8	67.3	64	80.8	8	100	100	100
9	67.3	64	80.8	9	100	100	100
10	67.3	64	80.8	10	100	100	100