US Army Corps of Engineers®
New York District

Raritan Bay and Sandy Hook Bay, New Jersey
Hurricane Sandy Limited Reevaluation Report
for
Coastal Storm Risk Management

Union Beach, New Jersey

June 2017

EXECUTIVE SUMMARY

This Hurricane Sandy Limited Reevaluation Report (HSLRR)[1] serves as a decision document to support the construction of the Raritan Bay and Sandy Hook Bay, New Jersey Coastal Storm Risk Management Project located in the Borough of Union Beach. It addresses relevant changes to existing conditions that have occurred since the Feasibility Report was completed in September 2003, including changes to existing conditions that resulted from Hurricane Sandy.

This HSLRR also provides minor design refinements and updated costs associated with changed conditions and updated guidance that has been issued since project authorization that serve as the basis for a Project Partnership Agreement (PPA) between the Federal Government and the non-Federal Sponsor, New Jersey State Department of Environmental Protection (NJDEP). This HSLRR, which includes a Supplemental Environmental Assessment (SEA), also provides an updated economic analysis and demonstrates that the plan is economically justified, environmentally sound and technically acceptable in accordance with current policy.

Reevaluation of Design Features

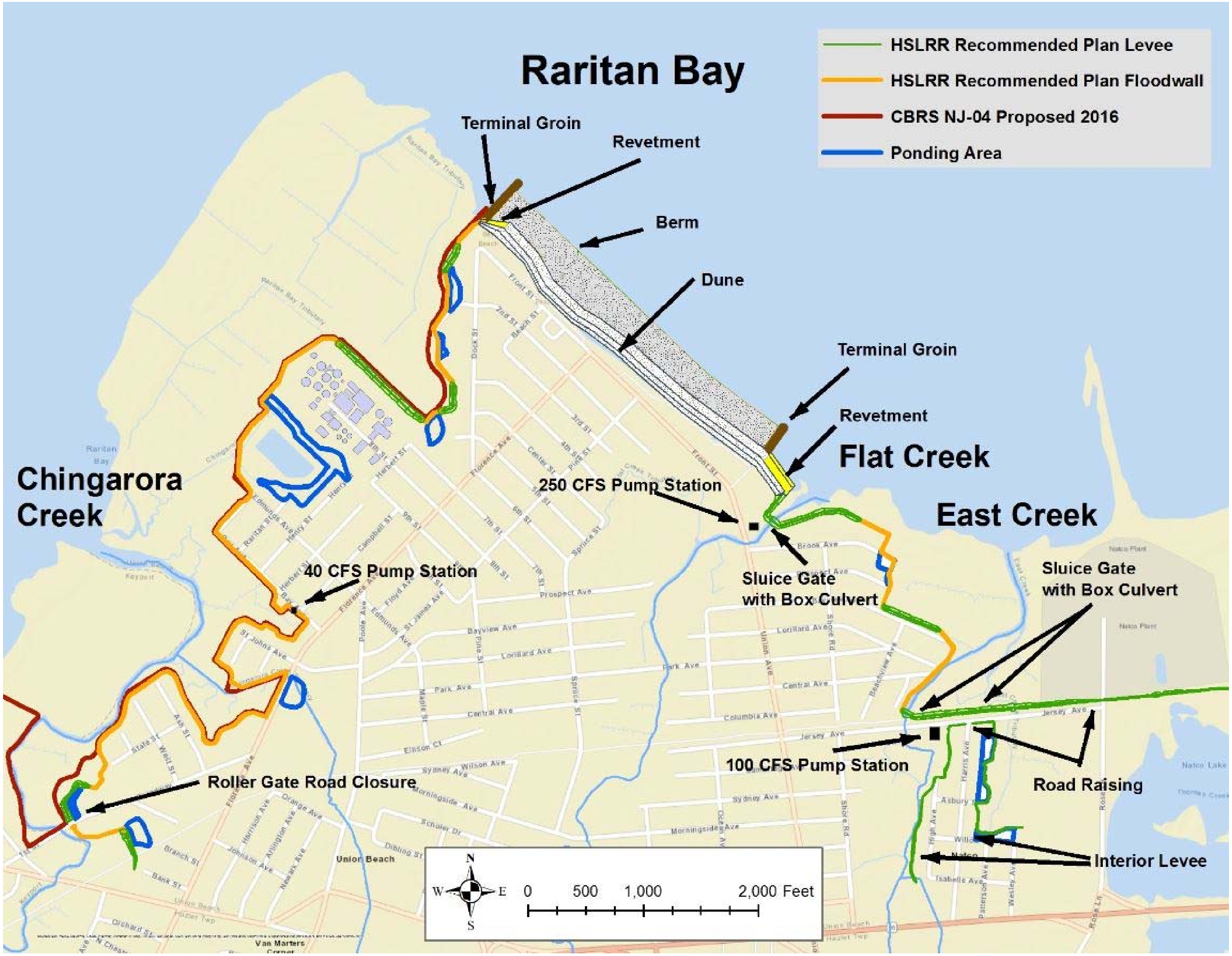
The 2007 Authorized Plan alignment and project components were reviewed to identify current policy compliance deficiencies and changes to existing conditions, and to update costs since the plan was authorized for construction in the Water Resources Development Act of 2007 (Public Law 110-114). After reevaluation of the 2007 Authorized Plan, several updates were incorporated into the HSLRR Recommended Plan. A summary of those updates is provided below, and the overall HSLRR Recommended Plan is shown on Figure ES-1. It is important to note that the HSLRR Recommended Plan alignment is unchanged from the 2007 Authorized Plan for <u>all</u> areas east of the termination of the Chingarora Creek floodwall at the northwestern terminal groin.

1. The 2007 Authorized Plan alignment was modified so that the project would avoid infringements on the Coastal Boundary Resources System boundary. This modification consists of a shift in the alignment, and an increase in the overall length of the Chingarora Creek element of the project plan. The 2007 Authorized Plan for the Chingarora Creek element called for 6,428 linear feet of levee and 4,956 linear feet of floodwall – an overall length of 11,384 linear feet. The HSLRR Recommended Plan updates to the Chingarora Creek element result in an overall length of 13,220 linear feet, which is comprised of 2,243 linear feet of levee and 10,977 linear feet of floodwall.

2. All floodwalls in the 2007 Authorized Plan were changed to T-Wall on piles in the HSLRR Recommended Plan. USACE design requirements were revised per EC 1110-2-6066 "*Design of I-Walls*" issued on 1 April 2011 as a result of lessons learned from studies of the performance of I-Walls during major coastal storms. Compliance with this change in design requirements resulted in the HSLRR Recommended Plan's replacement of all I-Wall (4,472 linear feet in the 2007 Authorized Plan) with T-Wall on piles, and all T-Wall on spread footings (496 linear feet in the 2007 Authorized Plan) with T-Wall on piles.

[1] All costs and benefits are presented in fiscal year 2016 price level, with the exception of the Executive Summary and Pertinent Data sections, which were updated to October 2016 (fiscal year 2017) price levels and discount rate of $2^{7/8}$ percent.

Figure ES-1: HSLRR Recommended Plan Overview



3. Additional real estate easements that are required to comply with current USACE vegetation management policy were incorporated into the HSLRR Recommended Plan.
4. The 2007 Authorized Plan levee section was updated in the HSLRR Recommended Plan to be in compliance with current design practice, and to better address potential seepage risks. A revised levee cross section was also used to update quantity estimates and all associated costs.
5. A modified road closure structure design was incorporated into the HSLRR Recommended Plan based on post-Katrina lessons learned.
6. The design of Flat and East Creek closure gates was modified in the HSLRR Recommended Plan based on post-Katrina lessons learned.

Reevaluation of Costs and Benefits

Table ES-1 shows project costs from the September 2003 Feasibility Report in their original form, and escalated to first quarter 2017 price levels[2]. All cost items include contingencies ranging from 10 to 20 percent, with the overall weighted average contingency for all September 2003 Feasibility Report project first costs equal to 13 percent. For the purpose of consistency in comparison between the original and escalated estimate, escalated costs are annualized at a $5^{7/8}$ discount rate (in effect for the September 2003 Feasibility Report).

The table shows that escalated project First Costs are $51 million higher, and escalated total annual costs are roughly $3.7 million higher than reported in the September 2003 Feasibility Report.

Table ES-1
Project Cost and Annualized Cost Comparison
2003 Feasibility and Escalated to Q1-2017

	2003 Feasibility Report	2003 Escalated to Q1-2017 ($)
First Cost	96,669,000	148,297,000
Interest During Construction	7,237,700	11,103,000
Total Investment Cost	103,907,000	159,400,000
Annualized Investment Cost	6,478,000	9,937,000
Annual LOP System O&M Costs	231,000	356,000
Annual Interior Drainage O&M Costs	155,000	239,000
Annual Project Cost (50 years)	6,864,000	10,532,000

[2] Final costs are presented in October 2016 price levels and the FY 2017 discount rate of $2^{7/8}$ percent.

Table ES-2 shows the HSLRR Recommended Plan costs along with the escalated September 2003 Feasibility Report costs provided in Table ES-1. The HSLRR Recommended Plan project First Costs, which includes real estate administration costs and pertinent contingency, engineering and design and construction management costs, is \$273,005,000 – total average annual costs are \$12,404,000. As shown in the table, escalated Total Investment Costs as stated in the September 2003 Feasibility Report have increased by \$132.0 million, though the annualized investment costs have increased by only \$1.74 million and total annual costs have increased by \$1.1 million. The increase in annualized and total annual costs is not as dramatic as the increase in total investment costs because the annualized investment costs in the September 2003 Feasibility Report were calculated using a discount rate of $5^{7/8}$ percent, and the discount rate used in this HSLRR is $2^{7/8}$ percent (quarter one 2017 price level).

Table ES-2
Project Cost and Annualized Cost Comparison
2003 Feasibility Escalated and 2017 HSLRR

	2003 Feasibility Escalated to Q1-2017 ($)	2017 HSLRR ($)
Initial Project Cost	148,297,000	273,005,000
Interest During Construction	11,103,000	18,722,000
Total Investment Cost	159,400,000	291,727,000
Annualized Investment Cost	9,937,000	11,071,000
Annual LOP System O&M Costs	356,000	682,000
Annual Interior Drainage O&M Costs	239,000	651,000
Annual Project Cost (50 years)	10,532,000	12,404,000

Design criteria changes and material and labor cost increases resulted in a major impact on the initial cost of the 2007 Authorized Plan. As discussed above under the heading “Reevaluation of Design Features”, the HSLRR Recommended Plan updates the 2007 Authorized Plan alignment and project components to account for changes in existing conditions and to bring the project into compliance with current design policies. Each modification made to bring the 2007 Authorized Plan into compliance with current policy (see itemized list under the heading “Reevaluation of Design Features”) resulted in an increase to project costs over and above the consideration of escalation alone.

In addition to updates made to bring the project into compliance with current policies, the cost of the HSLRR Recommended Plan contains higher contingencies and subcontractor markups than used for the 2007 Authorized Plan (as stated in the September 2003 Feasibility Report). Contingencies used in the HSLRR Recommended Plan cost estimate have an overall weighted average of 21 percent, while the overall weighted average contingency used in the September 2003 Feasibility Report was 13 percent. The September 2003 Feasibility Report cost estimate assumed a prime contractor markup of 13 percent, whereas the HSLRR Recommended Plan cost estimate assumes a prime contractor markup of 28 percent. Also, the September 2003 Feasibility Report cost estimate is based on the prime contractor directly performing most of the construction. The HSLRR Recommended Plan estimate reflects conditions more consistent with today's market, with the majority of direct construction tasks being performed by subcontractors. Subcontractor execution of most construction adds a layer of 20 percent subcontractor markup in addition to the 28 percent prime contractor markup for the HSLRR Recommended Plan.

Table ES-3 provides a comparison of the economic performance metrics as documented in the September 2003 Feasibility Report and the economic performance metrics documented in this HSLRR. The table shows that the HSLRR Recommended Plan will provide total average annual benefits of $14,415,000 (October 2016 price levels and the FY 2017 discount rate of $2^{7/8}$ percent). Analyses documented in this HSLRR demonstrate that the HSLRR Recommended Plan (i.e., the updated 2007 Authorized Plan) remains economically justified with a benefit-to-cost ratio of 1.2 and net excess annual benefits of $2,011,000. The annual cost impact of the decrease in the discount rate (fiscal year 2017 price level) noted above is significant, and helps to explain how economic justification is maintained when the project cost has more than doubled – economic justification is based on a comparison of annual benefits to annual costs.

Table ES-3
Economic Performance Metrics Comparison

	2003 Feasibility Report	2017 HSLRR
Without-Project Expected Annual Damages	11,047,000	19,889,000
Without-Project Expected Annual Emerg Svc Costs	1,554,000	1,949,000
With-Project Expected Annual Damages	1,069,000	6,230,000
With-Project Expected Annual Emerg Svc Costs	186,000	680,000
Benefits: Reduced Damage to Structures	9,978,000	13,659,000
Benefits: Reduced Public Emergency Costs	1,368,000	1,269,000
Benefits: Reduced FIA Administration Costs	127,000	0
Total Annual Flood Damage Reduction Benefits	11,174,000	14,928,000
Less: Residual Interior Drainage Damages with Selected Features in Place	474,000	564,000
Net Flood Damage Reduction Benefits	10,999,000	14,364,000
Ancillary Benefits: Reduced Maintenance	25,000	38,000
Ancillary Benefits: Recreation	9,000	13,000
TOTAL ANNUAL PROJECT BENEFITS	**11,160,000**	**14,415,000**
TOTAL ANNUAL PROJECT COSTS	**6,864,000**	**12,404,000**
BENEFIT TO COST RATIO	**1.6**	**1.2**
NET EXCESS ANNUAL BENEFITS	**4,296,000**	**2,011,000**

Coastal Barrier Resources Act Compliance

In the 2003 Environmental Impact Statement, compliance with the Coastal Barrier Resources Act (CBRA) was pending. The 2008 Record of Decision made no mention that compliance with the CBRA, and the U.S. Fish and Wildlife Service (USFWS) has no records of compliance. In 2013, when this HSLRR was initiated, the New York District proceeded with acquiring a determination regarding CBRA from the USFWS. The USFWS stated that parts of the Union Beach project were within the Coastal Barrier Resources System (CBRS) Unit NJ-04. USACE requested an exemption from the 2008 unit alignment (see Supplemental EA Appendix D – Pertinent Correspondence) which the USFWS denied.

USFWS, in response to Hurricane Sandy, drafted a revised alignment for CBRS Unit NJ-04. On 7 July 2016, the USFWS announced in the Federal Register that it is developing a new CBRS mapping protocol for critical facilities located within and immediately adjacent to the CBRS. In the announcement, the USFWS stated that it may consider mapping a CBRS area to allow for the protection of existing critical facilities (e.g., sewage treatment facilities) that primarily serve areas located outside of the CBRS.

The USFWS developed this new protocol for critical facilities to allow for the protection of the Bayshore Regional Sewerage Authority Wastewater Treatment Facility (located within the project area). In cases where the USFWS recommends the removal of an area from the CBRS in accordance with the new protocol, the change became effective when the updated map was adopted through legislation enacted by Congress in December 2016

As discussed above under the heading “Reevaluation of Design Features”, the 2017 HSLRR Recommended Plan modified the 2007 Authorized Plan alignment so that the project would avoid infringements on CBRS Unit NJ-04.

Reevaluation of Project Design Performance

Using current terminology, the 2007 Authorized Plan described in the September 2003 Feasibility Report gave a level of performance for a 1% coastal storm flood event.

This HSLRR evaluated the design performance of the updated 2007 Authorized Plan after the incorporation of bay storm stage/frequency analyses updated in 2013, and post-Katrina levee/floodwall overtopping and failure analyses. Policy Guidance Letter No. 26, Benefit Determination Involving Existing Levees of 23 Dec 1991 defines the highest vertical elevation on the levee such that it is likely that the levee would not fail if the water surface elevation were to reach this level as the Probable Non-failure Point (PNP). It defines the lowest vertical elevation on the levee such that it is highly likely that the levee would fail as the Probable Failure Point (PFP). Highly likely is 85% confidence or greater. These analyses determined that the non-failure point of the Union Beach levee/floodwall system would be +13.1 feet National Geodetic Vertical Datum of 1929 (NGVD29) (1.9 feet below the levee/floodwall crest elevation of +15 feet NGVD29) and the failure point of the system would be +13.6 feet NGVD29 (1.4 feet below the crest elevation of +15 feet NGVD29).

At the beginning of the period of analysis in 2022, the non-failure-point elevation of +13.1 feet NGVD29 corresponds to a 1.1% level of performance for coastal storm inundation and wave attack. At the end of the period of analysis in 2072, after which +0.7 feet of sea level rise is assumed to have occurred, the non-failure-point elevation of +13.1 feet NGVD29 corresponds to a 1.5% level of performance for a coastal storm risk management against inundation and wave attack.

PERTINENT DATA

DESCRIPTION: The 2007 Authorized Plan, including updates developed for this Hurricane Sandy Limited Reevaluation Report (HSLRR), provides for a beach berm and dune system, groins with interior drainage structures (levees/floodwalls, gates, pumps, road-raising and wetland mitigation) at Union Beach, New Jersey. The purpose of this HSLRR is to determine whether the authorized, unconstructed project remains economically justified.

LOCATION: Borough of Union Beach - Monmouth County, New Jersey

	2003 Feasibility	2017 HSLRR
LEVEE/FLOODWALL ELEMENT		
Levee		
Length (Chingarora: 6,428) (Flat/East: 4,442)	10,870 FT	
Length (Chingarora: 2,243) (Flat/East: 4,560)		6,803 FT
Top Elevation (NGVD29 / NAVD88)	15.0 FT / 14.0 FT	15.0 FT / 14.0 FT
Crest Width	10 FT	10 FT
Slopes	1V:2,5H	1V:2.5H
Fill Volume	156,700 CY	111,378 CY
Interior Levee		
Length	3,388 FT	3,388 FT
Top Elevation (NGVD29 / NAVD88)	8.0 FT / 7.0 FT	8.0 FT / 7.0 FT
Crest Width	2 FT	2 FT
Slopes	2.0:1	2.0:1
Fill Volume	3,997 CY	3,953 CY
Interior Drainage		
Primary Outlet Structures	11	11
Secondary Outlet Structures	37	45
8 @ 18" Concrete Pipe	210 FT	210 FT
23 @ 24" Concrete Pipe	905 FT	
31 @ 24" Concrete Pipe		1,055 FT
7 @ 36" Concrete Pipe	270 FT	270 FT
3 @ 48" Concrete Pipe	230 FT	480 FT
1 @ 4' x 4' Box Culvert	80 FT	25 FT
6 @ 60" Concrete Pipe	840 FT	840 FT
6 ft x 6 ft Tide Gate Structures w/ Sluice Gates	6	6
Natural Ponding Areas	4.21 AC	4.21 AC
Floodwall		
Length – Total	6,885 FT	12,907 FT
Chingarora Creek		
I-wall	4,468 FT	0 FT
T-wall on spread footing	488 FT	0 FT
T-wall on piles	0 FT	10,977 FT
Flat / East Creek		
T-wall on piles	1,929 FT	1,929 FT
Top Elevation (NGVD29 / NAVD88)	15.0 FT / 14.0 FT	15.0 FT / 14.0 FT

	2003 Feasibility	2017 HSLRR
Road Raising	580 FT	580 FT
Stream Closure Gates & Pump Stations		
Road Closure Gate (Miter 50' x 7')	1	1
Flat Creek Sector Gate	1	
Flat Creek Sector Gate Width Opening	35 FT	
Flat Creek Sector Gate Height	20 FT	
Flat Creek Sluice Gate		1
Flat Creek Sluice Gate Width Opening		35 FT
Flat Creek Sluice Gate Height		20 FT
East Creek Sector Gate	1	
East Creek Sector Gate Width Opening	35 FT	
East Creek Sector Gate Height	20 FT	
East Creek Sluice Gate		1
East Creek Sluice Gate Width Opening		35 FT
East Creek Sluice Gate Height		20 FT
Flat Creek Pump Station Capacity	250 CFS	250 CFS
East Creek Pump Station Capacity	100 CFS	100 CFS
Chingarora Creek (CI-3- CI-5) Pump Station Capacity	40 CFS	40 CFS
SHOREFRONT ELEMENT		
Length of Beach and Dune	3,160 FT	3,160 FT
Width of Dune Crest	50 FT	50 FT
Width of Beach Berm	50- 164 FT	50- 164 FT
Elevation of Dune (NGVD29)	17 FT	17 FT
Elevation of Beach Berm (NGVD29)	9 FT	9 FT
Length of Eastern Terminal Groin	228 FT	228 FT
Length of Western Terminal Groin	245 FT	245 FT
Length of Northwestern Revetment	405 FT	405 FT
Length of Southeastern Revetment	630 FT	630 FT
Dune Slopes		
Landward	1V:5H	1V:5H
Seaward	1V:10H	1V:10H
Beach Berm Slope	1V:15H	1V:15H
Renourishment - every 9 years thereafter by trucking	21,000 CY	21,000 CY
Total Initial Fill Beach and Dune (design, advance, overfill and tolerance)	688,000 CY	688,000 CY
REAL ESTATE REQUIREMENTS		
Fee Simple		29.67 AC
Permanent Easements	87.30 AC	63.01 AC
Temporary Easements	3.25 AC	15.25 AC

	2003 Feasibility	2017 HSLRR
ENVIRONMENTAL CONSIDERATIONS		
Wetland Mitigation	17.5 AC	22.0 AC
Mitigation Acquisition	17.5 AC	22.0 AC
ECONOMICS		
Price Level	October 2002	October 2016
Discount Rate	5 7/8 %	2 7/8 %
Initial Project Cost	$ 96,669,300	$ 273,005,000
Annual Project Cost	$ 6,864,000	$ 12,403,700
Average Annual Benefits		
Damage Reduction	$ 10,999,000	$ 14,3164,000
Reduced Maintenance	$ 25,000	$ 38,000
Recreation	$ 8,500	$ 12,500
Total	$ 11,159,500	$ 14,414,500
Net Excess Benefits	$ 4,295,500	$ 2,010,700
Benefit to Cost Ratio	1.6	1.2
COST APPORTIONMENT (First Cost)		
Federal (65%)	$ 59,372,300	$ 177,453,250
Non-Federal (35%)	$ 31,969,700	$ 95,551,750
COST APPORTIONMENT (Continuing Construction Cost - Renourishment)		
Federal (50%)	$ 3,054,600	$ 7,071,000
Non-Federal (50%)	$ 3,054,600	$ 7,071,000
PHYSICAL CONDITIONS		
Tides		
Semi Diurnal	Mean 5.0 FT	Mean 5.0 FT
Tide Range*	Spring 5.6 FT	Spring 5.6 FT
Stage		
Highest Observed Water Level		
Keyport, Sept 12, 1960, (NGVD29 / NAVD88)	10.5 FT / 9.4 FT	
Battery Park, Oct 29, 2012, (NGVD29 / NAVD88)		12.0 FT / 10.9 FT

* Tide data is interpolated from NOAA values at Atlantic Highlands and WayCake Creek

TERMS, ACRONYMS, AND ABBREVIATIONS

AAHU	Average Annual Habitat Unit
APE	Area of Potential Effect
BFE	Base Flood Elevation
CAA	Clean Air Act
CBRA	Coastal Barrier Resources Act
CBRS	Coastal Barrier Resources System
CEQ	Council on Environmental Quality
CFR	Code of Federal Regulations
cfs	Cubic Feet Per Second
CZM	Coastal Zone Management
DPS	Distinct Population Segment
DRV	Depreciated Replacement Value
EC	Engineering Circular
ECB	Engineering Construction Bulletin
EFH	Essential Fish Habitat
EGM	Economic Guidance Memorandum
EIS	Environmental Impact Statement
EM	Engineer Manual
ENR	Engineer News Record
EPW	Evaluation for Planned Wetlands Model
ERDC	Engineer Research and Development Center, U.S. Army Corps of Engineers
ESA	Endangered Species Act
ETL	Engineer Technical Letter
FCU	Functional Capacity Unit
FEMA	Federal Emergency Management Agency
GIS	Geographic Information System
HEC-FDA	Hydrologic Engineering Center - Flood Damage Analysis model
HEC-HMS	Hydrologic Engineering Center - Hydrologic Modeling System
HEP	Habitat Evaluation Procedures Model
HRTW	Hazardous, Toxic, and Radioactive Waste
HSLRR	Hurricane Sandy Limited Reevaluation Report
HWM	High Water Mark
IDC	Interest During Construction
IPCC	Intergovernmental Panel for Climate Change
IWR	USACE, Institute for Water Resources
KCS	Known Contaminated Site
LER	Lands, Easements, and Rights of Way
LERRD	Lands, Easements, Rights-of-way, Relocations, and Disposal areas
LiDAR	Light Detection And Ranging
LOP	Line of Protection
NAAQS	National Ambient Air Quality Standards
NACCS	North Atlantic Coast Comprehensive Study

NAVD88	North American Vertical Datum of 1988
NEPA	National Environmental Policy Act
NFIP	National Flood Insurance Plan
NGVD29	National Geodetic Vertical Datum of 1929
NJDEP	New Jersey Department of Environmental Protection
NOAA	National Oceanic and Atmospheric Administration
NOx	Oxides of Nitrogen
NRC	National Research Council
O&M	Operations and Maintenance
PED	Planning, Engineering, and Design
PPA	Project Partnership Agreement
RCRA	Resource Conservation Recovery Act
REP	Real Estate Plan
ROD	Record of Decision
RONA	Record of Non-Applicability
SBBA	Sea Bright Borrow Area
SBEACH	Storm-induced Beach Change Model
SEIS	Supplemental Environmental Impact Statement
SLR	Sea Level Rise
USACE	U.S. Army Corps of Engineers
USFWS	U.S. Fish and Wildlife Service
USGS	United States Geological Service
UST	Underground Storage Tank
VLM	Vertical Land Movement
VOC	Volatile Organic Compound
WRDA	Water Resources Development Act

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1. INTRODUCTION

1.1 Background

The “Raritan Bay and Sandy Hook Bay, New Jersey Feasibility Report for Hurricane and Storm Damage Reduction – Union Beach, New Jersey” was completed in September 2003. The plan recommended within the report was authorized for construction in the Water Resources Development Act of 2007 (WRDA 2007)[3]. The primary purpose of the project is to provide National Economic Development (NED) benefits for coastal storm risk management.

As a consequence of Hurricane Sandy in October 2012, Congress passed Public Law (P.L.) 113-2, the “Disaster Relief Appropriations Act, 2013”, which authorized supplemental appropriations to federal agencies for expenses related to the consequences of Hurricane Sandy. Chapter 4 of P.L. 113-2 identifies those actions directed by Congress specific to the U.S. Army Corps of Engineers (USACE), including preparation of two interim reports to Congress, a project performance evaluation report, and a comprehensive study to address the flood risks of vulnerable coastal populations in areas affected by Hurricane Sandy within the boundaries of the North Atlantic Division of USACE.

1.2 Purpose and Scope of Hurricane Sandy Limited Reevaluation Report

This Hurricane Sandy Limited Reevaluation Report (HSLRR) serves as a decision document to support the construction of the Raritan Bay and Sandy Hook Bay, New Jersey Coastal Storm Risk Management Project[4]. It addresses relevant changes to the existing conditions that have occurred since the Feasibility Report was completed in September 2003, including changes due to Hurricane Sandy. This HSLRR was prepared to expedite implementation of the authorized but unconstructed project in response to Public Law (P.L.) 113-2 of January 29, 2013, “Disaster Relief Appropriations Act, 2013”.

This HSLRR also provides updated costs that serve as the basis for a Project Partnership Agreement (PPA) between the Federal Government and the non-Federal Sponsor, the New Jersey State Department of Environmental Protection (NJDEP). This HSLRR, which includes a Supplemental Environmental Assessment (SEA), also provides an updated economic analysis and demonstrates that the updated 2007 Authorized Plan is economically justified, environmentally acceptable and technically feasible, and in accordance with current policy. Finally, this HSLRR is prepared to address the requirements of P.L. 113-2, including cost sharing, sustainability, resiliency and consistency with the North Atlantic Coast Comprehensive Study (NACCS).

Consistent with the content of a Limited Reevaluation Report (LRR), this report does not reanalyze the full set of alternatives from the September 2003 Feasibility Report, but updates the 2007 Authorized Plan, and incorporates changes in existing conditions. As such, the project

[3] Referred to throughout this document as the 2007 Authorized Plan.
[4] Formerly referred to as the Raritan Bay and Sandy Hook Bay, New Jersey Coastal Storm Damage Reduction Project.

recommended by this HSLRR is identical to the 2007 Authorized Plan described in the September 2003 Feasibility Report in terms of project composition, and contains minor modifications to design cross sections and alignment refinements – there are no changes in project scope. Accordingly, this HSLRR:

- Summarizes changes that have occurred since approval of the September 2003 Feasibility Report and the effects of these changes on the 2007 Authorized Plan;
- Updates project benefits and costs to the current price level at the applicable FY 16 Federal discount rate of $3^{1/8}$ percent[5];
- Provides changes in benefits and costs compared to September 2003 Feasibility Report values;
- Identifies changes in environmental conditions since the September 2003 Feasibility Report;
- Confirms that the HSLRR Recommended Plan, which incorporates required policy-compliance changes to the 2007 Authorized Plan, remains technically feasible, economically justified and environmentally acceptable and addresses sustainability and resiliency; and
- Establishes the costs, cost sharing and items of local cooperation necessary for the execution of the PPA.

As required by P.L. 113-2, this document is to be approved at the Major Subordinate Command (MSC) level, and further Congressional authorization is not required. This HSLRR will serve as the decision document to use funds provided by P.L. 113-2 and as the basis for executing a Project Partnership Agreement (PPA) with the non-Federal sponsor, in order to proceed to project construction.

1.3 Authorizations

The USACE's involvement in Raritan Bay and Sandy Hook Bay, New Jersey planning was first authorized in 1955 with a second study authorization issued in 1990. Authorization for construction of the recommended plan documented in the September 2003 Feasibility Report was issued in 2007, and this reevaluation was authorized in accordance with P.L. 113-2 in 2013.

1955 Study Authorization

A hurricane protection study[6] was authorized by Public Law 71, 84th Congress, 1st Session on June 16, 1955, in response to severe damage to coastal and tidal areas of the eastern and

[5] All costs and benefits are presented in fiscal year 2016 price level, with the exception of the Executive Summary and Pertinent Data sections, which were updated to October 2016 (fiscal year 2017) price levels and discount rate of $2^{7/8}$ percent

[6] The term "Hurricane Protection" has been replaced by the term "Coastal Storm Risk Management".

southeastern United States, from the hurricanes of August 31, 1954 and September 11, 1954 in New England, New York and New Jersey, and the damages caused by other hurricanes in the past.

> *Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That: In view of the severe damage to the coastal and tidal areas of the eastern and southern United States from the occurrence of hurricanes, particularly the hurricanes of August 31, 1954, and September 11, 1954, in the New England, New York, and New Jersey coastal and tidal areas, and the hurricane of October 15, 1954, in the coastal and tidal areas extending south to South Carolina, and in view of the damages caused by other hurricanes in the past, the Secretary of the Army, in cooperation with the Secretary of Commerce and other Federal agencies concerned with hurricanes, is hereby authorized and directed to cause an examination and survey to be made of the eastern and southern seaboard of the eastern and southern seaboard of the United States with respect to hurricanes, with particular reference to areas where severe damages have occurred.*

1962 Construction Authorization

The existing Federal Project, Raritan Bay and Sandy Hook Bay, New Jersey, was authorized by the Flood Control Act of 12 October 1962 in accordance with House Document No. 464, 87th Congress, 2nd Session. The project provides for: combined shore and hurricane protection at Old Bridge Township (formerly Madison Township), shore protection at Aberdeen Township (formerly Matawan Township) and Union Beach, and shore and hurricane protection at Keansburg and North Middletown (formally East Keansburg). While the Keansburg portion was completed in 1973, the Union Beach portion was not constructed, and was deauthorized in January 1990.

1990 Study Authorization

The September 2003 Feasibility Study for Hurricane and Storm Damage Reduction at Union Beach, New Jersey[7] was authorized by a resolution of the Committee of Public Works and Transportation of the U.S. House of Representatives adopted 1 August 1990, which states:

> *Resolved by the Committee on Public Works and Transportation of the United States House of Representatives, that the Board of Engineers for Rivers and Harbors is requested to review the report of the Chief of Engineers on Raritan Bay and Sandy Hook Bay, New Jersey, published as House Document 464, Eighty-seventh Congress, Second Session, and other pertinent reports, to determine the advisability of modifications to the recommendations contained therein to provide erosion control and storm damage prevention for the Raritan Bay and Sandy Hook Bay.*

2007 Construction Authorization

The project was authorized for construction in the Water Resources Development Act of 2007 (Public Law 110-114) on November 8, 2007, which reads in pertinent part:

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[7] Documented in: *Raritan Bay and Sandy Hook Bay, New Jersey Feasibility Report for Hurricane And Storm Damage Reduction - Union Beach, New Jersey, Final Feasibility Report*, September 2003.

RARITAN BAY AND SANDY HOOK BAY, UNION BEACH, NEW JERSEY. The project for hurricane and storm damage reduction, Raritan Bay and Sandy Hook Bay, Union Beach, New Jersey: Report of the Chief of Engineers dated January 4, 2006, at a total cost of $115,000,000, with an estimated Federal cost of $74,800,000 and an estimated non-Federal cost of $40,200,000, and at an estimated total cost of $6,500,000 for periodic nourishment over the 50-year life of the project, with an estimated Federal cost of $3,250,000 and an estimated non-Federal cost of $3,250,000.

2013 HSLRR Authorization

The First Interim Report of the Public Law (P.L.) 113-2 identifies the Raritan Bay to Sandy Hook Bay, Union Beach, NJ project among the list of projects that meet the criteria for "Authorized but Unconstructed Projects". The language in the Report directing the preparation of this HSLRR states:

"When determining how to move forward in implementing project specific measures in accordance with the funding and direction in the Act, the Corps will perform an expedited limited re-evaluation that addresses resiliency, economics, risks, environmental compliance, and long-term sustainability…."

1.4 Prior Studies and Reports

February 1960 Report

Funds for a hurricane survey of Raritan Bay and Sandy Hook Bay from Highlands to South Amboy, New Jersey were allotted by the Chief of Engineers by letter, dated 1 October 1957. A combined report covering the cooperative beach erosion control study and the hurricane survey was approved by the Chief of Engineers on 12 February 1960. Recommendations of the report included a shore protection improvement providing for about 0.6 mile of beach fill at an elevation of 5.5 feet above mean sea level at the Borough of Union Beach, New Jersey.

March 1993 Reconnaissance Report

The community of Union Beach was addressed in the Reconnaissance Study Report for Raritan Bay and Sandy Hook Bay, dated March 1993. The Reconnaissance Report focused on Port Monmouth (a community within Middletown Township). The Reconnaissance Report also identified potential Federal interest for Leonardo (a community within Middletown Township), Highlands, Union Beach, Keyport, and Cliffwood Beach.

March 1996 Preliminary Feasibility Study

Considering the complexity of coastal processes and interior drainage in the area, and lack of primary data, a preliminary-feasibility study was undertaken to verify interest in conducting feasibility level studies at Union Beach. The preliminary-feasibility study for Union Beach was completed in March 1996 and determined that there was Federal interest in conducting a full feasibility study. The State of New Jersey supported the findings and agreed to participate as the local sponsor and cost share partner for the study.

The Pre-Feasibility Report was approved in July 1996 as a basis to execute a Feasibility Cost Sharing Agreement, which was signed in April 1997.

September 2003 Feasibility Study

The purpose of the September 2003 Feasibility Study was to evaluate at Union Beach, New Jersey, all reasonable solutions to the problems identified in the Reconnaissance Study, which included tidal flooding and shoreline erosion. The final Union Beach Feasibility Report and Environmental Impact Statement (EIS) were approved and released to the public in January 2004. The report recommended implementation of a coastal storm risk management project consisting of a combination of levees and floodwalls, tide gates, pump stations and a dune and beach berm with terminal groins. The project would also construct wetland mitigation sites to mitigate for the loss of wetlands. The final feasibility report and EIS (Chief's Report) was approved by USACE Headquarters on January 4, 2006.

Construction for the project was authorized in November 2007, and a Design Agreement was executed with the New Jersey Department of Environmental Protection (NJDEP) in July 2008.

January 2011 Value Engineering Study

A Value Engineering Study report was completed and the results were presented to the Borough of Union Beach and NJDEP on January 20, 2011. In coordination with NJDEP and Borough representatives, USACE began moving forward with the Preconstruction, Engineering and Design (PED) which was underway when the project area was impacted by Hurricane Sandy in October 2012.

1.5 Nearby Federal Projects and Studies for Coastal Storm Risk Management

Four (4) additional Federal projects and studies for coastal storm risk management are located near the project area along Raritan and Sandy Hook Bay:

- Highlands Borough;
- Keyport Borough;
- Leonardo (a community within Middletown Township);
- Port Monmouth (a community within Middletown Township); and
- Keansburg, North Middletown (formally East Keansburg) and Laurence Harbor.

Highlands Borough

The Raritan Bay and Sandy Hook Bay, New Jersey, Hurricane and Storm Damage Reduction Highlands Study was authorized by a resolution of the Committee on Public Works and Transportation, U.S. House of Representatives, adopted August 1, 1990. The Highlands study area is roughly 0.7 square miles in extent, and is located at the eastern limit of the overall Raritan Bay and Sandy Hook Bay study area. The Highlands study area is bordered to the north by Sandy Hook Bay, to the west by the corporate limits of Atlantic Highlands, and to the east by the

Shrewsbury River and Route 36 Bridge. Highlands Borough is generally about 2,000 feet wide, and its topography is flat for about 1,500 feet onshore from the bay, after which the ground rises rapidly to an elevation of 240 feet.

Highlands Borough is a fully developed community with most year-round residences and commercial establishments located on the low lying area along the bay. Highlands has a history of devastating flood damages, as most of the bulkheads in the study area are low and allow frequent flooding. More than 1,000 homes in the low-lying area were damaged during Hurricane Sandy, as well as municipal buildings, restaurants, and many small businesses. The draft Feasibility Report and Environmental Assessment described a combination bulkhead and floodwall plan, and was released for public and agency review in July 2015. The work ongoing includes optimization of the plan, with the final Feasibility Report to be completed in 2017, however project implementation is in doubt due to a Borough of Highlands Resolution (#17-083), dated April 6, 2017, rejecting the proposed coastal storm risk management project and declining to issue a Letter of Support.

Keyport Borough

The Raritan Bay and Sandy Hook Bay, New Jersey Hurricane and Storm Damage Reduction Keyport Study was authorized by a resolution of the Committee on Public Works and Transportation, U.S. House of Representatives, adopted August 1, 1990. The Borough of Keyport has a total area extent of about 1.4 square miles and is situated along the Raritan Bay shoreline. Keyport is bounded by the Township of Raritan to the south, Raritan Bay to the north, Chingarora Creek to the east, and Matawan Creek to the west. Elevations range from 0 feet at the shore to nearly +50 feet at the southwestern portion of the Borough.

Keyport Borough is a fully developed residential and commercial community. Flooding primarily occurs in the low-lying waterfront commercial and marine commercial area in the central and western portions of the Borough, as well as residential areas in the east. Flooding also occurs in inland portions of the Borough (primarily residential) in the vicinity of the Luppatatong and Chingarora Creeks. Prior to Hurricane Sandy, the feasibility study found no Federal interest in a costal storm risk management project. At the request of the Borough, NJDEP and the Borough’s Congressional representative, the analysis was updated to include additional data that was developed after Hurricane Sandy. The 2016 analysis confirmed no Federal Interest.

Leonardo (a community within Middletown Township)

The Raritan Bay and Sandy Hook Bay, New Jersey, Hurricane and Storm Damage Reduction Leonardo Study was authorized by a resolution of the Committee on Public Works and Transportation, U.S. House of Representatives, adopted August 1, 1990. The Leonardo study area is located in the northeastern portion of Middletown Township in Monmouth County. An existing Federal navigation project provides access for the Leonardo State Marina to deep water in Raritan Bay. Low-lying residential and commercial structures in the area experience tidal flooding by coastal storm events.

A draft Feasibility Report, which would have recommended nonstructural treatments to residences in the area, was nearly complete when the project area was struck by Hurricane Sandy. Extensive damages to the community have made the study eligible for re-evaluation in consideration of damages sustained and changes in conditions via P.L. 113-2. The draft Feasibility Report and Environmental Assessment described a nonstructural plan to elevate a small group structures, and was released for public and agency review in March 2015. The final Feasibility Report was completed in 2016 and recommended a nonstructural plan to be implemented under Section 103 of the Continuing Authorities Program.

Port Monmouth (a community within Middletown Township)

The Raritan Bay and Sandy Hook Bay, New Jersey, Hurricane and Storm Damage Reduction Port Monmouth Project was authorized for construction in the Water Resources Development Act of 2000 (Public Law106-541) on December 11, 2000. The project area is in Middletown Township, Monmouth County, situated between Pews Creek and Compton's Creek. The selected plan in the June 2000 feasibility report includes about 7070 feet of levees, 3585 feet of floodwalls, 2640 feet of dune (4640 feet of placement with taper sections), a storm-tide gate, and periodic beach nourishment on a 10-year cycle.

The Preconstruction, Engineering and Design (PED) Phase was initiated in May 2002, and a Hurricane Sandy Limited Reevaluation Report (HSLRR) approved December 2013. The first set of Plans and Specifications have been completed and a PPA between USACE and New Jersey Department of Environmental Protection was executed in January 2014. The dune, groin, pier extension and beach fill coastal features of the project was part of the first construction contract awarded in the Spring/Summer of 2014. Currently the engineering and design work is underway for the remaining project components that include Wetland mitigation, Pump Stations, Road Raising, Closure Gates, Levees, and Floodwalls.

Keansburg, North Middletown (formally East Keansburg) and Laurence Harbor

The Raritan Bay and Sandy Hook Bay, New Jersey (Keansburg, East Keansburg, and Laurence Harbor, New Jersey) Beach Erosion and Hurricane Project was authorized by the Flood Control Act of October 12, 1962 (and reauthorized by Section 363 of WRDA 1996), as a dual purpose Beach Erosion Control and Hurricane Protection Project. The constructed project lies along Raritan Bay and Sandy Hook Bay and encompasses 2.7 miles of shoreline in the Borough of Keansburg and in North Middletown (formally East Keansburg), Monmouth County, and 0.6 miles of shoreline in Laurence Harbor, located in Old Bridge Township, Middlesex County, New Jersey. The completed project consists of groins, a beach berm, levees, pump station, floodwall, and a storm closure gate in the Keansburg area. Similarly, the Corps constructed a beach berm and levees at Laurence Harbor in 1966.

Periodic nourishment was not included in the original project authorization, but Section 506 of WRDA 1996 authorized periodic nourishment for 50 years from initiation of construction, subject to a review of the project, in accordance with WRDA 1976 and Section 934 of WRDA 1986, as amended. However, periodic nourishment was not approved due to the 50 year period of analysis of the project expiring.

The completed project was designed for an event with a 500-year return period, and the project sustained considerable damages during the flooding resulting from Hurricane Sandy. Among these damages were loss of beach fill (~269,000 CY), lowering and flattening of the berm over the entire project length, significant damage to the closure levees in Keansburg and two wingwalls at the tide gate structure in Keansburg. These damages were repaired, including the fully authorized beachfill profile, using the authorization of Public Law (PL) 84-99, Flood and Coastal Storm Emergencies (33 U.S.C. 701n) (69 Statute 186), which authorizes the rehabilitation of federally authorized and constructed hurricane or shore projection projects.

1.6 Organization of Report

The remainder of this report is arranged to provide the following information:

Section 2: Overview of the 2007 Authorized Plan

Section 3: Existing Conditions

Section 4: Reevaluation of Project Design and Performance

Section 5: Reevaluation of Project Real Estate Requirements

Section 6: Reevaluation of Project Costs

Section 7: Reevaluation of Economic Benefits

Section 8: Reevaluation of Economic Performance

Section 9: Reevaluation of Environmental Impacts

Section 10: Public Law 113-2 Considerations

Section 11: Recommendations

2. OVERVIEW OF THE 2007 AUTHORIZED PLAN

2.1 Project Area

The Union Beach project area is located in the northern portion of Monmouth County, New Jersey as shown in Figure 1. It occupies a 1.8 square mile area of land along the coast of the Raritan Bay. The project area is defined by the Raritan Bay to the north, the Borough of Keansburg to the east, the Township of Hazlet to the south, and Chingarora Creek to the west (see Figure 2). Flat Creek and East Creek both flow through sections of Union Beach; all creeks flow north into Raritan Bay. To the east of East Creek is a levee with a nominal crest elevation of +15 feet NGVD29[8], which is part an adjacent Federal project – the Raritan Bay and Sandy Hook Bay Beach Erosion and Hurricane Protection project for the Borough of Keansburg, North Middletown and Laurence Harbor.

The western portion of Union Beach is characterized by low-lying marsh with some beach. The developed section of Union Beach at the Raritan Bay shoreline is lined by assorted bulkheads and seawalls. A locally constructed 1,850 foot long bulkhead parallels Front Street. The eastern shoreline of Union Beach is also characterized as an unprotected marsh.

Figure 1: Project Area Location

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[8] It is recognized that current practice is to use vertical datum NAVD88, though vertical datum NGVD29 was used in Union Beach HSLRR analyses to ease comparisons with the 2003 Feasibility Report.

Figure 2: Project Area Overview

The topography of Union Beach is characterized by low, flat terrain. Elevations range from 0 feet NGVD29[9] along the Raritan Bay coastline, to a maximum of approximately +20 feet NGVD29 in the extreme southeastern and southwestern portions. Wide stretches of tidal marsh are located along the creeks and a portion of the bay shoreline.

The Borough's interior stormwater drainage system contains 38 outfalls. One outfall discharges directly into Raritan Bay, one into Natco Lake, ten into the marshlands along the western end of the Borough and four into the marshlands into the eastern edge. East Creek provides drainage for six stormwater outfalls and Flat Creek provides for 16 outfalls. The flat gradient of the streams and the low relief of the surrounding terrain make the project area extremely vulnerable to interior flooding during the periods of heavy rainfall. Severe thunderstorm activity in conjunction with high tides causes the creeks to overtop and spread their floodwaters within the broad floodplain.

2.2 Description of the 2007 Authorized Plan

As shown in Figure 3, the 2007 Authorized Plan documented in the September 2003 Feasibility Report is a beach berm and dune system with revetments and two terminal groins along the Raritan

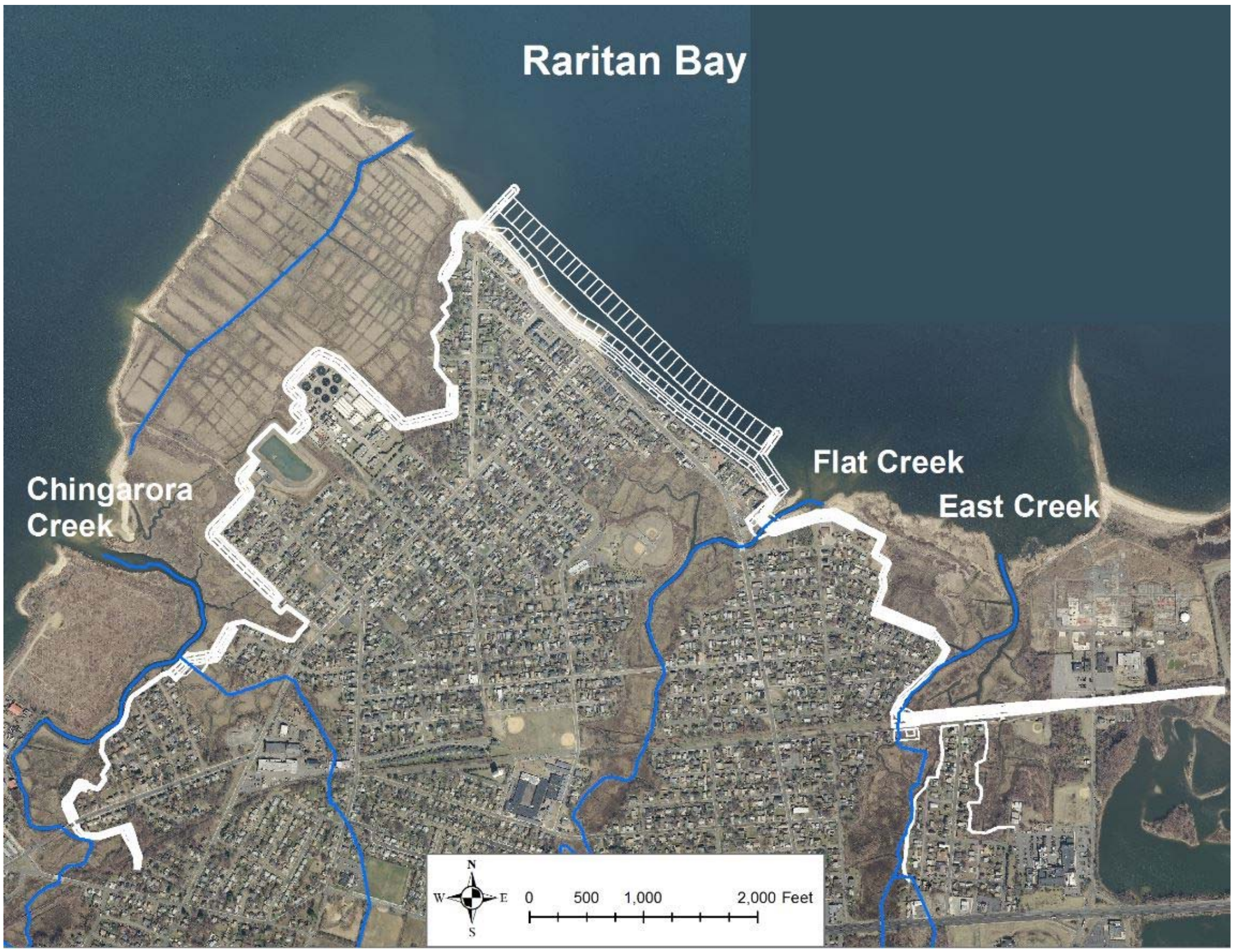
[9] 1929 NGVD is National Geodetic Vertical Datum, which is equal to Sea Level Datum

Bayshore, with a system of levees and floodwalls provided along Chingarora and East Creeks and crossing Flat Creek. The overall length of the 2007 Authorized Plan is 20,915 feet, and is comprised of 3,160 feet of dune, 10,870 feet of levee (Chingarora: 6,428 feet, Flat / East: 4,442 feet), and 6,885 feet of floodwall (Chingarora: 4,956 feet, Flat / East: 1,929 feet).

Also included in the 2007 Authorized Plan are a road closure gate, two road raisings, three pump stations, two sector gates, and six tide gate structures with sluice gates.

The discussion below separates the 2007 Authorized Plan into three elements: Chingarora Creek, Shorefront, and East Creek / Flat Creek.

Figure 3: Overview of 2007 Authorized Plan Alignment



2.2.1 Chingarora Creek Element of the 2007 Authorized Plan

The Chingarora Creek element of the 2007 Authorized Plan includes 6,428 feet of earthen levee, 4,468 feet of I-type floodwall, and 488 feet of T-type floodwall – each with a top elevation of + 15 feet NGVD29. Also included in this element are a 40 cfs pump station, a road closure gate, and three sluice gates that cross a Chingarora Creek tributary. The alignment begins at high ground

(+ 15 feet NGVD29) near the intersection of Florence Avenue and Bank Street and ends at the northwestern end of the shorefront element. Figures 4, 5, and 6 provide an overview.

Figure 4 shows the 2007 Authorized Plan alignment beginning as an earthen levee approximately 500 feet southwest of the intersection of Florence Avenue and Bank Street. The levee has a 10-foot top width and side slopes at 1V:2.5H. At the design elevation of +15 feet NGVD29, the levee ranges between five and 11 feet above existing grade through this section. The levee alignment crosses over the Monmouth County Parks Henry Hudson Trail and continues approximately 370 feet northwest. Access to the Henry Hudson Trail will be maintained with a paved transition to the trail over the levee. At this point, the alignment continues as a T-type floodwall, on a spread footing, for 488 feet along the north side of Chingarora Creek and the rear of the property lines of the homes fronting Broadway, with an average height of approximately 10 feet above existing grade.

The floodwall continues westerly along the properties on Broadway to a 45-foot long and 7-foot above existing grade hinged road closure gate crossing Broadway, which will be closed by public works crews during flood events. The alignment continues from the road closure gate as a levee, averaging seven feet above existing grade for approximately 440 feet along the rear property lines of the homes fronting State Street to a point approximately 500 feet northeast from the intersection of Broadway and Walnut Street. From this point, the alignment continues as an I-type floodwall seven feet above existing grade for approximately 1,500 feet along the wetlands east of the creek, perpendicular to Aspen, West and Ash Streets. The alignment continues as a levee 11 feet above existing grade along the wetlands north of Ash Street for approximately 130 feet to the three (2 gates at the main branch and 1 gate at the northern branch) 6 ft x 6 ft storm type sluice gates crossing the Chingarora Tributary.

Figure 4: Chingarora Creek Element (1 of 3)

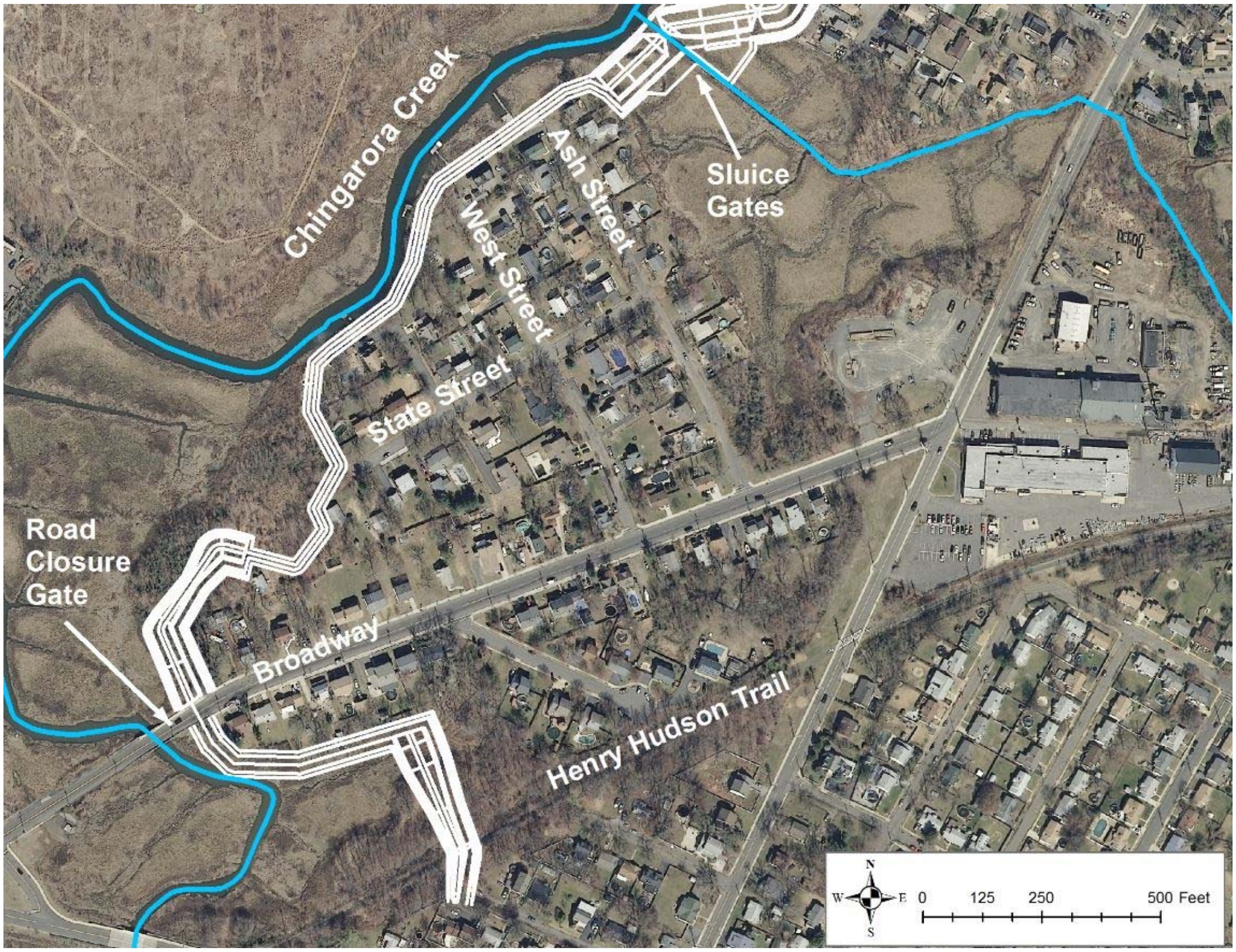
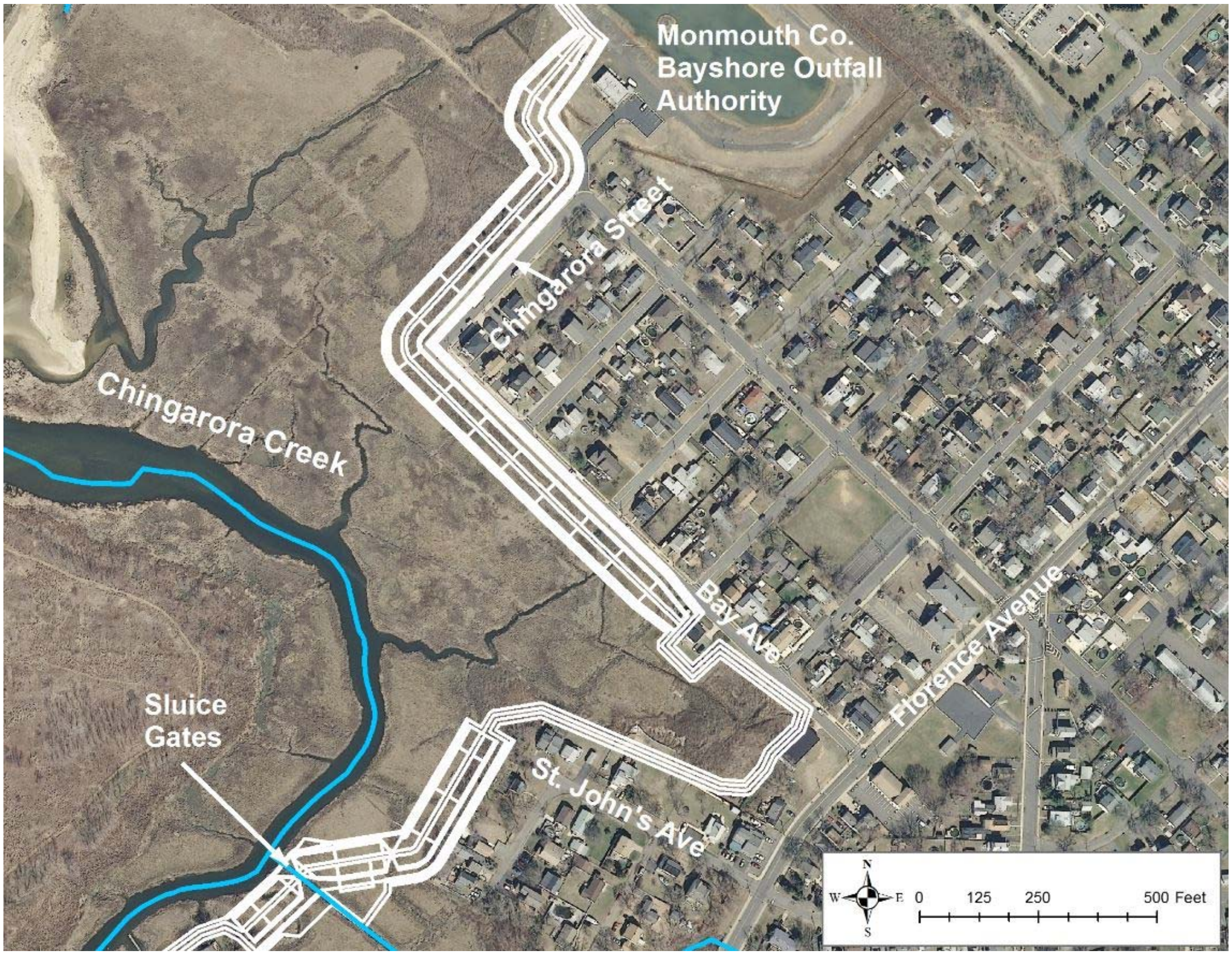


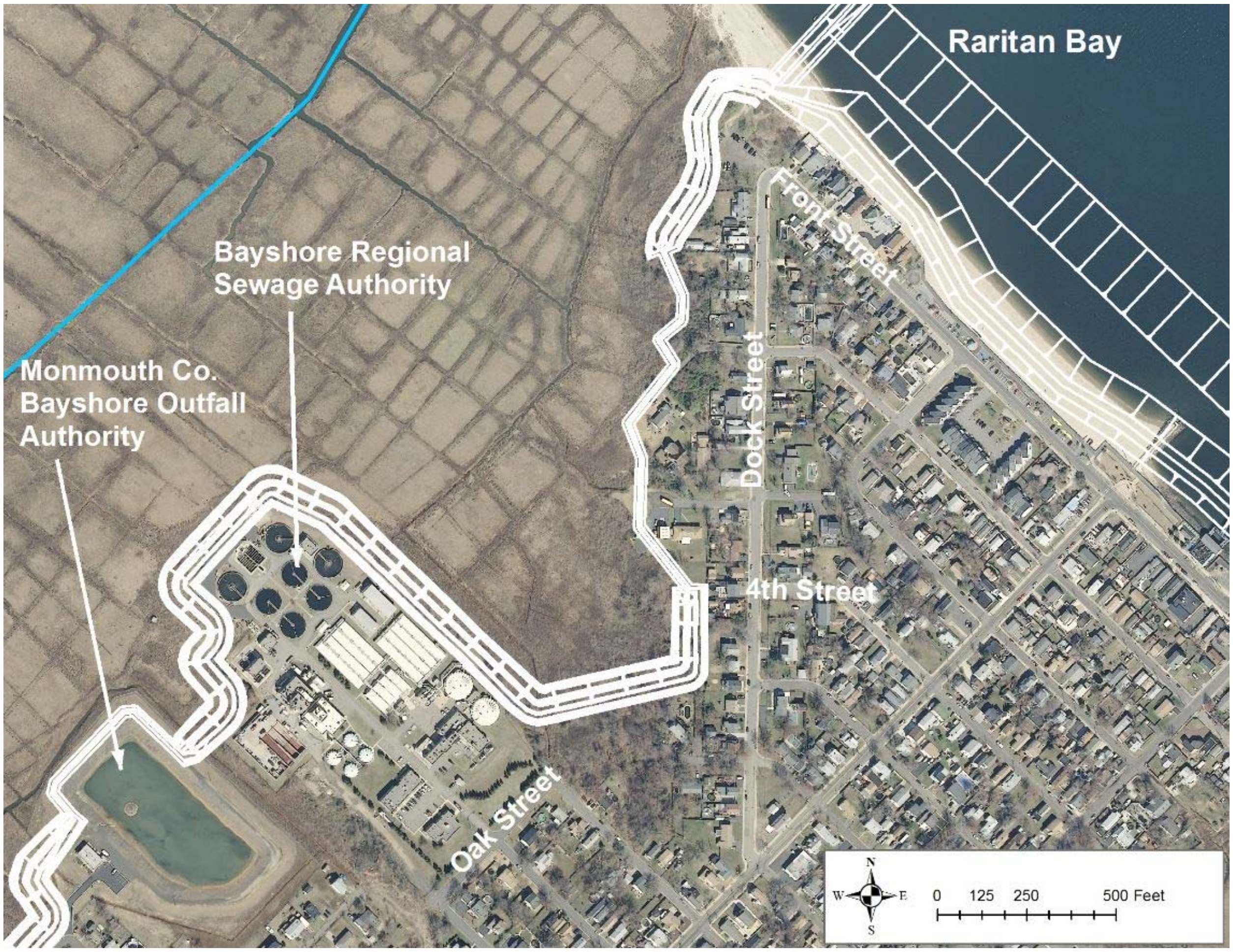
Figure 5 shows the Authorized Plan levee continuing for approximately 520 feet to St. Johns Avenue where it proceeds as an I-type floodwall with an average height of 10 feet above existing grade for 1,250 feet along the wetland limits between St. Johns Avenue, Florence Avenue, and Bay Avenue. A 40 cfs pump station will be located near Bay Avenue. The 2007 Authorized Plan alignment continues as a levee 11 feet above existing grade for 1,670 feet running parallel to Bay Avenue and Chingarora Street to the Monmouth County Bayshore Outfall Authority Settlement Pond.

Figure 5: Chingarora Creek Element (2 of 3)



The 2007 Authorized Plan alignment continues as an I-type floodwall three feet above existing grade for 600 feet along the westerly edge of the Monmouth County Bayshore Outfall Authority settlement pond to a levee about 910 feet northwest from the intersection of 8th Street and Oak Street. The levee alignment continues behind the Bayshore Regional Sewage Authority facility for approximately 2,610 feet along the wetlands limits to approximately 200 feet southwest from the intersection of Dock Street and 4th Street with an average height of 10 feet above existing grade. From this point, the alignment continues as an I-type floodwall nine feet above existing grade, running parallel and west of Dock Street for approximately 1,115 feet along the limits of the wetlands where it transitions to a levee. The levee alignment continues for approximately 670 feet with an average height of eight feet above existing grade, to tie into a sand dune behind the terminal groin of the bayshore approximately 250 feet north of the intersection of Dock Street and Front Street.

Figure 6: Chingarora Creek Element (3 of 3)

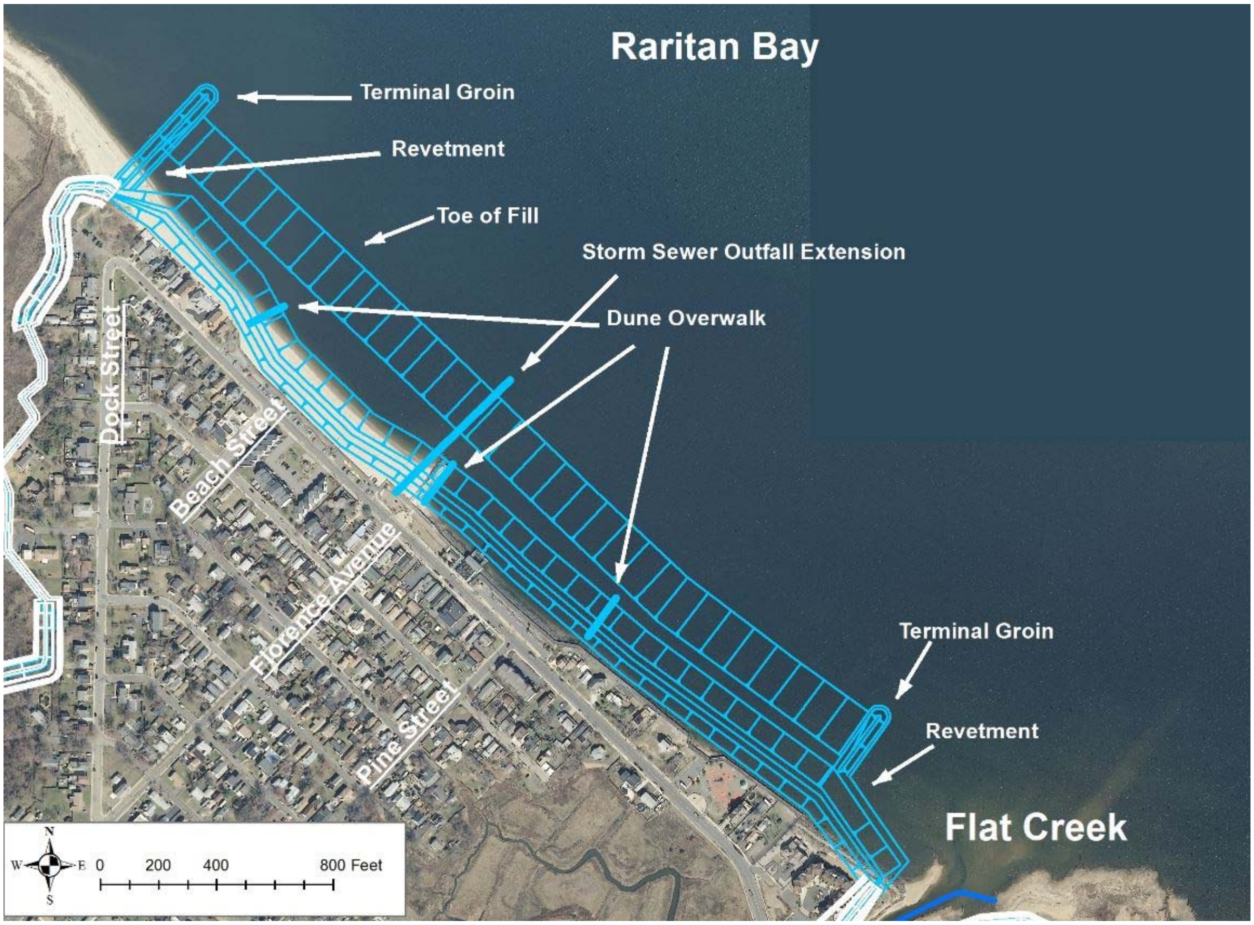


2.2.2 Shorefront Element of the 2007 Authorized Plan

The shorefront element consists of a beach and dune (overall length 3,160 feet) incorporating two terminal groins with adjoining revetments stretching from the Chingarora Creek levee/floodwall alignment to the southeastern limit of the dune that tie into the levee alignment near Flat Creek. The dune generally follows the layout of the existing shoreline and extends bayward along the existing bulkheads and beach.

To provide similar coastal storm risk management capability as the adjacent levees and floodwalls, a dune will be constructed with an elevation of + 17 feet NGVD29. The dune crest will be 50 feet wide, with a landward slope of 1 vertical on 5 horizontal (1V:5H) and a bayward slope of 1V:10H extending from the dune crest to the +9 feet NGVD29 berm elevation. The width of the horizontal berm will range from a minimum of 50 feet near the two terminal groins to a maximum of 164 feet between Beach Street and Florence Avenue. From the bayward edge of the berm, the beach will follow a slope of 1V: 15H to the existing bay bottom (approximately -3 feet NGVD29). The total initial fill volume will be approximately 688,000 cubic yards (cy), including advance fill, overfill, and tolerance.

Figure 7: Shorefront Element



Twelve feet of advance fill would be placed with initial construction, with 21,000 cubic yards of periodic renourishment to follow approximately 9 years after construction, continuing at a 9-year cycle. The nine-year renourishment interval was identified as the economically optimized renourishment interval. The periodic renourishment design meets both the long-term erosion needs as well as storm survivability requirements. Material would be utilized from the Sea Bright borrow area by hydraulic dredging for initial construction and an upland source by trucking for subsequent renourishment.

The dune section will be stabilized with dune grass and fencing. Three wood frame, dune walkovers located across from midway between Dock Street and Beach Street, across from Florence Avenue and across from Pine Street, will be constructed to allow for access to the beach, and to protect dune vegetation from pedestrian damage. A walkway connecting the overwalks will run along the crest of the dune to provide views of the bayfront. The existing storm outfall near

Florence Avenue will be extended in conjunction with other drainage improvements based on the structure's current design.

To reduce fill losses and the drift of fill material into the adjacent salt marshes and to reduce initial renourishment beach fill costs, terminal groins will be constructed at both ends of the beach and dune fill. The structures will extend to the seaward toe of the beach fill. The length of the eastern and western groins were designed to be approximately 228 and 245 feet long respectively, to contain the design cross section, advance fill, and expected sand fillet growth. Along the beach berm, the crest elevation of both groins will be +10 feet NGVD29. At the edge of the construction berm, the crests of the structures will decrease from +10 feet NGVD29 to +6 feet NGVD29 at a slope of 1V:15H. The offshore sections of the structures, designed to be visible at all phases of the tide, will feature a level crest at elevation +6 feet NGVD29. The slopes on the seaward ends of the structures will be 1V:2H. Side slopes along the entire length of the structure will be 1V:2H

Where the beach and dune fill ties in to the adjoining levees, the terminal groins will terminate at revetments. At the northwest end of the fill area, the revetment will extend 405 feet along the transition between the levee and the dune fill. Near the levee, the slope of the revetment will be 1V: 2.5H. Near the dune, the slope of the revetment will be 1V: 2.5H below +9 feet NGVD29 and 1V:10H above +9 feet NGVD29, equal to the slope of the dune.

At the southeast end of the fill area, the revetment will consist of two sections - a 380 foot long section extending from the terminal groin to Flat Creek, and a 250-foot section parallel to Flat Creek extending from the existing shoreline to the tide gate. Along the section parallel to Flat Creek, the slope of the revetment will be 1V: 2.5H. Along the section near the groin, the slope of the revetments will be 1V: 2.5H below +9 feet NGVD29 and 1V:10H above +9 feet NGVD29.

The landward end of the groin near Flat Creek coincides with proposed dune and levee. The landward end of the groin near Dock Street is located near the design berm. Between the landward end of the groin and the levee is a revetment section similar to the one protecting the dune/levee transition section.

2.2.3 Flat / East Creek Element of the 2007 Authorized Plan

The Flat / East Creek element of the 2007 Authorized Plan includes 4,442 feet of earthen levee, and 1,929 feet of T-type floodwall – each with a top elevation of + 15 feet NGVD29. Also included in this element are a 250 cfs pump station, a 100 cfs pump station, a sector gate crossing East Creek, a sector gate crossing Flat Creek, three sluice gates that cross an East Creek tributary, and an interior levee with a length of 3,888 feet and top elevation of + 8 feet NGVD29.

The Flat / East Creeks element begins at the southeastern limit of the Shorefront element and ties into the existing Keansburg levee at the eastern end of the project limits. Figure 8 provides an overview.

Figure 8: Flat / East Creek Element Overview

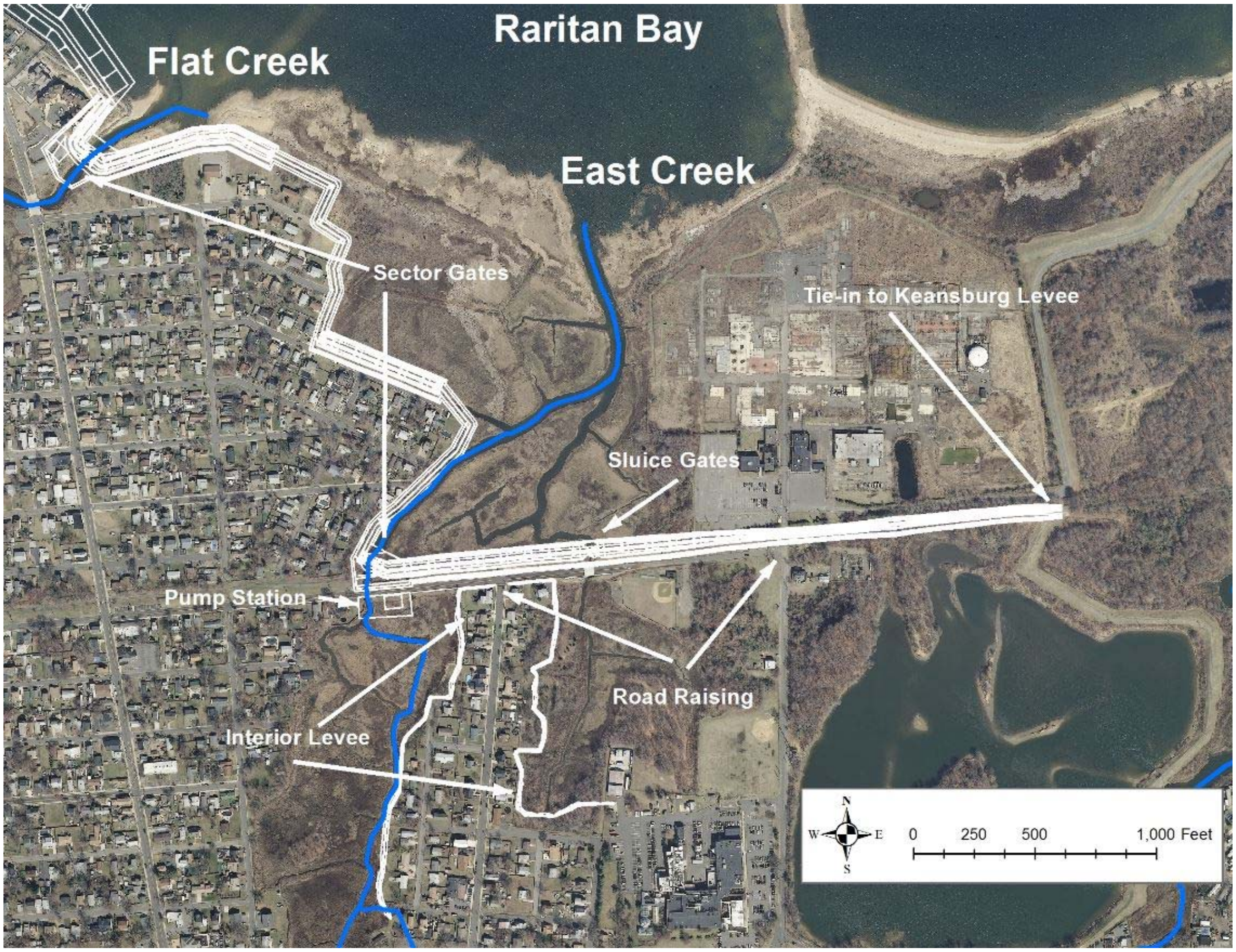
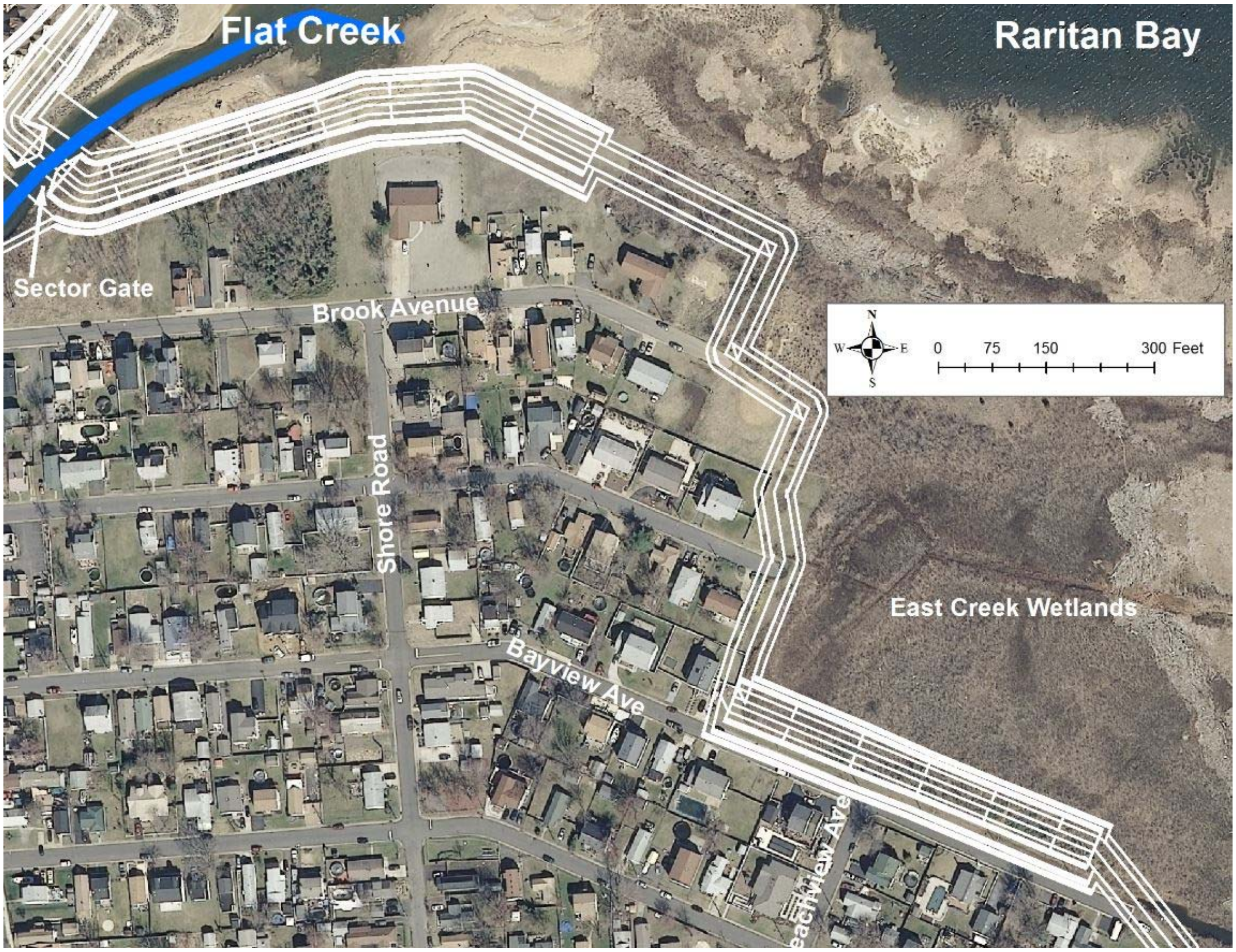


Figure 9 shows the 2007 Authorized Plan alignment beginning at the eastern end of the Shorefront element, approximately 550 feet northwest of the intersection of Union Avenue and Brook Avenue, as a levee running parallel to Flat Creek along the left descending bank for approximately 278 feet. The levee has a 10-foot top width and side slopes at 1V:2.5H. At the design elevation of +15 feet NGVD29 the levee ranges between five and 11 feet above existing grade through this section. A 35-foot long sector gate crosses Flat creek, approximately 150 feet downstream from the Union Avenue Bridge. A 250 cfs pump station will be located near the gate. The alignment continues along the east bank of Flat Creek as a levee for approximately 790 feet along the rear of the residential homes which front Brook Avenue. Riprap slope protection is provided for this section of levee to protect against wave action. The nine-foot high levee runs nearly parallel to Brook Avenue to a T-type floodwall, on pile foundations, about 350 feet northeast from the intersection of Brook Avenue and Shore Road.

The T-type floodwall continues southerly at a height of nine feet above existing grade for approximately 1,015 feet along the wetlands limits until it terminates 250 feet northwest from the intersection of Bayview Avenue and Beachview Avenue. From this point, a levee, averaging nine feet in height above existing grade, continues for approximately 540 feet easterly along the wetlands of East Creek parallel to Bayview Avenue.

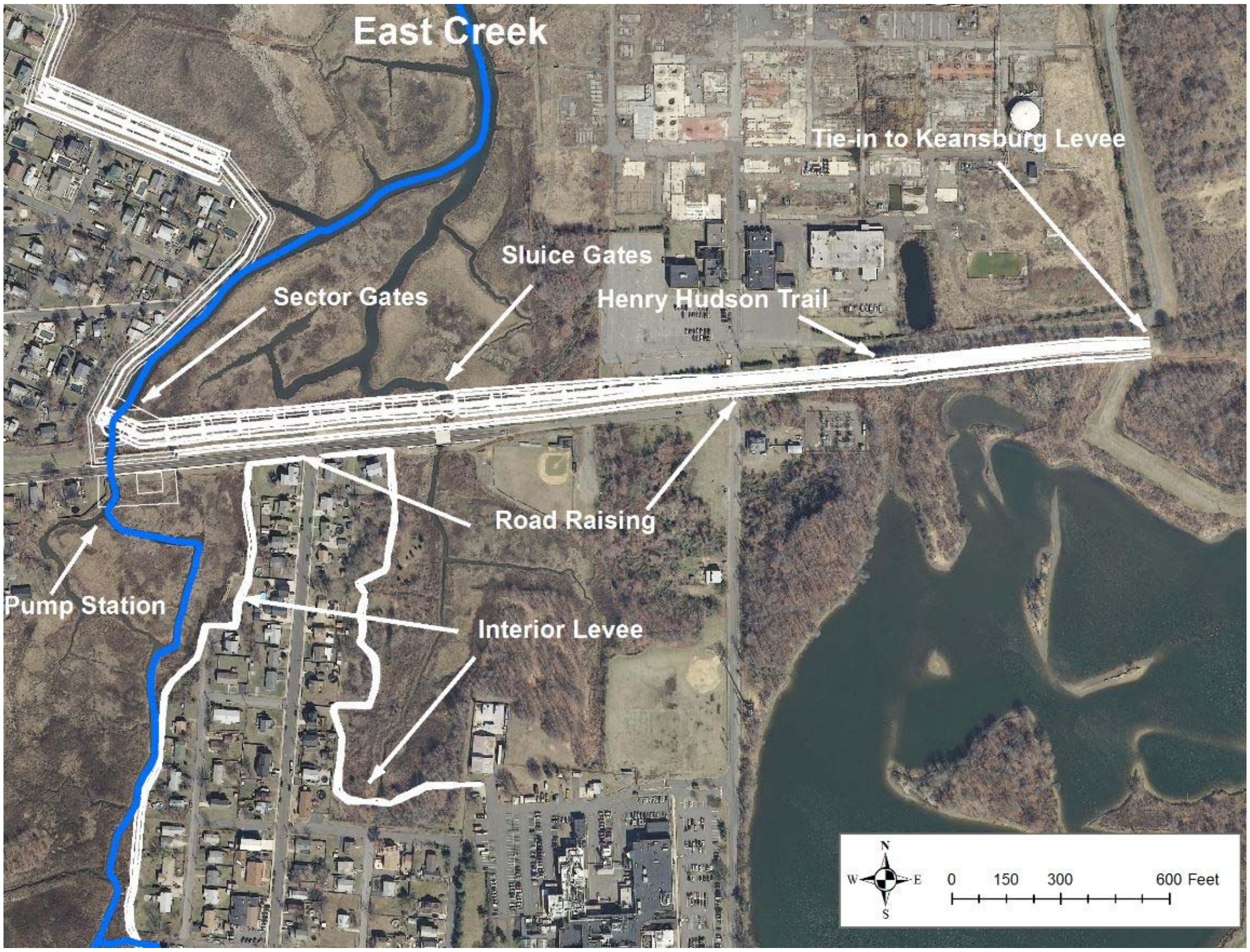
Figure 9: Flat / East Creek Element (1 of 2)



As shown in Figure 10, the levee abuts a T-type floodwall at nine feet above existing grade, on pile foundations, near the easterly end of Bayview Avenue, which continues along the edge of the wetlands for approximately 916 feet. The alignment continues east as a levee, ranging in height from three to ten feet above existing grade, for approximately 2,920 feet along the Monmouth County Henry Hudson Trail. A 35-foot long sector gate will cross East Creek, with a 100 cfs pump station located near the gate. Three 6 ft x 6 ft storm type sluice gates cross the East Creek tributary. The entrance to the International Foods and Flavors plant will be raised where the levee intersects the driveway.

The levee will tie into the high ground where the existing Keansburg levee intersects the Henry Hudson Trail at elevation + 15 NGVD29.

Figure 10: Flat / East Creek Element (2 of 2)



A small supplemental interior levee of the 2007 Authorized Plan will protect the low lying homes within the area between East Creek and East Creek Tributary while allowing flooding of the adjacent wetlands for the full range of non-storm tidal conditions. The interior levee has a top width of 2 feet and side slopes at 1V:2H. At the design elevation of + 8 feet NGVD29, the average levee height will be 2 feet above existing grade. The interior levee begins at the west end of Isabella Avenue and continues north along the edge of the wetlands for approximately 1,670 feet. The intersection of Harris Avenue and Jersey Avenue will be raised where the levee intersects Harris Avenue. The levee continues east and south along the edge of the wetlands for approximately 1,715 feet where it ties into the existing high ground, elevation +8 feet NGVD29, approximately 130 feet north of the Willow Street and Wesley Avenue intersection.

3. EXISTING CONDITIONS

This section provides a summary of the natural and human environment within the Union Beach project area. The description provides a baseline for measuring expected changes in the physical, environmental, cultural, social, and economic settings that would result from implementation of a coastal storm risk management project in the project area.

3.1 Description of the Problem

Tropical and extratropical storms have historically impacted the Raritan and Sandy Hook Bayshore areas, greatly altering the shoreline composition over time and causing extensive flooding and erosion to the project area. Storm induced erosion has removed much of the beachfront and expedited deterioration of the existing coastal protection and drainage structures prior to reconstruction of the public beach and the seawall. In addition to physical alterations, tidal surges often block existing storm drainage systems, resulting in prolonged and extensive flooding.

Storms impacting the area include:

- September 14, 1944 hurricane;
- Extratropical storm of November 25,1950 and November 6-7, 1953;
- Hurricane Donna (September 12, 1960);
- March 6-8, 1962, Nor'easter;
- March 12, 1984, Nor'easter;
- December 11, 1992, Nor'easter; and most recently
- Hurricane Sandy (October 29, 2012)

These storms also resulted in transportation problems such as loss of rail service and damaged roads and bridges; damage or destruction of shoreline structures such as dunes, jetties, bulkheads, groins; damage to utility lines and sewers; damage and destruction of homes and commercial properties; and the deposit of storm debris throughout Union Beach and surrounding Bayshore areas. Overall, these storms have resulted in extensive damage to shorefront and upland properties, numerous evacuations, and have been a significant constraint to commerce and regional economic development.

Historically, the largest damages within the Union Beach area have resulted from tidal inundation within the low-lying areas adjacent to Chingarora Creek, Flat Creek, and East Creek. Tidal floodwaters enter the creeks and rapidly spread over the low-lying flood plain from both the east and the west. Extensive damage to hundreds of structures has been recorded in Union Beach during such storms. In addition, nearshore structures are subject to damage when waves overwash the beach and bulkheads. It is estimated that 8 percent of building damages are due to waves or erosion, with the remaining 92 percent due to inundation alone.

3.1.1 Hurricane Sandy

When Hurricane Sandy struck the coast of New Jersey on October 29, 2012, it brought extensive damage to Union Beach. Approximately 90 percent of the Borough's land was flooded, ranging from 2 to 10 feet in depth. Union Beach reported that 60 properties were destroyed by Hurricane Sandy and 629 properties experienced substantial damage. Approximately 24,500 tons of storm damage debris littered the Borough. Trees and power lines throughout the Borough fell. The Borough also faced total power outages for over two weeks.

A summarized list of Hurricane Sandy's impacts[10] to Union Beach include (but are not limited to) the following:

- Major inundation of approximately 90 percent of the Borough's land ranging from 2 to 10 feet in depth.
- Inundation of over 2,000 housing units ranging from 2 to 10 feet in depth, and substantial damage to over 20 percent of the Borough's housing stock.
- Inoperability of most municipal buildings, fire houses, and emergency medical service buildings for months following the storm.
- Destruction of Borough-owned vehicles, including one EMS first responder unit, two ambulances, 12 police vehicles, and 16 public works vehicles.
- Inundation of the Bayshore Regional Sewage Authority wastewater treatment plant (serves 100,000 people in eight townships) in three to five feet of salt water. Every process in the plant was damaged, and full operation was delayed for several months while the plant's incinerator system was reconstructed.

Prior to Hurricane Sandy there were 35 properties with repetitive loss claims in Union Beach, but now the Borough has over 500 homes listed on the Severe Repetitive Loss and Repetitive Loss lists. A repetitive loss property is defined as one in which a National Flood Insurance Program (NFIP) claim of $1,000 has been reported at least twice in the last ten years.

3.1.2 Hurricane Sandy High Water Marks at Union Beach

In the days leading up to the storm making landfall, the United States Geological Survey (USGS) deployed storm-tide monitoring instruments to characterize the height, extent, and timing of storm tides better than could be accomplished by existing USGS or NOAA observational fixed-place networks. A temporary monitoring network of water-level and barometric pressure sensors was deployed at along the Atlantic coast from Virginia to Maine to continuously record the timing, areal extent, and magnitude of hurricane storm tide and coastal flooding generated by Hurricane Sandy. A total of 62 barometric pressure sensors, plus, 162 water-level and wave-height sensors were deployed at 147 locations during October 26-29 prior to landfall.

[10] Taken from *"Union Beach Strategic Recovery Planning Report"*, 17 April 2014. T&M Associates.

The records these sensors created were supplemented by an extensive post-flood high-water mark (HWM) flagging and surveying campaign from November to December 2012 involving more than 950 HWMs. This survey resulted in a database of 950 HWMs following Sandy, and was the single largest HWM recovery effort in recent USGS history. Details can be found on the USGS website at https://water.usgs.gov/floods/events/2012/sandy/.

Figure 11 shows the location of three HWMs within the project area, and the limits of inundation from Hurricane Sandy, which can be found at:

https://water.usgs.gov/floods/events/2012/sandy/sandymapper.html.

Characteristics of the three HWMs shown in the figure are provided in Table 1.

Figure 11: Hurricane Sandy Inundation Limits and USGS High Water Marks

Table 1: Hurricane Sandy High Water Mark Readings within the Project Area

USGS HWM Number	Latitude	Longitude	Elevation (NAVD88)	Elevation (NGVD29)	Feet Above Ground
HWM NJ-MON-116	40.450971	-74.174209	12.5	13.6	5.0
HWM NJ-MON-217	40.442903	-74.159472	13.0	14.1	5.6
HWM NJ-MON-216	40.446467	-74.163189	12.0	13.1	3.9

3.2 Physical Conditions

The physical characteristics of the project area are profiled in the following sub-sections. Discussions address horizontal and vertical datum, astronomical tides, sea level rise, and bay storm surge.

3.2.1 Vertical and Horizontal Datums

The September 2003 Feasibility Report was prepared using the NGVD 1929 vertical and NAD 1927 State Plane New Jersey horizontal datum. For this HSLRR, all analyses were conducted using these same datums to match the design drawings provided. All new data, (e.g., LiDAR etc.) was converted to these same datums. Per EM 1110-2-6065, the current datum recommended for use is the North American Vertical Datum of 1988 (NAVD88) and North American Datum 1983 (NAD83). Preconstruction Engineering and Design and construction will utilize NAVD88 and NAD83 but also be connected and modeled relative to the National Water Level Observation Network (NWLON) tidal datum and the National Spatial Reference System (NSRS) othometric datum established by the department of Commerce.

3.2.2 Astronomical Tides

Tides at Union Beach are semi-diurnal and have a mean range of 5 feet and a spring range of 5.6 feet. Until Hurricane Sandy, the maximum recorded storm water elevation in the vicinity of the project area was observed at Keyport Harbor[11] during Hurricane Donna, which was +10.5 feet NGVD29 on September 12, 1960. More recent storm water levels in Keyport were +10.1 feet NGVD29 on December 11, 1992. Water levels from the same storm reached approximately +10 feet NGVD29 in Union Beach.

Hurricane Sandy made landfall in Brigantine, New Jersey, approximately six (6) miles north of Atlantic City, New Jersey. According to the USGS's Hurricane Sandy Storm Tide Mapper[12] website, Sandy produced a water level in the location of Keyport Harbor of +14.5 feet NAVD88, which is approximately +15.6 feet NGVD29 (14.5 + 1.1 = 15.6 feet NGVD29). This is the highest tide recorded at this area. The gauge that recorded this water level was located on Beach Drive approximately 4,000 feet from downtown Keyport. The peak stage at the Sandy Hook NOS tide

[11] Keyport Harbor is immediately adjacent to the western boundary of Union Beach.
[12] https://water.usgs.gov/floods/events/2012/sandy/sandymapper.html

gage before it was destroyed by Hurricane Sandy was +10.49 feet NAVD88 which is +11.57 feet NGVD29 (10.5 + 1.1 = 11.6 feet NGVD29), and ranks as the highest mark for this location.

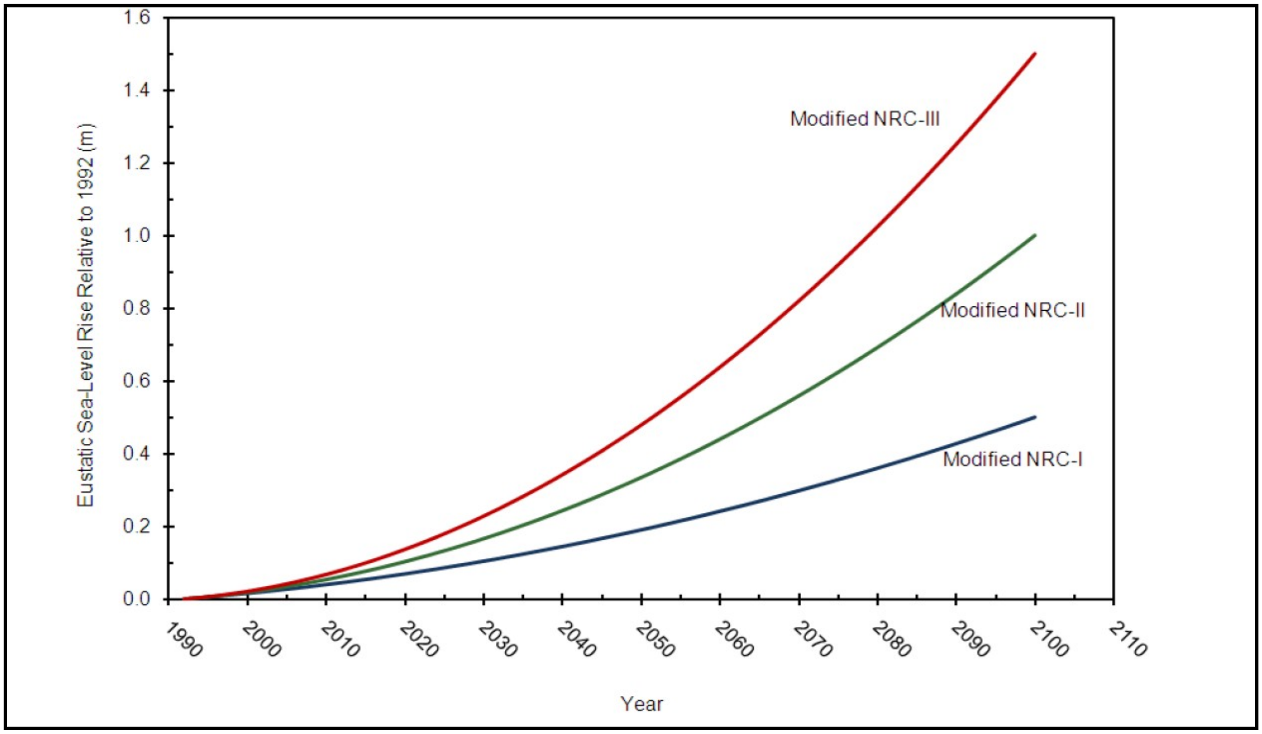
The previous highest tide recorded at Sandy Hook was +7.27 feet NAVD88 which occurred during Hurricane Donna, September 1960. Storm surge elevations can vary significantly depending on the locality. Characteristics impacting storm water elevations include bathymetry and topography on inundated areas and the physical properties of the storm, especially the size and angle of approach.

3.2.3 Sea Level change

The Department of the Army Engineer Regulation ER 1100-2-8162 (31 Dec 2013) and ETL-1100-2-1 (*Procedures to Evaluate Sea Level Change: Impacts, Responses, and Adaptation*) require that future sea level change (SLC) projections must be incorporated into the planning, engineering design, construction and operation of all civil works projects. The project team evaluated structural and nonstructural components of the proposed alternatives in consideration of the "low," "intermediate" and "high" potential rates of future SLC for both "with" and "without project" conditions. This range of potential rates of SLC is based on findings by the National Research Council (NRC, 1987) and the Intergovernmental Panel for Climate Change (IPCC, 2007). The historic rate of future sea-level change is determined directly from gauge data gathered in the vicinity of the project area. Tide conditions at Sandy Hook (National Oceanic and Atmospheric Administration (NOAA) Station #8531680) best represent the conditions experienced in Union Beach. A 75-year record (1932 to 2006) of tide data gathered at Sandy Hook, NJ indicates a mean sea level trend (eustatic SLR + the local rate of VLM) of +3.9 mm/year.

SLC considers the effects of (1) the eustatic, or global, average of the annual increase in water surface elevation due to the global warming trend, and (2) the "regional" rate of vertical land movement (VLM) that can result from localized geological processes, including the shifting of tectonic plates, the rebounding of the Earth's crust in locations previously covered by glaciers, the compaction of sedimentary strata and the withdrawal of subsurface fluids. See Figure 12 for Modified NRC curves for predicting future rates of eustatic SLC.

Figure 12: Modified NRC Curves for Predicting Future Rates of Eustatic SLC



The Union Beach project design water level stages were derived from Federal Emergency Management Agency (FEMA) modeling efforts in 2013. Using the base year 2013 from which future sea level elevations are estimated, Table 2 shows the projected increase in water surface elevation for the historic, intermediate and high rates of future sea level rise at Union Beach, New Jersey to the year 2100.

For example, in the year 2030, it is anticipated that the water surface elevation in Union Beach could increase by 0.44 feet under the historic rate future sea level rise scenario; by 0.56 feet under the intermediate scenario and by 0.96 feet under the high scenario. Water surface elevations at the end of the 50-year period of analysis in year 2072 could increase by 1.01 feet under the historic rate future sea level rise scenario; by 1.53 feet under the intermediate scenario and by 3.20 feet under the high scenario.[13]

For the Union Beach project, the low rate of sea level rise has been incorporated into project design, per standard practice. Water surface elevation changes for the intermediate and high rates of SLR are presented. Other modifications made to project design to incorporate intermediate or high rates of SLR, as the project consists of components that are adaptable to future increases in sea level due to climate change. The sand dune and berm cross section could include increases in dune crest height, and corresponding increase in berm elevation to compensate for increasing still water levels. The levee and wall systems could also be modified with parapet walls or additional wave baffles pending design analyses to support additional height. If applicable, additional pump

[13] Values for the year 2072 interpolated from values shown for the years 2068 and 2073.

station capacity could be added to handle additional overtopping. However, a post-authorization change report would be required to make these changes. Regular renourishment operations are part of the 2007 Authorized Plan.

Table 2: Predicted Sea Level Change on Water Surface Elevations at Union Beach

Year	USACE Low	USACE Int	USACE High
2013	0.27	0.31	0.44
2018	0.34	0.40	0.59
2023	0.40	0.49	0.76
2028	0.47	0.58	0.95
2033	0.53	0.68	1.16
2038	0.60	0.79	1.38
2043	0.66	0.90	1.63
2048	0.73	1.01	1.89
2053	0.79	1.13	2.17
2058	0.86	1.25	2.47
2063	0.92	1.37	2.79
2068	0.99	1.50	3.13
2073	1.06	1.64	3.49
2078	1.12	1.78	3.86
2083	1.19	1.92	4.26
2088	1.25	2.07	4.67
2093	1.32	2.22	5.10
2098	1.38	2.38	5.55
2100	1.41	2.44	5.73

Gauge NJ, Sandy Hook: 75 years, feet

3.2.4 Bay Storm Stage

When investigating the bay storm stage water surface elevations, the September 2003 Feasibility Report used a numerical/statistical model for three locations in New York Harbor, marked as nodes P1, P2, and I3. These were developed in 1998, by USACE's Engineer Research and Development Center (ERDC), which performed ADvanced CIRCulation (ADCIRC) modeling of the New York Harbor region for a Dredged Material Management Study. The P1 and P2 nodes developed for that study are nearly identical to new updated FEMA nodes 348054 and 422529, but the nearest node to I3 was Node 53246. Table 3 provides a comparison of node locations between the ERDC Nodes and the FEMA Nodes.

Table 3: Comparison of ERDC Node and FEMA Node Geographic Coordinates

DMMP Node	Latitude	Longitude	FEMA Node	Latitude	Longitude
P1	40.50270556	-74.08263438	348054	40.50327	-74.0822
P2	40.47429751	-74.16792754	422529	40.47454	-74.16823
I3	40.46502782	-73.84213115	53246	40.514370	-73.840250

The node selected for the SBEACH (Storm-induced BEAch CHange) modeling of Union Beach, NJ was FEMA Node 422529 or Node P2, and was used as the bay storm stage in this HSLRR. Table 4 compares the 1998 (used in the September 2003 Feasibility Report) and 2013 values (used for this HSLRR) for ERDC Node P2 and FEMA Node 422529.

Table 4: ERDC Node P2 and FEMA Node 422529 Stage Elevations Compared

Return Period in years	1998 Stage Elevation w/o Wave Setup ERDC Node P2	2013 FEMA Stage Elevation with Wave Setup FEMA Node 422529
2	5.7	
5	8.0	7.5
10	9.2	8.9
25	10.6	10.6
50	11.5	11.9
100	12.2	13.3
200	13.0	14.7
500	13.9	16.6

Elevation: ft NGVD29

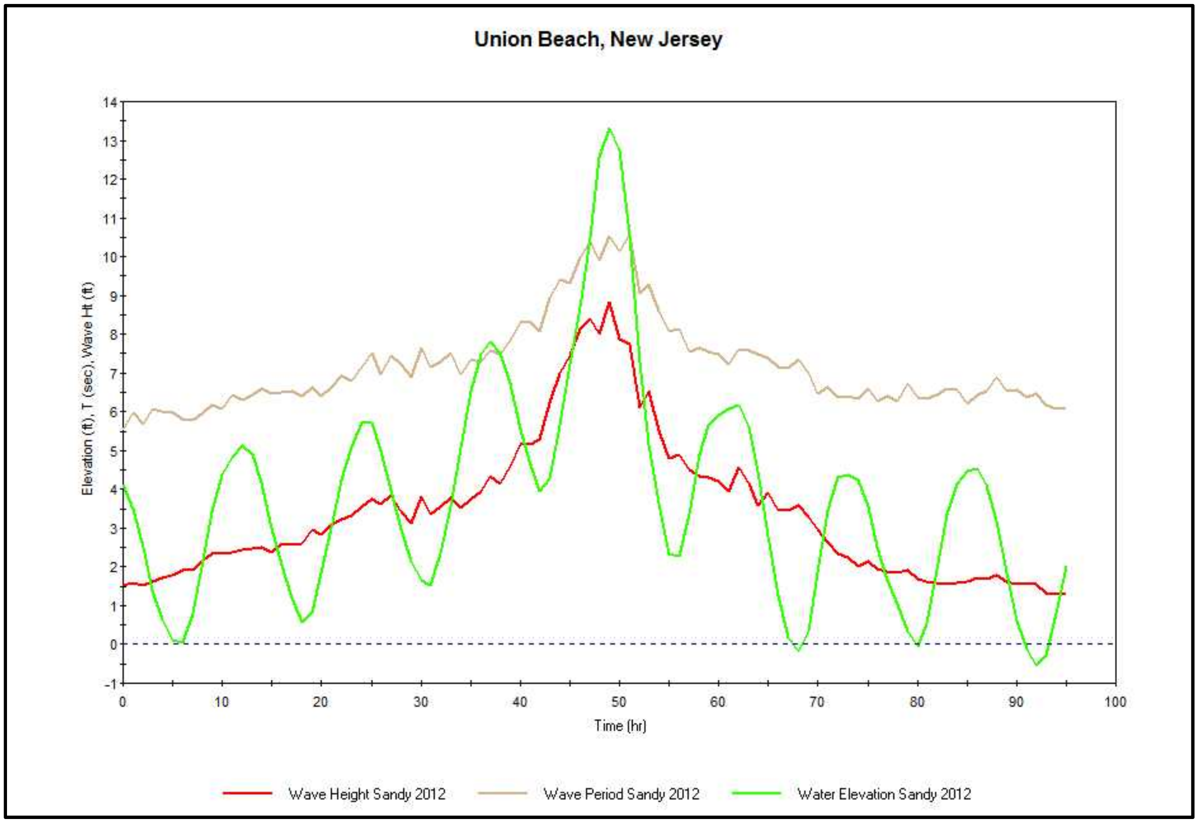
In comparison with the September 2003 Feasibility Report data used at node P2, the Node 422529 1-percent exceedance water elevation was 1.1 feet higher. This value included wave setup while the P2 value did not. It was considered prudent in light of the uncertainties associated with the limited SBEACH modeling being conducted for this HSLRR to select the higher water surface elevation. The maximum water surface elevation determined for the SBEACH modeling was the 1% flood event of +13.3 feet NGVD29.

When examining the storm hydrograph a review of the Hurricane Sandy tidal records at Sandy Hook, NJ and The Battery, NY found there was excellent correlation between the two hydrographs up until the point at the peak of the storm when the Sandy Hook gage stopped recording. Based on this finding it was considered appropriate to use the shape of the storm hydrograph at The Battery in the SBEACH Modeling.

The maximum water level at The Battery gage was slightly more than one foot less than the maximum water level discussed earlier in this section. The decision was made to ratio The Battery water levels during the significant portion of the hydrograph so the maximum elevation matched the 1 Percent Exceedance level.

A plot of the adopted storm hydrograph is shown below in Figure 13. Further details contained in Engineering Appendix A, Sub-Appendix D – SBEACH Modeling.

Figure 13: Plot of the Adopted Storm Hydrograph



3.3 Environmental Resources

This section describes only those environmental changes that have occurred since the September 2003 Environmental Impact Statement (2003 FEIS) analysis.

3.3.1 Topography, Geology, and Soils

There are no changes since the 2003 FEIS.

3.3.2 Water Resources

There are no changes since the 2003 FEIS.

3.3.3 Tidal Influences and Floodplain Values

For the changes since the September 2003 Feasibility Report, please see Sections 3.2 and 7.2 of this HSLRR.

3.3.4 Vegetation and Wetlands

Vegetation in the uplands and wetlands has only minimally changed since the evaluations presented in the 2003 FEIS. Because of the refinements to the planned right-of-way and continuing coordination with the U.S. Fish and Wildlife Service (USFWS) regarding the Coastal Barrier Resources Act (see discussion later in this section for more detail), the District has determined to update the existing wetland delineation during the Planning, Engineering, and Design (PED) phase of this project. The District will consult with all federal and state regulatory agencies during the PED phase in order to avoid and minimize wetland impacts. The Evaluation for Planned Wetlands (EPW) and Habitat Evaluation Procedures (HEP) implemented to characterize and assess impacts to wetland functions and values were used in the 2003 FEIS. Those same procedures will be utilized for the updated delineation.

3.3.5 Fish and Wildlife

A literature search for wildlife in the area yielded no changes since the 2003 FEIS. Please see the 2003 FEIS for a discussion of wildlife in the project area.

3.3.6 Federal Threatened and Endangered Species

Sea Turtles

On March 16, 2010, the National Oceanic and Atmospheric Administration (NOAA) published a proposed rule to list two DPS (Distinct Population Segment) of loggerhead sea turtles as threatened and seven DPS of loggerhead sea turtles as endangered. On September 16, 2011, a final listing determination was made designating the Northwest Atlantic Ocean DPS as threatened. The Northeast Atlantic Ocean DPS has been designated as endangered (76 FR 58868) effective October 24, 2011.

Four species of marine turtles may occur within the Atlantic waters around the project site including the Sea Bright Borrow Area (SBBA). They include the Northwest DPS of the loggerhead (*Caretta caretta*), the Kemp's ridley (*Lepidochelys kempi*), the green (*Chelonia mydas*) and the leatherback (*Dermochelys coriacea*) turtles. In New Jersey waters, the loggerhead is the most abundant species observed. The green turtle is relatively rare.

Whales

The 2003 FEIS lists three species of state and federally listed whales may also occur within the (offshore) project area. These species include the endangered North Atlantic right whale (*Eubalaena glacialis*), humpback whale (*Megaptera novaeangliae*), and fin or finback whale (*Balaenoptera physalus*). All three species are listed as endangered.

Atlantic Sturgeon

Five DPS of Atlantic sturgeon were listed as threatened or endangered under the Endangered Species Act, including a New York Bight DPS. Known spawning populations for the New York Bight DPS exist in two rivers: the Hudson and Delaware Rivers. In the Hudson River estuary, spawning, rearing, and overwintering habitats were reported to be intact by Bain (1997), supporting the largest remaining Atlantic sturgeon stock in the U.S. General factors that may impact Atlantic sturgeon include dredging and disposal; and water quality modifications such as changes in levels of dissolved oxygen (DO), water temperature and contaminants. Other threats to the species include vessel strikes.

Piping Plover

The federally listed (threatened) bird piping plover (*Charadrius melodus*) nests approximately eight miles east in Gateway National Recreation Area, Sandy Hook Unit during the breeding season between March 15 and August 31. The Union Beach project area has no history of nesting piping plovers.

Rufa Red Knot

The federally listed (threatened) bird rufa red knot (*Calidris canutus rufa*) is a large, bulky sandpiper with a short, straight, black bill. As with most shorebirds, the long-winged, strong-flying knots fly in groups, sometimes with other species. Red knots feed on invertebrates, especially small clams, mussels, and snails, but also crustaceans, marine worms, and horseshoe crab eggs. Small numbers of red knots may occur in New Jersey year-round, while large numbers of birds rely on New Jersey's coastal stopover habitats during the spring (mid-May through early June) and fall (late-July through November) migration periods. Smaller numbers of knots may spend all or part of the winter in New Jersey.

Seabeach Amaranth

The federally listed (threatened) plant seabeach amaranth (*Amaranthus pumilus*) is an annual plant endemic to Atlantic Coast beaches and barrier islands that was documented occurring in nearby Keansburg in 2013 approximately 2.5 linear miles from the proposed project area; the Union Beach project area has no history of seabeach amaranth plants.

Northern Long-Eared Bat

The federally listed (threatened) northern long-eared bat (*Myotis septentrionalis*) is a medium-sized bat found across much of the eastern and north-central United States and is found state-wide in New Jersey. The northern long-eared bat predominantly overwinters in hibernacula that include caves and abandoned mines. During the summer, this species typically roosts singly or in colonies underneath bark or in cavities or crevices of both live trees and snags. Northern long-eared bats are also known to roost in human-made structures such as buildings, barns, sheds, and under eaves of windows. Threats to the northern long-eared bat include disease due to the emergence of white-nose syndrome, improper closure at hibernacula, degradation and destruction of summer habitat, and use of pesticides (USFWS, 2014a). Tree removal could affect this species by killing, injuring, or disturbing breeding or roosting bats if conducted between April 1 and September 30.

3.3.7 State Threatened and Endangered Species

There are six known Osprey (*Pandion haliaetus*) nesting platforms in and around the project area (Center for Conservation Biology 2014). The usage of each platform for nesting is unknown; however, ospreys have been seen in the area. The USFWS notes that the State-listed (endangered) seabeach knotweed (*Polygonum glaucum*), seabeach sandwort (*Honckenya peploides*), and seabeach milkwort (*Glaux maritima*), as well as for the plant species of concern seabeach evening-primrose (*Oenothera humifusa*) could be found in the project area.

3.3.8 Essential Fish Habitat

Utilizing NMFS's essential fish habitat (EFH) designation and the EFH Mapper, one additional species, American plaice (*Hippoglossoides platessoides*), was identified that was not listed in the 2003 FEIS. The District conducted a finfish survey in 2004. Beaches at Port Monmouth, Keansburg, and Union Beach were sampled at seven stations each. Fish captured in that survey did not include any fish unidentified in the 2003 FEIS. Please see Appendix A of the Supplemental Environmental Assessment (SEA) for an EFH worksheet for the nearshore and Appendix F of the SEA for a detailed EFH evaluation for the SBBA.

3.3.9 Offshore Borrow Area

The SBBA located in the Atlantic Ocean offshore of Sea Bright, New Jersey will be the only borrow area utilized for the initial beach placement. This is an existing borrow area that has been subjected to review under NEPA and the Endangered Species Act (ESA) processes and has received all the necessary Federal and state permits, authorizations, and approvals for the previous uses. Following Hurricane Sandy the SBBA was used for the Sandy Hook to Barnegat Section I and II CSRM project as well as CSRM projects in Keansburg, North Middletown and Port Monmouth. A thorough discussion of the SBBA benthic resources and finfish is provided in the Supplemental EA.

3.3.10 Cultural Resources

The Phase I cultural resource study conducted during feasibility identified no historic properties within the Area of Potential Effect (APE) as defined at the time of study.

Of the proposed changes to project design as a result of analysis conducted under the HSLRR only the proposed shift in the alignment to avoid the CBRS zone has the potential to impact cultural resources as all other potential design changes are within the previously studied APE. Most of the proposed new alignment remains in the low-lying marsh where previous work in such environments, including deep testing, did not identify any significant resources or archeologically sensitive buried landforms. NJHPO concurred with the Corps that no further work would be undertaken in the low-lying locations. Further refinements to the alignment have been proposed to avoid the CBRS as delineated in 2016. These proposed realignments are on higher ground that may prove sensitive for archaeological resources. Also as a result of CBRS alignment modifications a section of floodwall is proposed near two properties associated with the Jersey Central Traction Company which operated from the turn of the 20th-century until 1923. NJHPO has concurred with the New York District's opinion that a floodwall built across the street from Jersey Central Traction Company buildings will have no effect on the resources.

A potential historic resource not addressed in the project's cultural resources survey reports or previous correspondence is the former Belford to Keyport extension of the New York and Atlantic Highlands Railroad, now a paved bikeway. NJHPO concurred with the District's opinion that this late and relatively minor addition to the northern Monmouth County railroad network, now a paved bike path, is not eligible for the National Register of Historic Places.

The 2003 FEIS states that monitoring will be conducted in the SBBA and in the beach renourishment area during construction to identify resources that might be pumped on the beach from the borrow area. Based on subsequent studies undertaken in the SBBA for other District projects the District and the NJHPO have developed protocols that will be followed in lieu of the monitoring previously stated in the 2003 FEIS (Panamerican Consultants, Inc. 2014).

3.3.11 Coastal Barrier Resources Act (CBRA)

In the 2003 FEIS, compliance with the Coastal Barrier Resources Act (CBRA) was pending. The 2008 ROD made no mention that compliance with the CBRA was completed and the USFWS has no records of compliance. In 2013, when this HSLRR was initiated, USACE proceeded with acquiring a determination regarding CBRA from the USFWS. The USFWS stated that parts of the Union Beach project were within the Coastal Barrier Resources System (CBRS) Unit NJ-04. USACE requested an exemption from the 2008 unit alignment (see Supplemental EA Appendix D – Pertinent Correspondence) which the USFWS denied, though the USFWS informed USACE in 2014 that CBRS Unit NJ-04 was to be reevaluated based on effects from Hurricane Sandy. Below is a discussion of the CBRA and its application regarding the Union Beach project.

Background

CBRA encourages the conservation of hurricane prone, biologically rich coastal barriers by restricting federal expenditures that encourage development, such as federal flood insurance. To remove the federal incentive to develop these areas, CBRA designated relatively undeveloped coastal barriers along the Atlantic and Gulf Coasts as part of the John H. Chafee Coastal Barrier Resources System (CBRS), and made these areas ineligible for most new federal expenditures. Private developers or other non-federal parties that bear the full cost can develop areas within the CBRS.

Section 5 of the CBRA (16 U.S.C. 3504) prohibits new federal expenditures within System Units of the CBRS. An expenditure or financial assistance is considered new under CBRA (16 U.S.C. 3504(b)), if:

- No money for construction or purchase purposes was appropriated before the date on which the relevant System Unit was included within the CBRS; or

- No legally binding commitment for the expenditure or financial assistance was made before such date, except as provided in Section 6 of CBRA (16 U.S.C. 3505), no new expenditures or new financial assistance may be made available under authority of any Federal law for any purpose within the CBRS, including, but not limited to, the following:
  - The construction or purchase of any structures, appurtenance, facility, or related infrastructure;
  - The construction or purchase of any road, airport, boat landing facility, or other facility on, or bridge or causeway to, any System Unit; and
  - The carrying out of any project to prevent the erosion of, or to otherwise stabilize, any inlet, shoreline, or inshore area, except that such assistance and expenditures may be made available on units designated pursuant to Section 3503 of this title on maps numbered S01 through S08 and LA-07 for purposes other than encouraging development and, in all units, in cases where any emergency threatens life, land and property immediately adjacent to that unit.

Section 6 of CBRA (16 U.S.C. 3505) permits certain federal expenditures and financial assistance within the CBRS after consultation with the USFWS. The exceptions are divided into two groups. The first group only requires that the proposed funding is in fact a listed exception. The second group requires that the exception also meet the three purposes of the CBRA. Those purposes are:

- To minimize the loss of human life;
- To minimize the wasteful expenditure of federal revenues; and
- To minimize the damage to fish, wildlife and other natural resources associated with coastal barriers.

2007 Authorized Plan Alignment and CBRS Boundaries

The 2007 Authorized Plan contains a portion of the CBRS System Unit NJ-04 within its alignment. USFWS, in response to Hurricane Sandy drafted a revised alignment for CBRS Unit NJ-04 in 2016. On 7 July 2016, the USFWS announced in the Federal Register that it is developing a new CBRS mapping protocol for critical facilities located within and immediately adjacent to the CBRS. In this announcement, the USFWS stated that it may consider mapping a CBRS area to allow for the protection of existing critical facilities (e.g., sewage treatment facilities) that primarily serve areas located outside of the CBRS.

The USFWS also states that in such cases, the following criteria must be met:

1. The protection of the facility must be consistent with the three purposes of the CBRA: To minimize the loss of human life, wasteful expenditure of Federal revenues, and damage to the fish, wildlife, and other natural resources associated with coastal barriers;
2. The protection of the facility should not encourage new development within the CBRS (e.g., a levee protecting a facility should not also unnecessarily protect an undeveloped area

within the CBRS or an area within the CBRS that developed after the unit was established); and

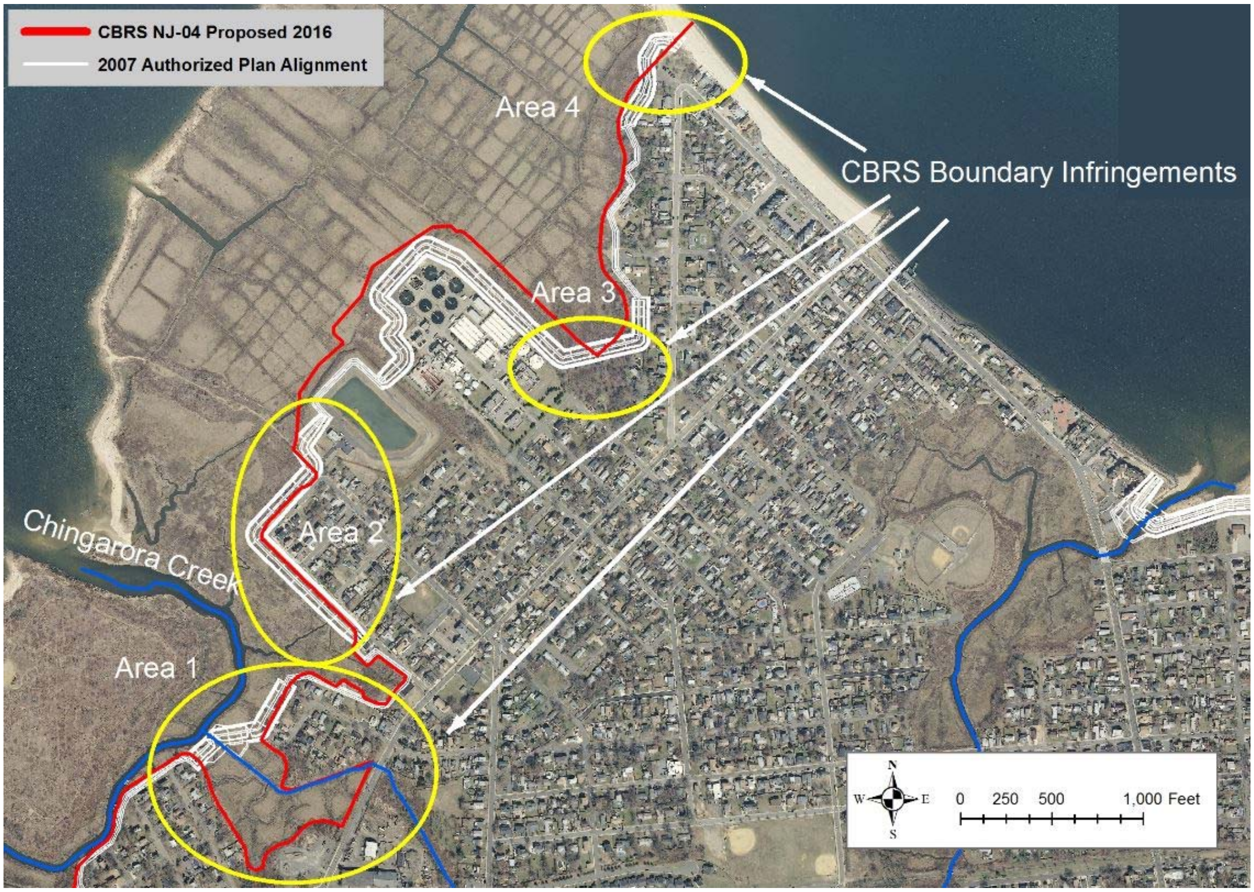
3. There must be no reasonable alternative to protect the facility (e.g., nonstructural floodproofing, buyouts to allow for construction of levees and flood walls outside of the CBRS, alternative project design that does not infringe upon the CBRS, etc.).

For the purpose of this protocol, the USFWS defines “existing” as being on-the-ground as of the date the area was added to the CBRS, and “critical facility” as a structure or other improvement that, because of its function, would likely cause catastrophic human health and safety impacts if it is destroyed or damaged or if its functionality is impaired. The USFWS developed this new protocol for critical facilities to allow for the protection of the Bayshore Regional Sewerage Authority Wastewater Treatment Facility in Monmouth County, New Jersey. In cases where the USFWS recommends the removal of an area from the CBRS in accordance with this protocol, the change will become effective only if the updated map is adopted through legislation enacted by Congress.

The 2007 Authorized Plan was evaluated against the 2016 CBRS Unit NJ-04 boundaries (as modified by the USFWS public comment period following draft publication on 1 July 2016) in order to determine whether any part of the 2007 Authorized Plan alignment fell within the new CBRS boundary. As shown in Figure 14, four areas of the 2007 Authorized Plan alignment have been identified as infringements on the new CBRS boundary.

- Area 1 includes a levee and associated sluice gates along a major tributary to Chingarora Creek that intersect an extensive area of the CBRS.
- Area 2 includes levee footprint infringements running adjacent to the CBRS boundary approaching the Monmouth County Bayshore Outfall Authority.
- Area 3 includes a portion of a levee that intersects the CBRS to the southeast of the Bayshore Regional Sewage Authority.
- Area 4 includes a portion of a levee that intersects the CBRS to the west of the shorefront element.

Figure 14: 2007 Authorized Plan Infringements on CBRS Boundary



3.3.12 Coastal Zone Management

As a federally funded project within the coastal zone of New Jersey, the project must be reviewed by the NJDEP for consistency with the policies of the New Jersey State Coastal Zone Management (CZM) Plan. A new CZM statement has been prepared for this HSLRR and its Supplemental EA. The applicable policies, along with an impact analysis and consistency determination are discussed within the environmental consequences section of this report that is presented in SEA Appendix B (New Jersey Coastal Zone Act Consistency Statement for Shore Component) for the beach portion of the project and SEA Appendix C (New Jersey Coastal Zone Act Consistency Statement for Inland Component) for the shore component of the project.

3.3.13 Hazardous, Toxic, and Radioactive Wastes (HTRW)

As stated in the September 2003 Feasibility Report, soil borings were collected in May 2001 and 2002. A number of samples exceeded the NJDEP Residential Direct Contact Soil Cleanup Criteria (RDC-SCC) for arsenic and lead. These results were attributed in part to the geologic formations in this part of Monmouth County, which contain naturally occurring high levels of arsenic. For an older, urbanized area, such as Union Beach, with disturbed soils, such results were not unexpected. The samples with lead exceedances were collected in waterways known to be receptors for the area's storm sewers.

For this update, a review of the state and Federal data sources was conducted. The NJDEP list of Known Contaminated Sites (KCS) was consulted for Union Beach. The database identified nine active sites, no pending sites and 30 closed sites (NJDEP 2014). Active sites are sites having one or more actives cases, under the supervision of a NJDEP case manager, as well as pending and/or closed sites. Closed sites are those sites that have been closed. Most of the active sites involved underground storage tanks. Only one active site, the Bayshore Regional Sewerage Authority, is adjacent to the 2007 Authorized Plan alignment. This site has a mix of active and closed actions involving underground storage tanks and potential groundwater contamination within the facility.

One of the NJDEP KCS active sites, the former International Flavors Fragrances (IFF) site, is also a site listed under the USEPA Resource Conservation Recovery Act (RCRA) database. The site, now closed, is located on Rose Lane, at the eastern end of Union Beach. The IFF site was a source of volatile organics and polychlorinated biphenyls (PCBs) in the ground water and soil. With impacted ground water migrating towards Raritan Bay, an interceptor trench was installed on the property to treat this flow, and several thousand tons of contaminated soil was removed from the site. The site is situated outside of the proposed project alignment.

3.3.14 Air Quality

Based on the National Ambient Air Quality Standards (NAAQS), Monmouth County is located in the New York, Northern New Jersey, Long Island, Connecticut, nonattainment area, which is currently classified as "marginal" nonattainment for the 2008 8-hour ozone standard. The nonattainment area is part of the Ozone Transport Region. Ozone is controlled through the regulation of its precursor emissions, which include oxides of nitrogen (NOx) and volatile organic compounds (VOCs).

3.3.15 Navigation

A literature search for navigation in the area yielded no changes since the 2003 FEIS. Please see the 2003 FEIS for navigation in the project area.

3.3.16 Aesthetics and Scenic Resources

A literature search for aesthetics and scenic resources in the area yielded no changes since the 2003 FEIS. Please see the 2003 FEIS for aesthetics and scenic resources in the project area.

3.3.17 Recreation

A literature search for recreation in the area yielded no changes since the 2003 FEIS. Please see the 2003 FEIS for recreation in the project area.

3.3.18 Transportation

A literature search for transportation in the area yielded no changes since the 2003 FEIS. Please see the 2003 FEIS for transportation in the project area.

3.3.19 Noise

A literature search for noise in the area yielded no changes since the 2003 FEIS. Please see the 2003 FEIS for noise in the project area.

3.3.20 Land Use and Zoning

A literature search for land use and zoning in the area yielded no changes since the 2003 FEIS. Please see the 2003 FEIS for land use and zoning in the project area.

3.4 Socio-Economic Conditions

The 2010 Census shows 6,245 persons, 2,143 households, and 1,624 families residing in Union Beach. Population for Union Beach has fluctuated within 10 percentage points up or down over the last fifty years, and has shown a relatively small net growth of 7 percent from 1960 to 2010.

The demographic characteristics of Union Beach in comparison to Monmouth County, and the state are shown in Table 5. The Union Beach population is 93 percent Caucasian, versus 84 percent for Monmouth County and 71 percent for the State. In 2010, the percentage of family households was 76 percent for Union Beach, versus 70 percent for Monmouth County and 69 percent for the state.

Table 5: Demographic Characteristics

	Union Beach	Monmouth County	New Jersey
White	93%	84%	71%
Black or African-American	2%	8%	15%
American Indian and Alaska Native	1%	1%	1%
Asian	3%	6%	9%
Some Other Race	4%	3%	8%
Family Households	76%	70%	69%
Average Household Size	2.91	2.66	2.68
Average Family Size	3.32	3.22	3.22

Source: factfinder2.census.gov

Table 6 shows income levels for the project area. Borough median household income is $66,419 and per capita income is $26,625, both of which are lower than county and state figures. However, the percent of persons below the poverty line is 4.1 percent in Union Beach, versus 6.6 percent in the county and 9.9 percent in the state.

Table 6: Income Levels in the Project Area

	Union Beach	Monmouth County	New Jersey
Median Household Income	$66,419	$84,746	$71,637
Per Capita Income, last 12 months	$26,625	$42,678	$35,928
Persons below poverty level	4.1%	6.6%	9.9%

Source: factfinder2.census.gov, 2008-2012 American Community Survey 5-Year Estimates

The 2012 unemployment rates were 8.5 percent in Union Beach, 8.9 percent in Monmouth County and 9.5 percent in New Jersey.

4. REEVALUATION OF PROJECT DESIGN AND PERFORMANCE

The 2007 Authorized Plan alignment and project components were reevaluated to identify current policy compliance deficiencies, opportunities for design refinement, and changes to existing conditions.

In addition, this HSLRR evaluated the 2007 Authorized Plan's design performance in managing coastal storm risk after the incorporation of new bay storm stage/frequency analyses, and post-Katrina levee/floodwall overtopping and failure analyses.

4.1 Policy Compliance

The following policy compliance issues were identified:

- Compliance with the Coastal Barrier Resources Act would require refinements to the alignment;
- Compliance with EC 1110-2-6066, Design of I-Walls (April 2011), would require the replacement of I-type floodwalls with T-type floodwalls; and
- Compliance with ETL 1110-2-571, USACE Vegetation Management Policy (April 2009) would require the acquisition of additional real estate easements.

4.1.1 Compliance with the Coastal Barrier Resources Act

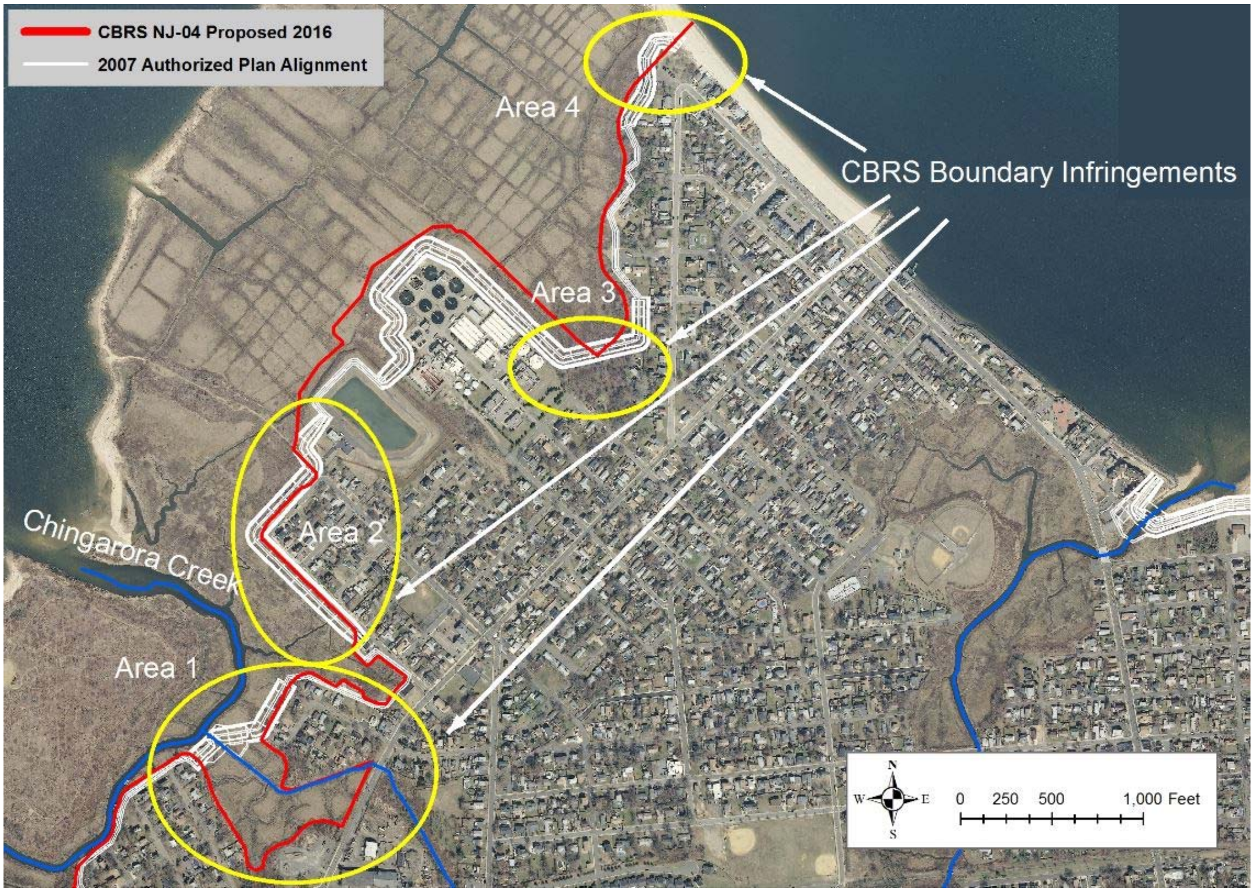
The New York District consulted with the U.S. Fish and Wildlife Service (USFWS) to determine which features of the 2007 Authorized Plan alignment infringe upon the Coastal Barrier Resources System (CBRS) [14] boundary. Four general areas of infringement were identified within the Chingarora Creek element of the alignment, and are noted on Figure 15[15], and summarized below.

- Area 1 includes a levee and associated sluice gates along a major tributary to Chingarora Creek that intersect an extensive area of the CBRS. A substantial alignment shift in this area would be required in order to comply with the CBRA.
- Area 2 includes levee footprint infringements running adjacent to the CBRS boundary approaching the Monmouth County Bayshore Outfall Authority. A slight alignment shift away from the CBRS and conversion from levee to floodwall would be required to comply with the CBRA and maintain the overall line of protection.
- Area 3 includes a levee portion that intersects the CBRS to the southeast of the Bayshore Regional Sewage Authority. An alignment shift to the south would be required in order to comply with the CBRA in this area.

[14] CBRS is the mapping system used to define lands within the Coastal Barrier Resources Act boundaries.
[15] The content of Figure 15 has been shown previously in Section 3.3.8 as Figure 14. The figure and description of the infringement areas is included here to aid in the discussion of proposed changes to the alignment.

- Area 4 includes a levee portion that intersects the CBRS to the west of the shorefront element. An alignment shift to the east would be required in order to comply with the CBRA in this area.

Figure 15: 2007 Authorized Plan Alignment Infringements on CBRS Boundary



4.1.2 Compliance with Floodwall Design Policy

Floodwalls included in the 2007 Authorized Plan are I-Walls, T-Walls on spread footings and T-Walls on piles. While T-Walls were used in the design, the majority of the floodwalls were designed as I-Walls, a slender cantilever wall embedded into the base soil and stabilized by reactive lateral earth pressure.

Due to concerns on performance of I-Walls in major storm events in coastal regions, EC 1110-2-6066 “Design of I-Walls” was issued on 1 April 2011 by consolidating the findings and lessons learned from studies performed after Hurricane Katrina and other major coastal storms.

EC 1110-2-6066 paragraph 2-2e(9)states:

> *“While overtopping of the I-walls led to significant scour and damage in many cases, overtopping of T-walls did not lead to extensive scour and erosion, because the base of the inverted T-wall sections extended over the protected side. T-walls performed well during*

> *Katrina. Because of their pile foundations, they are better able to transfer high lateral water loads into stronger underlying foundation materials."*

Since the EC has expired, and a replacement has not been completed, Engineering Construction Bulletin (ECB) No. 2014-18 has been issued to provide the following interim guidance:

> *For the design of I-walls, use EC 1110-2-6066. For the evaluation of I-walls, use ETL 1110-2-575. For the design of cantilever and single anchored earth retaining sheet pile walls, use EM 1110-2-2504.*

Based on these criteria changes, it was necessary to reevaluate the 2007 Authorized Plan floodwall design I-Walls. Of the total 6,885 feet of floodwall included in the 2007 Authorized Plan, nearly 85 percent is greater than six (6) feet in height above existing grade. In addition, erosion control along the I-Wall also was a major concern during the HSLRR review. Significant changes on the protected side of I-Walls would be required to prevent loss of material due to overtopping. The cost to construct erosion control along the unprotected side of I-Walls and overtopping protection on the landside was determined to be less cost effective than a T-Wall system. Additionally, the T-Wall provides a more stable floodwall system and has better performance noting that erosion is a significant concern for any coastal storm risk management project.

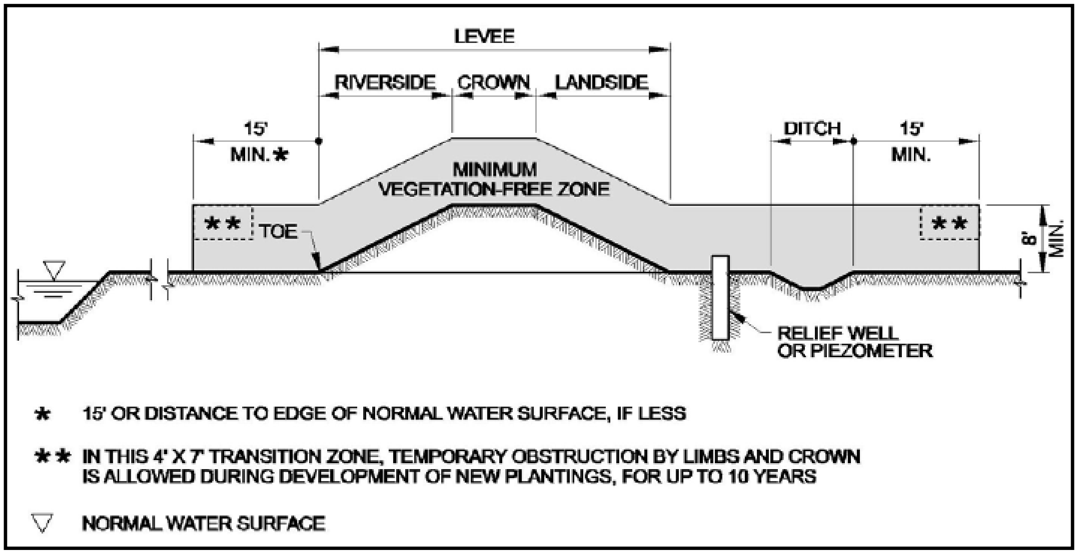
After consideration of new criteria and limited foundation information, the decision was made to replace all floodwall (both I-Wall and T-Wall on spread footings) with T-wall on piles for the HSLRR Recommended Plan.

4.1.3 Compliance with Vegetation Management Policy

Project easements of the 2007 Authorized Plan were reviewed for compliance with respect to the USACE's vegetation management policy, ETL 1110-2-571, 10 April 2009, *Guidelines for Landscape Planting and Vegetation Management at Levees, Floodwalls, Embankment Dams and Appurtenant Structures*. The current vegetation management guidelines were not in place when the September 2003 Feasibility Report was completed. The new guidance requires a vegetation free zone 15 feet from levee toes, drains or structural features and 15 feet from the faces of floodwalls and a minimum of 8 feet beyond the footing.

This revised easement allows for operation and maintenance, surveillance, and access during high-water events. Vegetation has potential to impact the operations and degrade the performance of the system, including compromising the integrity of foundation if potential seepage paths are created by root penetration and/or root decay. Additionally, significant levee damage and creation of points of concentrated seepage discharge can be created by the uprooting of large trees during a flood event. The root-free zone provides a margin of safety between the greatest expected extent of plant roots critical to the performance and reliability of the flood damage risk reduction system. The typical configuration for a levee, as set forth under USACE's vegetation management policy, is shown in Figure 16.

Figure 16: Typical Vegetation Free Zone Configuration at Levee



For T-Walls, the vegetation-free zone extends horizontally 15-feet from the face of the wall and 8-feet minimum from the footing. Just as in the case with the levee sections, the vertical extent of the vegetation-free zone is a minimum of 8-feet.

After review of the 2007 Authorized Plan's compliance with vegetation management policy adopted since 2003, real estate requirements were revised in the HSLRR Recommended Plan. Details are included in the discussion of Real Estate Requirements.

4.2 Design Refinements

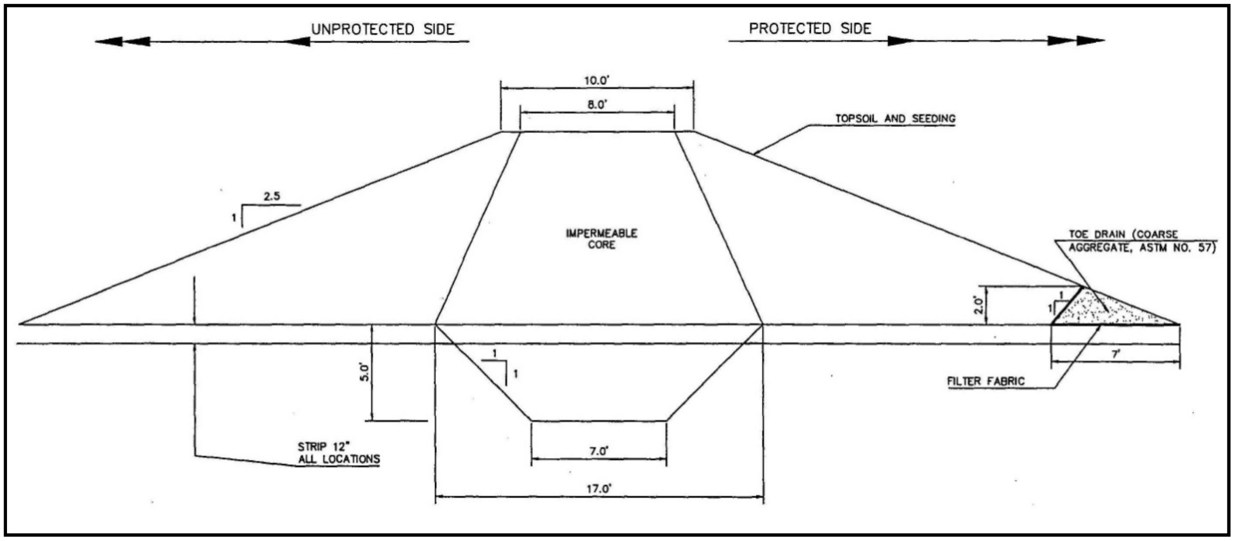
The following design refinements were identified:

- Levee embankment design of the 2007 Authorized Plan may not provide adequate protection against seepage; and
- Several ninety-degree bends in the 2007 Authorized Plan alignment may result in constructability problems and erosion at floodwall and levee junctures.

4.2.1 Embankment Design

Levee design was conducted in accordance with EM 1110-2-1913 Design and Construction of Levees. The 1978 edition was utilized by the New York District for the preliminary design conducted as part of the September 2003 Feasibility Report. During that study it was determined that a single levee embankment section could be utilized to represent the subsurface conditions for both the east and west alignments. The levee section from the 2007 Authorized Plan is shown in Figure 17.

Figure 17: 2007 Authorized Plan Levee Section



Two selected representative levee cross sections were utilized for the preliminary design, one at Sta. 63+64 and the other at Sta. 51+50. Previously completed coastal storm risk management feasibility studies for nearby sites, (i.e. Port Monmouth, New Jersey) with similar geologic and hydraulic conditions were used to select initial side slopes and embankment material components, which were applied in stability and seepage analyses of the proposed levees. Conditions that controlled the design along with the results of all analyses supported the recommended slopes and material components.

The 2007 Authorized Plan levee was designed with a crest width of 10 feet and 1V:2.5H side slopes. Levee heights varied from 4.5 to 12.5 feet above existing grade to support the design flood elevation of +15 feet NGVD29. The design in the September 2003 Feasibility Report recommends using commercially available embankment materials from known suppliers. The 2007 Authorized Plan indicated a toe drain that theoretically would meet the standards determined in the seepage analyses; however, it did not include any penetration of the toe drain into the foundation which by current state of the practice is recommended. In addition, no overtopping protection was provided.

The HSLRR Recommended Plan includes an updated levee design. Details on the updated levee design are included Section 4.5.4 of this HSLRR.

4.2.2 Bends in the Alignment

Upon review of aerial photography and following site visits, there was concern regarding the number of floodwall bends that occur close to transitions from floodwall to levee embankment. These bends could result in wave diffraction and increase turbulence and cause erosion. Refinements to the alignment to soften wall angles and minimize transitions to levee adjacent to wall bends along with the need for limited slope protection will be investigated in PED. Impacts to the cost estimate because of any design modification during PED has been taken into account by the Abbreviated Risk Analysis and associated cost contingencies in the total project cost.

4.3 Changes to Existing Conditions

The following changes to existing conditions since the September 2003 Feasibility Report were identified:

- Residential development has occurred within the alignment easements;
- Bayshore Regional Sewage Treatment Authority has constructed a storage / treatment tank within the levee footprint; and
- Erosion of the banks of East Creek may have occurred.

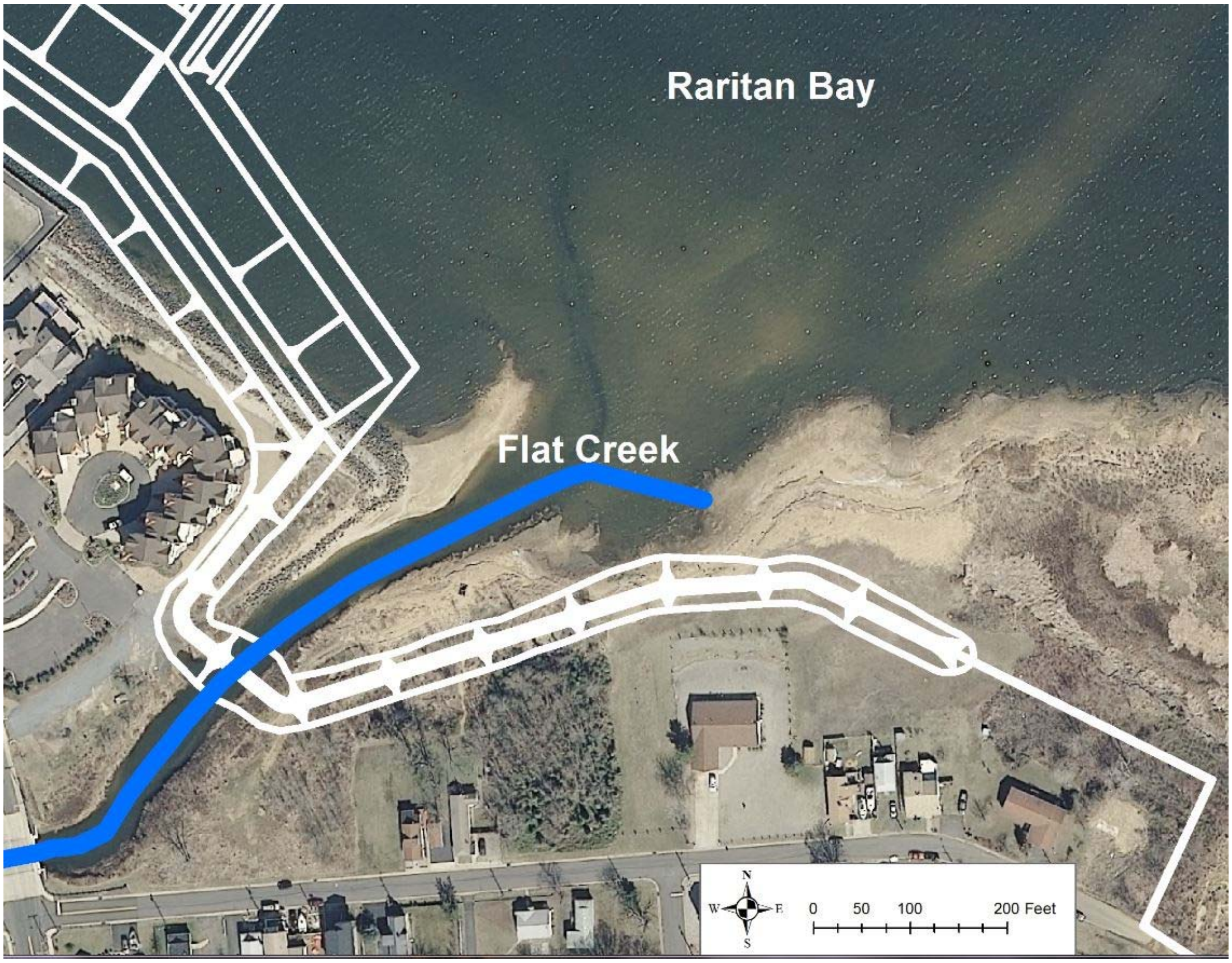
4.3.1 Property Development and Easements

Since completion of the September 2003 Feasibility Report, a condominium development adjacent to Flat Creek, a storage/treatment tank at the Bayshore Regional Sewage Treatment Authority plant, swimming pools, fences, outbuildings and other structures have been constructed along the alignment or within the required easements.

The primary impact of a new condominium development constructed at the east end of the beach near Flat Creek (Figure 18) is the encroachment of required easement. The structure is located approximately 25 feet from the levee centerline. Since the levee height is almost nine (9) feet above existing grade in this location, the levee toe would be at the doorstep of the easternmost condominiums. As currently designed, the project would impact property owners due to the obstruction of their existing views of the waterfront and reduced open space.

No attempt was made to avoid any encroachments on the alignment easements as part of the HSLRR Recommended Plan, and the additional costs of any necessary alignment shifts were not calculated. Alignment refinements to address these identified easement issues issue are to be fully analyzed as part of the PED phase. Surveys taken in the PED phase will refine easement requirements, though impacts to the cost estimate have been taken into account by the Abbreviated Risk Analysis and associated cost contingencies in the total project cost estimate.

Figure 18: New Condominium Development Adjacent to Flat Creek



In other areas along the 2007 Authorized Plan alignment or within the updated easements (not pictured above) swimming pools, fences, and outbuildings have been constructed since the September 2003 Feasibility Report. It is assumed that many of these structures may be avoided during PED with minor adjustments to the alignment. A number of movable structures may also be relocated as part of the real estate requirements. For the HSLRR Recommended Plan, no attempt was made to avoid these features and the added costs of real estate acquisition are not included in the cost estimate, as land surveys are to be conducted in the PED phase. Cost estimates include appropriate contingencies to account for any uncertainty during this phase.

4.3.2 Erosion of Streambank

Portions of the 2007 Authorized Plan T-Wall were aligned immediately along the top of the bank of East Creek. Cross sections of the floodwall reach from Sta 39+50 to Sta 43+50, indicate that a portion of the unprotected side of the wall footing is in the creek. Since current cross sections of the creek were not conducted as part of this HSLRR, there is concern that the footing depth may need to be greater than planned, and will result in taller stem and redesign. Adjustments to the alignment may be possible for limited reaches but the impact to residential properties is a concern. This will be further investigated in PED once updated surveys have been conducted.

4.4 Lessons Learned and Best Management Practices

The following opportunities to apply lessons learned from constructed projects and updated best management practices for closure structures and pump stations were identified:

- Broadway road closure structure;
- Flat Creek and East Creek closure structures; and
- Chingarora Creek pump station.

4.4.1 Broadway Closure Structure

The roadway at Broadway is about 35 feet wide, with a 4-foot sidewalk. A gate is necessary at this location since the roadway could not be elevated to the design height while maintaining traffic design speeds. The 2007 Authorized Plan specified a miter-type of gate with a 40-foot wide opening for a total length of 50 feet and approximately 7 feet above existing grade. The support structure would be set back from the roadway five feet on either side, which would reduce the potential for impact by vehicles and provide space for pedestrian passage.

During reevaluation, alternatives to the miter gate at Broadway were considered. Miter gates require an extensive pile foundation due to the swinging of the gate through a minimum of 90 degrees from open to close position. Review of the September 2003 Feasibility Report revealed that the miter gate cost was based on a width of 40 feet, not the 50 feet specified in the 2007 Authorized Plan. In addition, the miter gate cost provided in the September 2003 Feasibility Report appeared low when compared to miter gates constructed within the past 12 years as part of the Baltimore District Civil Works Program (Lackawanna River Project).

The HSLRR Recommended Plan includes an updated Broadway closure design. Details are included in Section 4.5.5 of this HSLRR.

4.4.2 Flat Creek and East Creek Closure Structures

The September 2003 Feasibility Report stated that the selection of sector gates for the closures on Flat and East Creeks was primarily based on the fact that sector gates can operate in areas with channel sedimentation more reliably than sluice gates.

The sector gates, referred to as “storm gates” within the 2007 Authorized Plan, were sized using a UNET model to maintain tidal interchange of the wetland areas behind the alignment. Each sector gate facility was proposed to be 35-feet wide to allow normal tidal flushing. For Flat Creek, the existing bridge over Union Avenue/Front Street is 25 feet wide and restricts the flow more than the 2007 Authorized Plan’s 35-foot wide downstream sector gate. For East Creek, a 35-foot wide sector gate was specified just downstream of the existing Henry Hudson Trail bridge. Since the existing Jersey Avenue Bridge over East Creek is only 15 feet wide, this upstream bridge constricts the existing tidal flows. The downstream bridge for the Henry Hudson Trail is 34 feet wide. The specified height of the 2007 Authorized Plan sector gates is +15 feet NGVD29. This alternative would require two sector gates, each about 17’ to 18’ wide to meet the necessary 35’ wide opening.

Based on information from the nearby Keansburg project, the cost to maintain sector gates is extensive. In addition, there is experience that when sector gates are closed during a storm, sediment and debris get trapped in the gate pockets, and require considerable effort before the gates can be reopened. If debris is not cleared, the gears that operate the gates could be damaged.

Construction costs of sector gates also are high relative to other possible options, such as sluice gates. Alternatives to sector gates were evaluated, and design changes have been incorporated into the HSLRR Recommended Plan. Details are provided in Section 4.5.6 of this HSLRR.

4.4.3 Chingarora Creek Pump Station

Results for East Creek are similar to the original elevations presented in the 2003 Feasibility Report. The Flat Creek interior flooding elevations recomputed for this HSLRR are higher than reported in the September 2003 Feasibility report, which could be explained by the number of larger storm events that have occurred since the September 2003 Feasibility Report was completed.

Further study during the PED phase of the project will be needed to refine the pumping requirements for both the East Creek and Flat Creek drainage areas to maximize ponding areas provided by the pump stations. For this pumping analysis, only the 100-yr with 100-yr tailwater scenario was computed as this is the most critical event. To better model this scenario and the other scenarios, actual low-head pump curves should be selected to better portray real world conditions. In addition, peak pond with normal tide and peak pond elevation with the 2-year tailwater should also be modeled during the PED phase to provide better operational guidance under multiple head scenarios.

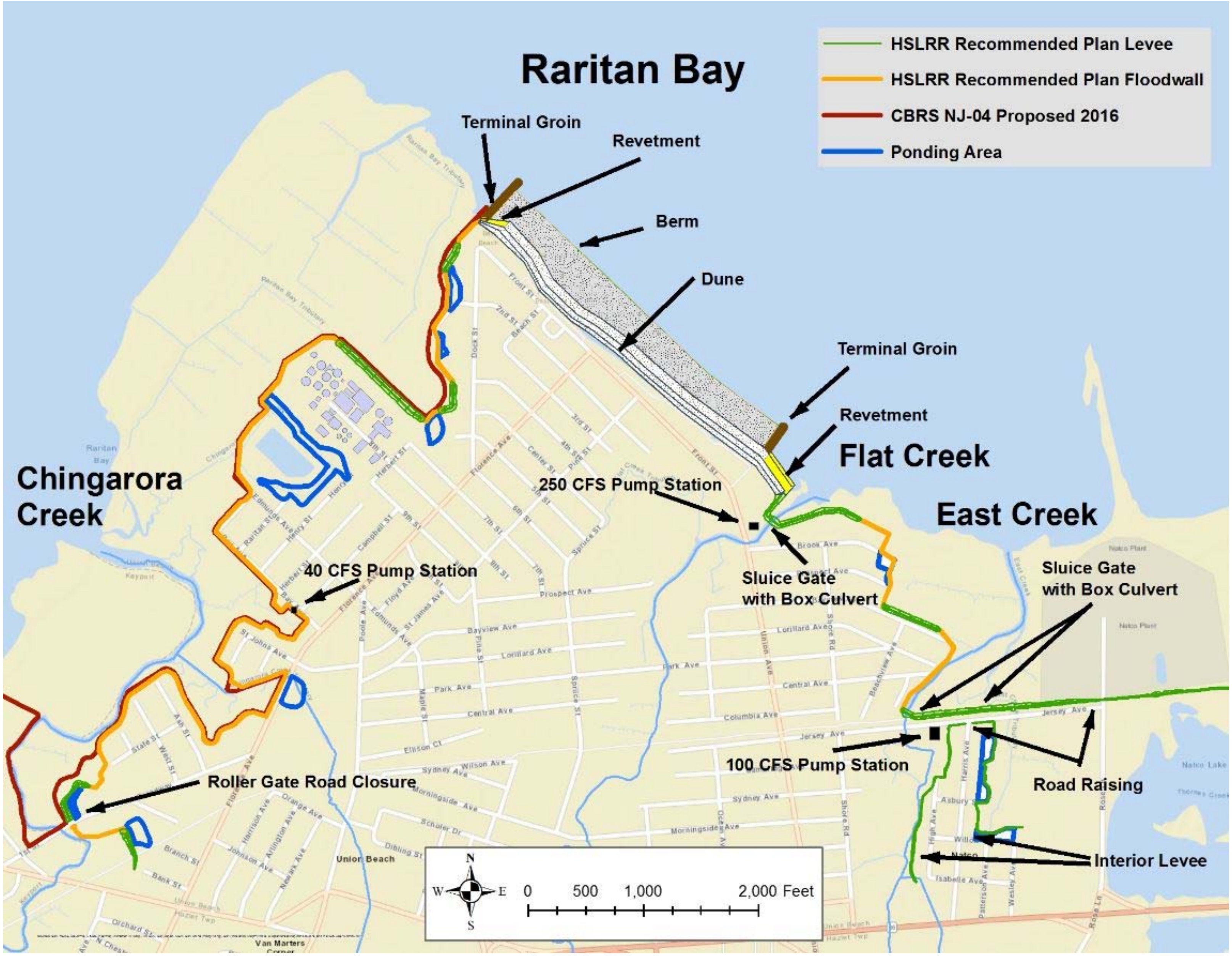
4.5 Design Changes to the 2007 Authorized Plan Incorporated into the HSLRR

After reevaluation of the 2007 Authorized Plan, several updates were incorporated into the HSLRR Recommended Plan – summarized below and discussed in Sections 4.5.1 through 4.5.6.

1. Changes in alignment to avoid CBRS boundary;
2. Floodwall design change – all T-Wall on piles;
3. Easements adjusted to comply with USACE vegetation management policy;
4. Levee embankment design change to address seepage risks;
5. Broadway closure structure design modification; and
6. Flat and East Creek gates design modification.

A general overview of the HSLRR Recommended Plan is shown on Figure 19. It is important to note that the HSLRR Recommended Plan alignment is unchanged from the 2007 Authorized Plan for <u>all</u> areas east of the termination of the Chingarora Creek floodwall at the northwestern terminal groin.

Figure 19: HSLRR Recommended Plan Overview



4.5.1 Changes in Alignment and Composition to Comply with CBRA

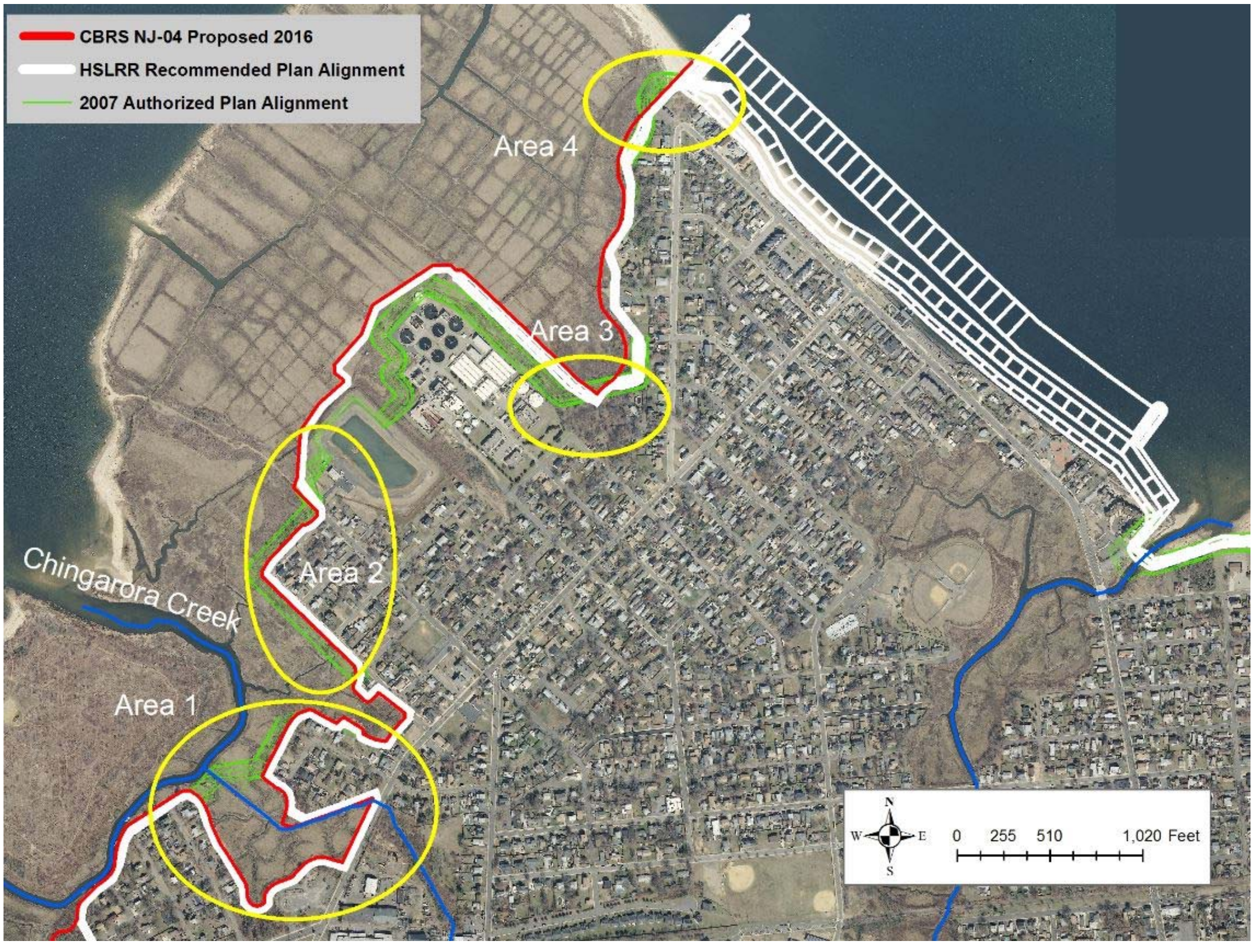
This HSLRR incorporates changes to the 2007 Authorized Plan alignment so that infringements on the CBRS boundaries noted in Section 4.1.1 can be avoided (see Figure 15 above). This change increases the overall length of the Chingarora Creek reach of the alignment from 11,384 feet to 13,220 feet (an overall increase of 1,836 feet). Specifically, the HSLRR Recommended Plan alignment for the Chingarora Creek reach includes 10,977 linear feet of floodwall (an increase of 6,021 linear feet) and 2,243 linear feet of levee (a decrease of 4,185 linear feet). The HSLRR Recommended Plan alignment is shown on Figure 20, and changes from the 2007 Authorized Plan alignment are summarized below.

- Area 1: Alignment shift to the south and east to comply with the CBRS boundary. The HSLRR Recommended Plan alignment in this area is comprised of 2,975 linear feet of floodwall in order to remain outside of the CBRS boundary. The 2007 Authorized Plan alignment is comprised of 731 linear feet of levee and 128 linear feet of floodwall in this area, though the 2007 Authorized Plan alignment infringes on the CBRS boundary.
- Area 2: Slight alignment shift to comply with the CBRS boundary. The HSLRR Recommended Plan alignment includes about 1,500 linear feet of floodwall in order to remain outside of the CBRS boundary throughout this area. The 2007 Authorized Plan alignment is comprised of a roughly equivalent length of levee throughout this area, though the 2007 Authorized Plan alignment infringes on the CBRS boundary.
- Area 3: Alignment shift to the south to comply with the CBRS boundary. The HSLRR Recommended Plan alignment includes about 165 linear feet of floodwall and 100 linear feet of levee in order to remain outside of the CBRS boundary throughout this area. The 2007 Authorized Plan alignment includes 287 linear feet of levee that infringes on the CBRS boundary.
- Area 4: Alignment shift to the east to comply with the CBRS boundary. The HSLRR Recommended Plan alignment includes 251 linear feet of floodwall to replace 343 linear feet of levee from the 2007 Authorized Plan alignment.

In addition, an update of the interior drainage requirements was conducted because of the changes reflected in the HSLRR Recommended Plan alignment along Chingarora Creek. This resulted in maintaining minimum facilities by adding the following features to the interior drainage facilities for the Chingarora Creek segment:

- 8 additional secondary outlet structures (increased from 37 to 45 structures);
- 150 linear feet of 24-inch concrete pipe (increased from 905 feet to 1,055 feet); and
- 250 feet of 48-inch concrete pipe (increased from 230 feet to 480 feet).

Figure 20: HSLRR Recommended Plan Changes in Alignment to Avoid CBRS Boundary

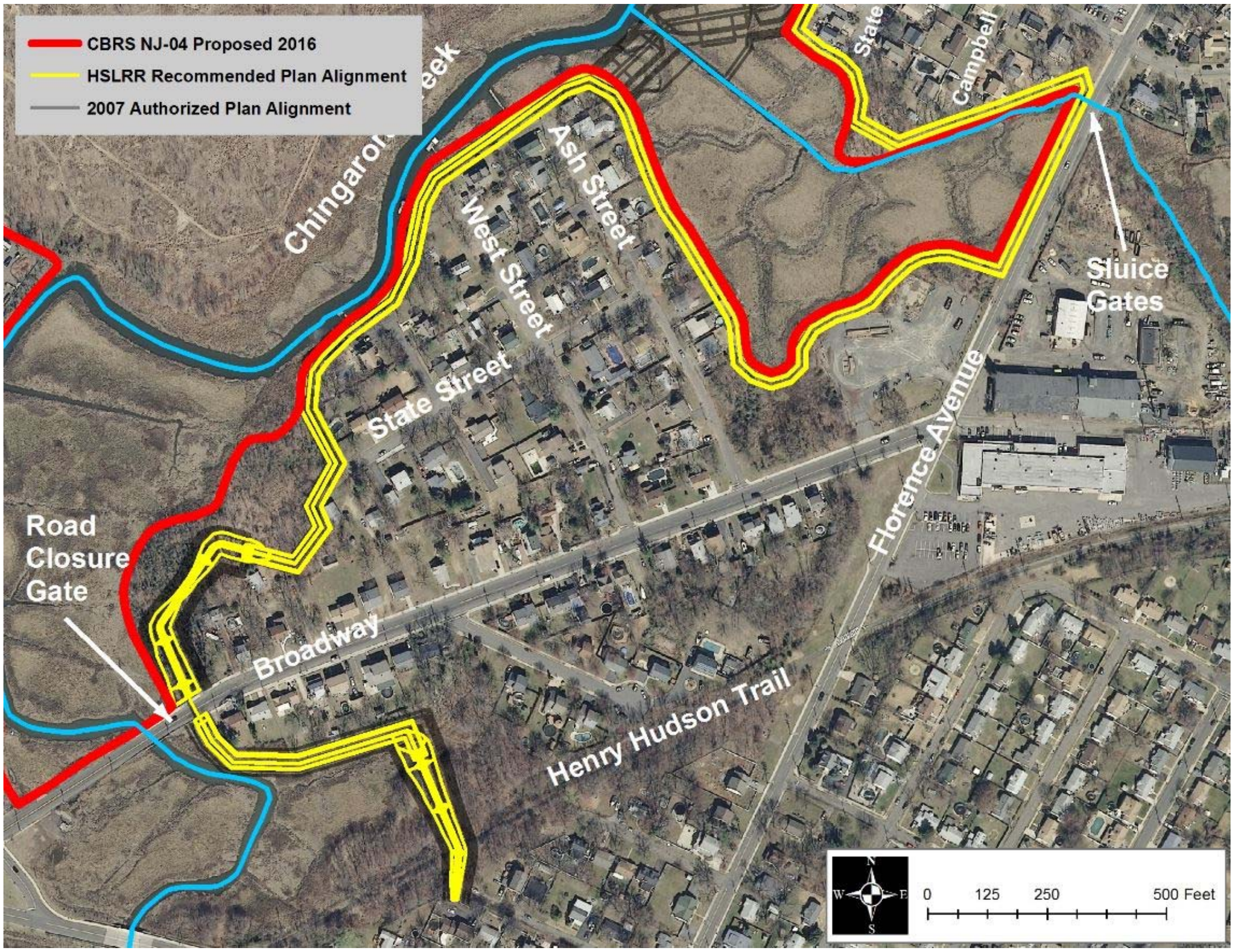


Chingarora Creek Element Alignment and Composition Changes

The Chingarora Creek element of the HSLRR Recommended Plan alignment includes 10,977 linear feet of floodwall and 2,243 linear feet of levee – each with a top elevation of +15 feet NGVD29. Also included in this element are a 40 cfs pump station, a road closure gate, and three sluice gates that cross a Chingarora Creek tributary. Figures 21, 22, and 23 provide an overview. Please note that the geographic coverage of Figures 21, 22, and 23 correspond to the geographic coverage limits of Figures 4, 5, and 6 shown previously for the Chingarora Creek Element of the 2007 Authorized Plan in Section 2.2.1 above.

Figure 21 shows the HSLRR Recommended Plan alignment beginning at high ground as an earthen levee approximately 500 feet southwest of the intersection of Florence Avenue and Bank Street (identical to the 2007 Authorized Plan alignment). The levee has a 10-foot crest width and side slopes at 1V:2.5H. At the design elevation of +15 feet NGVD29, the levee ranges between five and 11 feet above existing grade through this section.

Figure 21: HSLRR Recommended Plan Chingarora Creek Element (1 of 3)

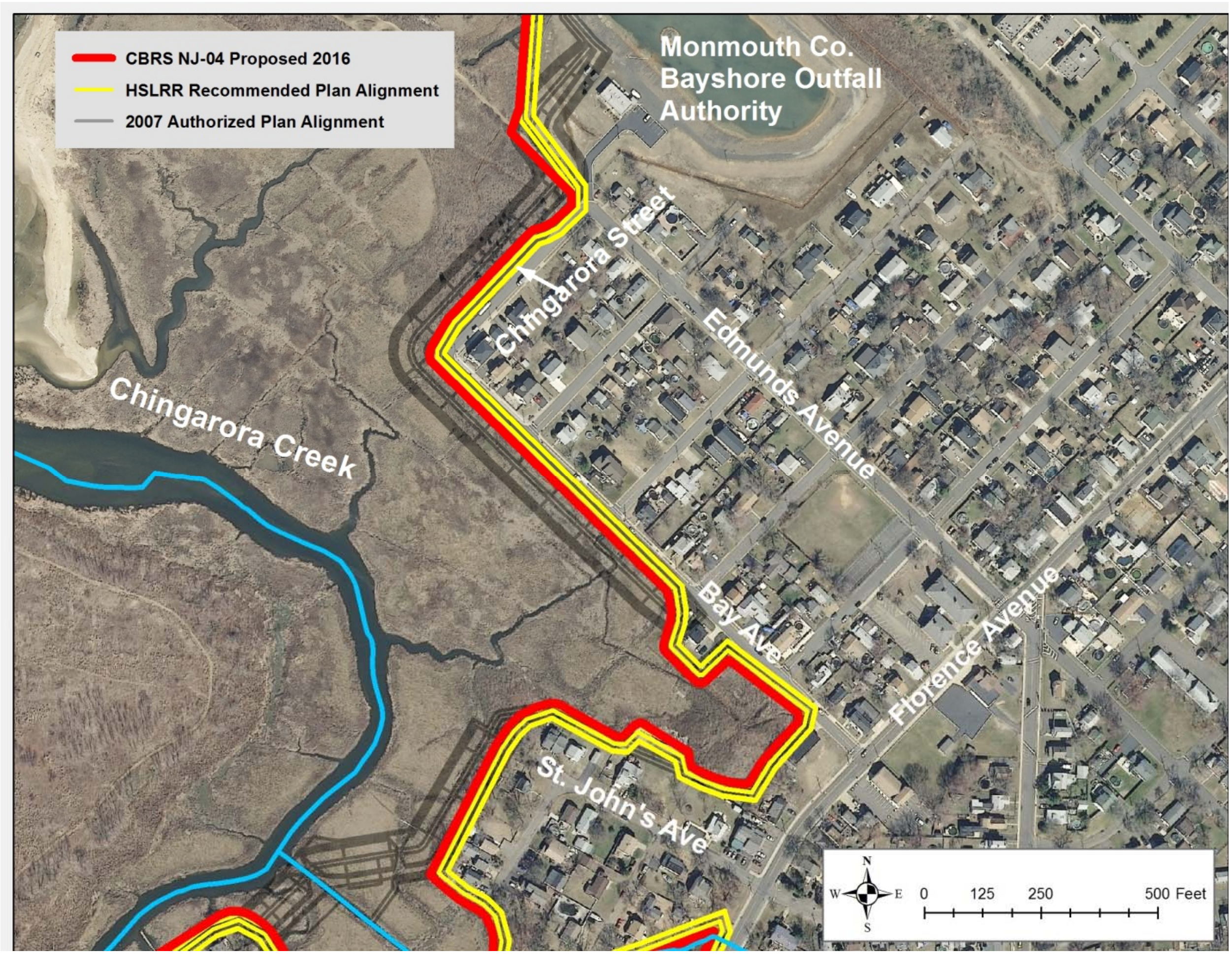


The levee alignment crosses over the Monmouth County Parks Henry Hudson Trail and continues approximately 370 feet northwest. Access to the Henry Hudson Trail will be maintained with a paved transition to the trail over the levee. At this point (identical to the 2007 Authorized Plan alignment), the HSLRR Recommended Plan alignment continues as a T-type floodwall, on a spread footing with an average height of approximately 10 feet above existing grade.

After 488 feet, the HSLRR Recommended Plan alignment diverges from the path of the 2007 Authorized Plan alignment (which transitioned to a levee at this point). The HSLRR Recommended Plan alignment continues as a T-type floodwall in a southerly direction toward Broadway, then northeasterly toward and adjacent to Florence Avenue, while maintaining its position outside of the CBRS boundary. After crossing a tributary to Chingarora Creek, the floodwall takes a sharp turn to the southwest, then to the north, staying outside of the CBRS boundary and maintaining its progress behind residential property located on Campbell and State Streets.

Figure 22 shows the HSLRR Recommended Plan alignment continuing as a floodwall outside of the CBRS boundary as it approaches St. John’s Avenue.

Figure 22: HSLRR Recommended Plan Chingarora Creek Element (2 of 3)



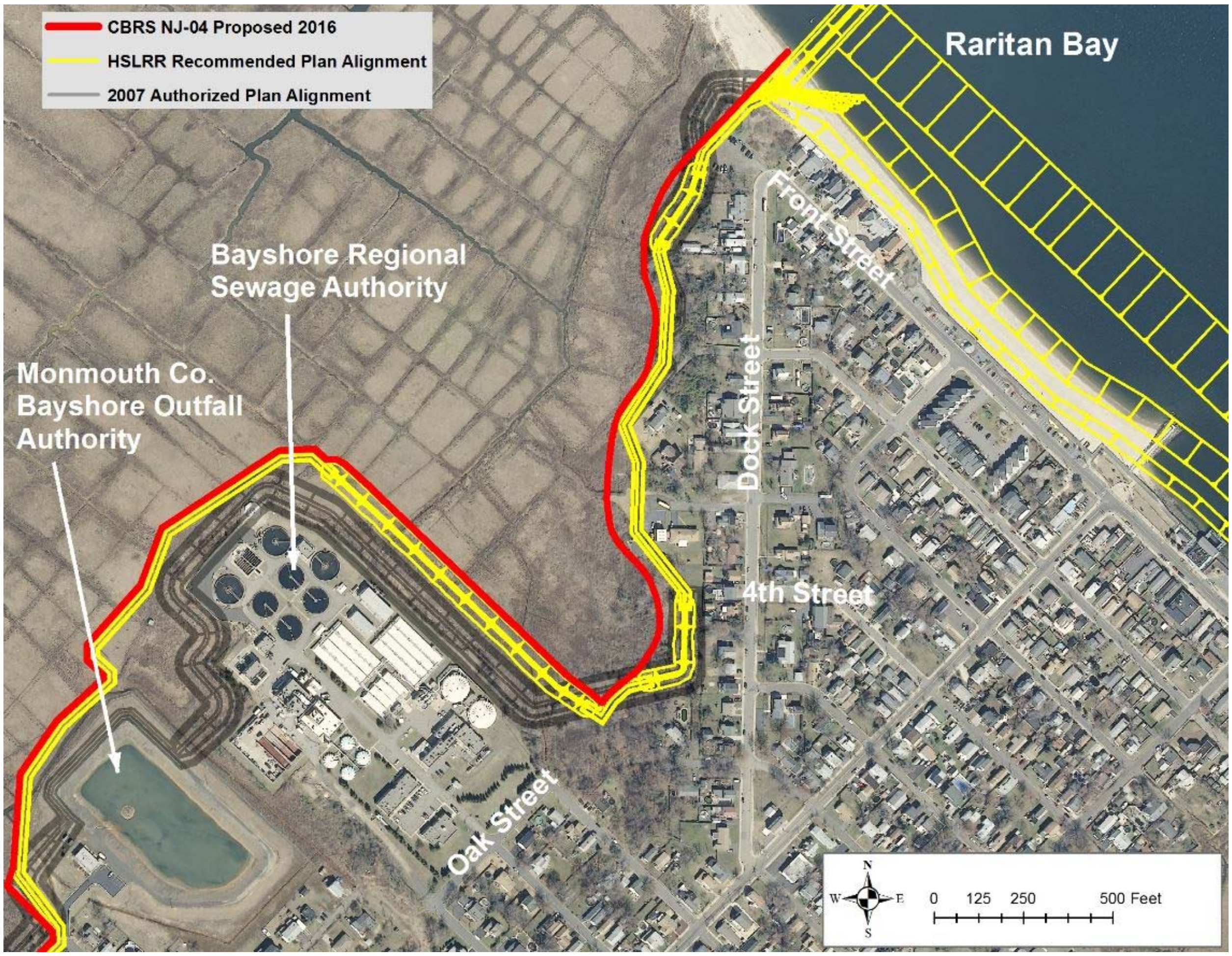
The floodwall takes a southeasterly direction toward Florence Avenue as it continues on a path nearly identical to the 2007 Authorized Plan alignment, and then takes a northeasterly turn parallel to Florence Avenue. When the T-type floodwall reaches Bay Avenue, it continues along the southwestern edge of Bay Avenue, and skirts around one residential property located on the western side of Bay Avenue (still following the general path and composition of the 2007 Authorized Plan alignment). The HSLRR Recommended Plan alignment continues northwesterly along Bay Avenue as a T-type floodwall in order to stay outside of the CBRS boundary. While the 2007 Authorized Plan alignment continues on this path, as well, the levee of the 2007 Authorized Plan infringes on the CBRS boundary. The revised alignment could impact Bay Avenue and will be evaluated to ensure that 2-way traffic can be maintained. During the design phase of the project, all effort will be made to minimize any impact to existing Bay Avenue traffic access.

When the floodwall reaches the northwestern edge of Chingarora Street, it turns to the northeast, and continues toward Edmunds Avenue. Upon reaching Edmunds Avenue, the HSLRR

Recommended Plan alignment makes a 90-degree turn to begin its path around the Monmouth County Bayshore Outfall Authority.

Figure 23 shows the HSLRR Recommended Plan alignment continuing as a floodwall outside of the CBRS boundary until the alignment approaches the northwestern edge of the Bayshore Regional Sewage Authority.

Figure 23: HSLRR Recommended Plan Chingarora Creek Element (3 of 3)



At this point, the HSLRR Recommended Plan alignment transitions to a levee and continues in a southeasterly direction until it approaches Oak Street. The levee then transitions to a T-type floodwall for about 230 feet in order to stay outside of the CBRS boundary. The 2007 Authorized Plan alignment is shown infringing on the CBRS boundary in this area.

The T-type floodwall continues to the east, and then transitions to a levee for roughly 350 feet. The alignment transitions back to a T-type floodwall in order to remain outside of the CBRS boundary, and continues in a northerly direction for about 1,050 feet toward Front Street.

The floodwall transitions to a levee 300 feet to the southeast of Front Street, and continues as a levee in a northerly direction for 275 feet. The HSLRR Recommended Plan alignment makes a final transition to floodwall in order to stay outside of the CBRS boundary (the 2007 Authorized

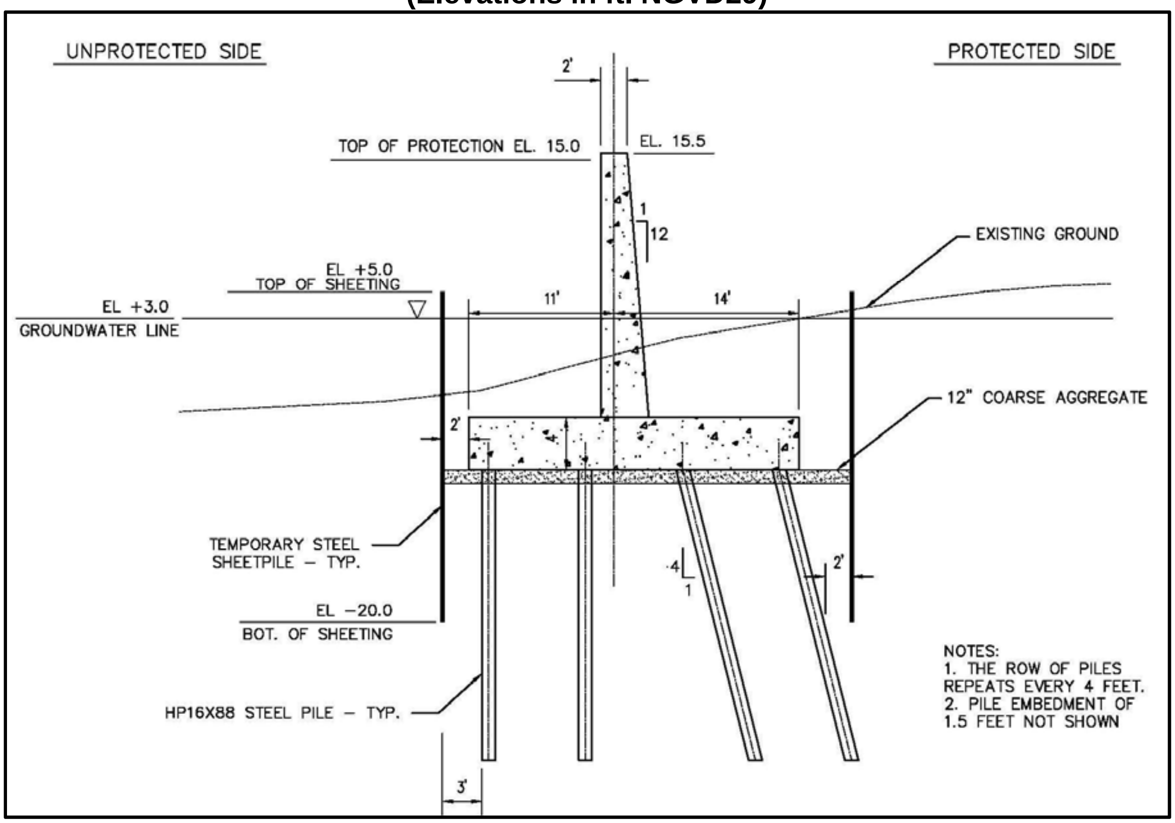
Plan alignment infringes on the CBRS boundary in this area) until it reaches the Shorefront Element.

4.5.2 Floodwall Design Change – All T-Wall on Piles

The HSLRR Recommended Plan updated the 2007 Authorized Plan floodwall design to be in compliance with criteria specified in EC 1110-2-6066 "Design of I-Walls", issued on 1 April 2011. This resulted in the replacement of all of I-Wall and T-Wall on spread footings within the 2007 Authorized Plan with T-Wall on piles for the HSLRR Recommended Plan.

Conservative assumptions were made for the wall and pile capacity design because of the limited availability of, and often off-alignment subsurface investigations. Further analysis of the existing ground elevations revealed that where a 20-foot stem was necessary, a row of 4 piles repeating every 4 feet would be required. Where the stem height averages 14 feet, a row of 3 piles repeating every 4 feet would be required. These two typical revised wall sections were incorporated into the HSLRR Recommended Plan, and the revised plan design for a 20-foot section is shown on Figure 24. The preliminary design analysis for the wall and piles are detailed in Engineering Appendix A, Sub-Appendix A – Preliminary Floodwall Design and Engineering Appendix A, Sub-Appendix B – Floodwall Pile Analyses. The T-Wall design will be further analyzed in PED after additional subsurface explorations are completed.

Figure 24: HSLRR Recommended Plan Floodwall Section for 20-Foot Stem (Elevations in ft. NGVD29)



4.5.3 Easements Adjusted to Comply with USACE Vegetation Management Policy

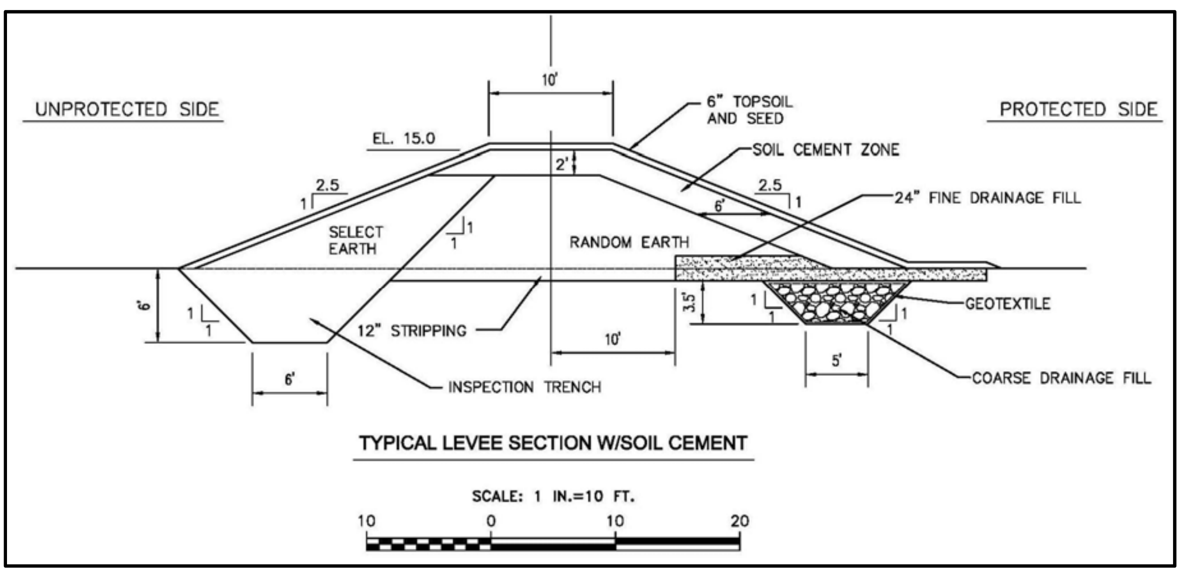
Easements included in the 2007 Authorized Plan do not include temporary easements on the unprotected side of the levees, which are required to enable construction. Therefore, a temporary easement of 10 feet is now included on the unprotected side for the HSLRR Recommended Plan. Since the I-walls are now being replaced with T-Walls (see discussion above), additional perpetual easement to provide 21 feet (8 feet beyond footing) from the wall faces is required because only 10 feet of easement is specified in the 2007 Authorized Plan. In addition, the easements and wetland impacts are based on a conservative T-Wall footing width of 30 feet. Design refinements are expected to result in a T-Wall footing width of 25 feet. Thus a conservative assumption (i.e., assumed to be a larger area than necessary) was calculated for easements, which has resulted in slightly greater impacts to properties during the detailed real estate analysis.

The HSLRR Recommended Plan incorporates the additional real estate easements required to comply with current USACE vegetation management policy. Additional details can be found in Section 5 of this HSLRR and in the Real Estate Plan (REP) provided as Appendix D to this HSLRR.

4.5.4 Levee Embankment Design Changes

The HSLRR Recommended Plan updates the 2007 Authorized Plan levee section to better address potential seepage risks in accordance with current design practices. Specifically, a blanket drain and a more robust toe drain extending into the foundation were included to assure adequate seepage control. The levee side slopes and footprint of the levee have not been changed. In addition, soil cement was added to the landside slope for overtopping protection. The updated levee cross section is shown in Figure 25. This section was used to update quantities and all associated costs for the HSLRR Recommended Plan.

Figure 25: HSLRR Recommended Plan Levee Section (Elevations in ft. NGVD29)

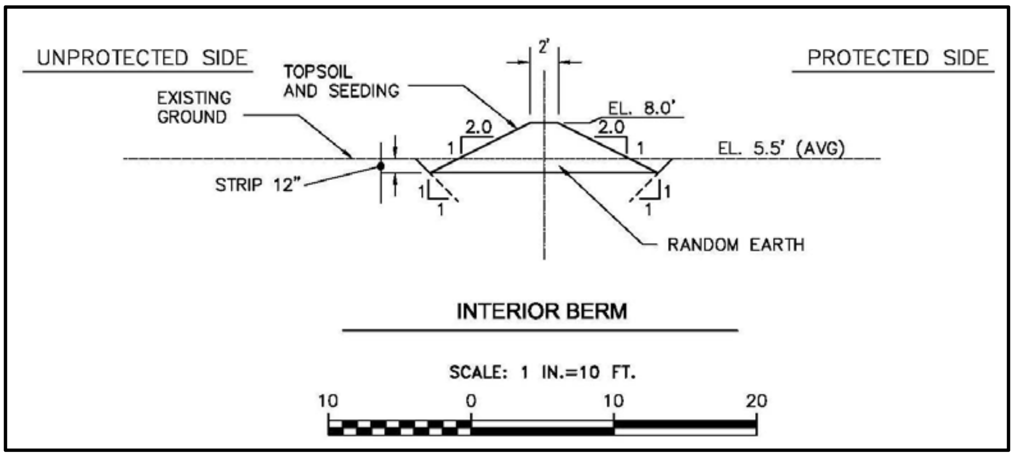


For the HSLRR Recommended Plan, it is assumed that the embankment will utilize a zone of select earth (impervious) consisting of more impervious material with a plasticity index (PI) greater than 5 and at least 25 percent fines. The random earth zone would consist of materials classified as GW, GM, GC, SW, SM, SC, ML, or CL or combinations thereof.

Final design will be based on the best utilization of available materials.[16] Materials for the blanket and toe drain will be designed in accordance with New Jersey or AASHTO aggregate standards. The soil cement will be designed during PED based on the materials available. For the main levee, the overall fill quantities increased by about 13 percent, primarily due to the revised toe drain.

The cross section for the interior berm presented in the 2007 Authorized Plan also held a central core of impervious material and a toe drain with side slopes at 1V:2H. The purpose of this embankment is to prevent spring tides from inundating the low lying area along Harris Avenue. While the interior levee geometry was unchanged for the HSLRR Recommended Plan, the interior levee embankment composition was changed to all random earth and the toe drain eliminated. A typical section is shown below in Figure 26.

Figure 26: HSLRR Recommended Plan Interior Berm (Elevations in ft. NGVD29)



4.5.5 Broadway Closure Structure Design Changes

A design change in the Broadway closure structure from a miter gate to a roller gate was incorporated into the HSLRR Recommended Plan. Based on best management practices for closure structures, a roller gate closure structure at Broadway has been determined to be a more operationally effective than the miter gate specified in the 2007 Authorized Plan. A roller gate would require a more simple foundation, would require only a limited number of piles, and would be closed just as quickly.

[16] Most of the material suppliers listed in the 2003 Feasibility Report appear to be either sand and gravel suppliers or general contractors - no test reports were furnished indicating availability of supplying impervious levee fill. The design based material requirements primarily focused on desired permeability (hydraulic conductivity) parameters.

Similar to the miter gate specified in the 2007 Authorized Plan, the roller gate specified in the HSLRR Recommended Plan would have a 40-foot wide opening with a total length of 50 feet and be approximately 7 feet above existing grade. The support structure will be set back from the roadway five feet on either side, which will reduce the potential for impact by vehicles and provide space for pedestrian passage. The roller gate in Bound Brook, New Jersey, shown in Figure 27, is 58 feet wide and 8 feet above existing grade. This type of gate would require an abutment wall on one end and a section of floodwall behind where the gate is stored in the open position that would complete protection. A limited pile foundation may be required and the final design will be refined in PED.

Figure 27: Roller Gate Road Closure - Bound Brook, New Jersey

4.5.6 Flat and East Creek Gates Design Change

A design change for Flat and East Creek gates from sector gates to sluice gates with box culverts was incorporated into the HSLRR Recommended Plan. Box culverts and sluice gates were determined to be less maintenance intensive and more operationally simple alternatives to the sector gates included in the 2007 Authorized Plan. The sluice gates and box culverts would be sized to provide equivalent tidal exchange and meet any other environmental and recreation requirements. Flat Creek is already restricted by the existing Union Avenue/Front Street Bridge to a width of 35 feet, and East Creek is restricted by the 15-foot wide Jersey Avenue Bridge.

Additional foundation information from geotechnical investigations will also be utilized to refine the design in the PED phase. The scope of this HSLRR did not provide for a detailed design of this alternative, though similar structures were used to develop a conservative cost estimate. A possible configuration of sluice gates with box culverts is shown in Figure 28.

Figure 28: Sluice Gates with Box Culverts Closure

4.6 Reevaluation of Project Design Performance

The September 2003 Feasibility Report states (page 161) that the Union Beach levee/floodwall system would provide "protection against the 100 year (1% annual chance) storm with 92% reliability...". Economic analyses of the 2007 Authorized Plan documented in the September 2003 Feasibility Report accrued benefits up to the levee/floodwall elevation of +15 feet NGVD29. This HSLRR incorporates lessons learned from Katrina regarding the susceptibility of levees and floodwalls when still water elevations allow waves to interact with the levee/floodwall system.

The Union Beach levee/floodwall system[17] is subject to wave action during more severe events on the northeast and west-facing alignments. When the still-water elevation is significantly lower than the top of the levee/floodwall system at +15 feet NGVD29, small waves may break on the levee/floodwall system, but the freeboard (defined as the vertical distance between the top of the levee/floodwall system and flood waters) prevents waves from overtopping the system. When the still-water elevation approaches +15 feet NGVD29 – yet still below this elevation – less freeboard exists, and waves impacting the levee/floodwall system are more likely to result in overtopping.

As part of this HSLRR (based on December 2012 stage frequency curves), five overtopping models were used to develop the mean overtopping flowrates for the different return intervals, and overtopping calculations were performed for stage elevations both with and without 0.7 feet of sea level rise over the period of analysis. Using post-Katrina levee studies, and assuming soil cement reinforcing on the landward slopes of the levees, the non-failure point of the Union Beach levee/floodwall system would be +13.1 feet NGVD29 and the failure point of the system would

[17] The 2007 Authorized Plan and the HSLRR Recommended Plan are identical for the purposes of an analysis of project design performance, which is based on the top elevation (+15 feet NVGD 29) of the levee/floodwall system.

be +13.6 feet NGVD29. Policy Guidance Letter No. 26, Benefit Determination Involving Existing Levees of 23 Dec 1991 defines the highest vertical elevation on the levee such that it is likely that the levee would not fail if the water surface elevation were to reach this level as the Probable Non-failure Point (PNP). It defines the lowest vertical elevation on the levee such that it is highly likely that the levee would fail as the Probable Failure Point (PFP). Highly likely is 85% confidence or greater.

At the beginning of the period of analysis in 2022, the non-failure-point elevation of +13.1 feet NGVD29 corresponds to an event with a 1.06% flood event, and the failure-point elevation of +13.6 feet NVGD29 corresponds to an event with a 0.8% flood event. At the end of the period of analysis in 2072, when 0.7 feet of sea level rise is assumed to have occurred, the non-failure-point elevation of +13.1 feet NGVD29 corresponds to an event with a 1.5% flood event, and the failure-point elevation of +13.6 feet NVGD29 corresponds to an event with a 1.15% flood event.

5. REEVALUATION OF PROJECT REAL ESTATE REQUIREMENTS

The updated Real Estate Plan (REP) provided as Appendix D to this HSLRR (herein referred to as the HSLRR REP) provides an overview of the real estate requirements for the HSLRR Recommended Plan, and supersedes the Real Estate Plan provided as part of the September 2003 Feasibility Report (herein referred to as the 2003 REP). All lands, easements, rights of way, relocations and disposal (LERRDs) required for the HSLRR Recommended Plan will be acquired prior to construction, with the LERRDs required for each phase of construction to be secured first by the non-Federal Sponsor.

5.1 Current Real Estate Estimate

The total LERRDs required in support of the HSLRR Recommended Plan is approximately 108.20 acres, as shown below in Table 7.

Table 7: HSLRR Recommended Plan REP Acreage Requirements

	Acres
In Fee Simple[18]	29.94
Permanent (Perpetual) Easements	63.01
Temporary Work Area Easements	15.25
TOTAL	108.20

The HSLRR Recommended Plan impacts approximately 184 parcels, affecting approximately 119 private owners and 2 public owners.

5.1.1 In Fee Simple Acquisitions

Approximately 29.94 acres are required in fee simple for varying purposes. In total, 31 parcels are required in fee simple (25 privately-owned and 6 publicly-owned). Of the total 29.94 acres:

- 22.0 acres are required for Environmental Mitigation
- 0.55 acres are required to accommodate free standing pump stations; and
- 7.12 acres are required for the alignment right of way and ponding areas.

Environmental Mitigation

Of the total 29.94 acres required in fee simple, approximately 22.0 acres are required for environmental mitigation purposes. Although the project was designed to avoid and or minimize ecological impacts, there are still unavoidable impacts to wildlife resources and wetlands. These unavoidable impacts require mitigation pursuant to the National Environmental Policy Act

[18] An acquisition in fee simple includes all land ownership rights with no encumbrances.

(NEPA), Clean Water Act and Engineering Regulation 1105-2-100, Planning Guidance Notebook, 22 Apr 00. Mitigation efforts involve restoring wetlands near Flat Creek and East Creak as a result of environmental loss caused by the construction of the levee/floodwall system. Sites upon which mitigation actions will take place have not yet been identified.

Free Standing Pump Stations

Approximately 0.55 of an acre (impacting 4 parcels; 1 privately-owned and 3 publicly-owned, including public streets) is required in fee simple for construction of two "free standing" pump stations that are not physically integrated into the levee/floodwall structure.

Private Property In-Fee Purchase for Alignment Right of Way and Ponding Areas

Approximately 7.18 acres (impacting 19 privately-owned parcels) is required in fee simple in support of the construction of the HSLRR Recommended Plan, including ponding areas. Traditionally, permanent easements are recommended for these purposes. However, at certain locations acquiring permanent easements would have such an adverse impact on a property owner – significantly encumbering the property – or leave a property owner with an uneconomic remnant that a fee simple acquisition of the entire parcel, or the easement area along with the uneconomic remnant, is recommended. Furthermore, at other locations, acquiring permanent easements and constructing the levee/ floodwall therein would create a landlocked situation where property owners would have no physical or legal means to access their property. Therefore, in these circumstances the acquisition of the entire landlocked parcel may be required.

5.1.2 Permanent (Perpetual) Easements

Approximately 63.01 acres are required for varying purposes. In total, 165 parcels are required (115 privately-owned and 50 publicly-owned). Of the total 63.01 acres:

- 6.86 acres are required for ponding easements associated with the seven interior drainage ponding areas
  (24 parcels: 16 private and 8 publicly-owned)
- 20.156 acres are required for the construction, operation and maintenance of the levee / floodwall system
  (111 parcels: 79 privately-owned and 32 publicly-owned); and
- 35.90 acres are required for the construction, operation and maintenance of the beach dune/berm system
  (29 parcels: 19 privately-owned and 10 publicly-owned).

5.2 Real Estate Estimate Comparison: HSLRR REP to 2003 REP

The 2003 REP required approximately 91.03 acres to be acquired in support of the 2007 Authorized Plan. However, the HSLRR Recommended Plan changes in the alignment as a result of changes in criteria, physical conditions resulting from Hurricane Sandy, cost savings, or subsequent development resulted in an adjustment to the footprint of the 2007 Authorized Plan. Furthermore, adverse impacts to private property based on the HSLRR Recommended Plan resulted in the acquisition of additional real estate. As a result, real estate requirements increased from 91.03 acres (2007 Authorized Plan) to 108.203 acres (HSLRR Recommended Plan). Table 8 shows a comparison of the difference between the real estate requirements identified in the 2003 REP and the HSLRR REP estimate.

Table 8: Comparison of September 2003 Feasibility Report and 2017 HSLRR Acreage Requirements

	2003 REP	2017 HSLRR REP
Temporary Work Area Easements	3.25 acres	15.25 acres
Permanent (Perpetual) Easements[19]	69.80 acres	63.01 acres
In Fee Simple	17.98 acres	29.94 acres
TOTAL	**91.03 acres**	108.20 acres
Private Owners	98	119
Public Owners	3	2
TOTAL	**101**	121

As shown in Table 8, the major differences between the two estimates are found in Temporary Work Area Easements, and in Acquisition in Fee Simple. Also, as can be seen in the table, there are minor differences in Permanent Easement acreages between the two estimates. Minor differences between the two estimates can be attributed to differences in methods employed in deriving the estimates as noted below.

5.2.1 Temporary Work Area Easements

Temporary Work Area Easement acreage calculated for the HSLRR REP exceeds the acreage reported in the 2003 REP by 12 acres. This difference is due to the inclusion of several large consolidated staging areas under the current estimate that do not appear to have been included in the 2003 REP.

5.2.2 In Fee Simple Acquisitions

In-Fee Simple Acquisition acreage under the HSLRR REP estimate exceeds the acreage reported in the 2003 REP by 11.69 acres. Of this difference, 4.5 acres is due to an increase in wetland mitigation area.

[19] In the 2003 REP, acres required for environmental mitigation were classified as a Conservation Easement, and included under the category of Permanent (Perpetual) Easements. The HSLRR REP includes Environmental Mitigation acreage under the category of In Fee Simple. For the purposes of comparison consistency, acreage for the 2003 Conservation Easement has been re-categorized as In Fee Simple.

An additional difference in the acreage required for In Fee Simple Acquisitions is found in the difference between significantly encumbered private property estimate in the September 2003 Real Estate Plan and the current estimate. In the HSLRR REP, it was determined that 7.12 acres (impacting 19 privately-owned parcels) would be required in because of significant adverse impact on a property owner. The 2003 REP reports this type of In Fee Simple acquisition to be 0.48 acres.

5.2.3 Wetlands Mitigation

Mitigation requirements outlined in the September 2003 Feasibility Report and documented in the project's Record of Decision included the conversion of approximately 17 acres of giant reed dominated inter-tidal wetlands to inter-tidal wetlands dominated by salt marsh cord grass. The recommended mitigation plan also involved monitoring benthos recovery and re-colonization and adaptive management to monitor the success of the mitigation.

Compliance with 2009 USACE Vegetation Management Policy (see Sections 4.1.3 and 4.5.3 above) has increased the amount of impacted wetlands, increasing the mitigation requirements from the initial 17.50 acres noted in the 2003 REP to the HSLRR REP estimate of 22 acres.

6. REEVALUATION OF PROJECT COSTS

Since the September 2003 Feasibility Report was completed, several design criteria changes and material and labor costs increases have resulted in a major impact on the cost of the 2007 Authorized Plan. This section presents a summary of the detailed cost estimate developed for the HSLRR Recommended Plan. Project first costs, annual operation, maintenance, repair, replacement and rehabilitation (OMRR&R – a 100% non-Federal cost), monitoring and renourishment costs developed for this HSLRR are discussed below, followed by a comparison of the 2017 HSLRR costs to the September 2003 Feasibility Report costs.

6.1 2017 HSLRR Project First Costs and Fully Funded Costs

Project First Costs developed for the HSLRR Recommended Plan are shown in Table 9 below. As shown in the table, the project First Cost is equal to $273,005,000 (October 2016 price levels and the FY 2017 discount rate of $2^{7/8}$ percent).

Table 9: HSLRR Recommended Plan Project First Costs (October 2016 Price Level)

Acct	Description	Cost ($)	Contingency ($)	Total ($)
01	Lands & Damages	13,916,000	2,783,000	16,699,000
02	Relocations	1,770,000	417,000	2,187,000
06	Fish & Wildlife Facilities	10,825,000	2,551,000	13,376,000
10	Breakwaters & Seawalls	10,690,000	2,520,000	13,210,000
11	Levees & Floodwalls	97,415,000	22,961,000	120,375,000
13	Pumping Plants	15,853,000	3,736,000	19,589,000
15	Flood Control Diversion Structures	12,696,000	2,992,000	15,688,000
17	Beach Replenishment	26,791,000	6,315,000	33,106,000
18	Cultural Resources Preservation	631,000	149,000	780,000
30	Planning, Engineering, & Design	22,199,000	2,087,000	24,285,000
31	Construction Management	12,530,000	1,178,000	13,708,000
	Total	225,316,000	47,689,000	273,005,000

Note: Numbers may not add to totals due to rounding.

The fully funded cost escalated to the midpoint of construction (varying between FY2018 Quarter 2 and FY2021 Quarter 2, depending on construction phase) is shown in Table 10. Note that the fully funded cost estimate of $289,245,000 differs from the estimate of project first costs of $273,005,000 shown in Table 9. This difference is due to the addition of $16,240,000 in escalation costs, which reflect expected cost increases between the October 2016 price level and the varying midpoints of construction.

Table 10: 2017 HSLRR Recommended Plan Fully Funded Cost

Acct	Description	Cost ($)	Contingency ($)	Escalation ($)	Fully Funded ($)
01	Lands & Damages	13,916,000	2,783,000	404,000	17,103,000
02	Relocations	1,770,000	417,000	65,000	2,252,000
06	Fish & Wildlife Facilities	10,825,000	2,551,000	525,000	13,901,000
10	Breakwaters & Seawalls	10,690,000	2,520,000	381,000	13,591,000
11	Levees & Floodwalls	97,415,000	22,961,000	8,943,000	129,319,000
13	Pumping Plants	15,853,000	3,736,000	1,429,000	21,018,000
15	Flood Control Diversion Structures	12,696,000	2,992,000	1,210,000	16,898,000
17	Beach Replenishment	26,791,000	6,315,000	955,000	34,061,000
18	Cultural Resources Preservation	631,000	149,000	46,000	826,000
30	Planning, Engineering, & Design	22,199,000	2,087,000	566,000	24,852,000
31	Construction Management	12,530,000	1,178,000	1,716,000	15,424,000
	Total	225,316,000	47,689,000	16,240,000	289,245,000

Note: Numbers may not add to totals due to rounding.

6.2 Interest During Construction

Interest during construction was calculated to account for the cost of capital during the construction period prior to the realization of project benefits. Costs were separated into two categories for the IDC analysis: initial costs (PED, Real Estate, and Utility Relocations), which will be incurred at the inception of each construction phase, and construction costs, which will be distributed evenly across each construction period of each phase. Project costs were amortized over the expected period of project construction (52 months) at an interest rate of $3^{1/8}$ percent[20]. Total interest during construction for the project equals $20,402,000 (details of the calculation are provided in Appendix B: Economics)

6.3 2017 HSLRR Annual OMRR&R and Monitoring Costs

Annual OMRR&R and monitoring costs for maintaining the project are presented below in Table 11 (October 2016 price levels and the FY 2017 discount rate of $2^{7/8}$ percent). Charges attributed

[20] IDC is updated to an FY 2017 interest rate of $2^{7/8}$% presented in the Executive Summary and Pertinent Data.

to the OMRR&R of the project consist of annualized replacement costs, repair, anticipated energy charges, and labor charges for the care and cleaning of project facilities. Project components requiring routine care include the storm gate, levees and floodwalls, interior drainage closure and manhole structures, road closure gate, pump stations, beach dune grass and sand fence.

Major mechanical equipment within the storm gate and interior drainage pump stations have anticipated life expectancies of 20-25 years. The cost of periodic equipment replacement has been estimated, annualized over the 50-year period of analysis, and incorporated into the OMRR&R charge. In addition, electric power requirements based on the anticipated frequency of pump station and storm gate operation have been added to the project's annual operation charge.

Table 11: 2017 HSLRR Annual OMRR&R and Monitoring[21] Costs

Annual Cost Item	2017 HSLRR Annual Cost ($)
Annualized Scheduled Renourishment	136,600
Annualized Emergency Beach Fill Cost	50,700
Annual Coastal Monitoring Cost	79,400
Annual Federal Inspection Cost	52,800
Annual Rehabilitation Cost	46,000
Annual Environmental Monitoring Cost	85,400
Subtotal Monitoring & Rehabilitation	$ 450,900
Annual Dune Maintenance Cost	18,200
Annual Outfall Maintenance Cost	54,100
Annual Groin and Revetment Maintenance	52,400
Annual Levee and Floodwall Maintenance	86,600
Annual Interior Drainage O&M	120,900
Annual Roller Gate O&M	23,000
Annual Chingarora 40 cfs Pump Station O&M	120,000
Annual East Creek 100 cfs Pump Station O&M	160,000
Annual Flat Creek 250 cfs Pump Station O&M	250,000
Subtotal Operations & Maintenance	$885,200
Total OMRR&R and Monitoring Annual Costs	$1,336,100

6.4 Construction Sequencing

The September 2003 Feasibility Report proposed that there would be eight (8) phases of construction. Upon completion of an initial estimate for the HSLRR Recommended Plan, it was

[21] OMRR&R is a 100% non-Federal cost that is calculated to determine the overall annual cost of the project for benefit-to-cost ratio (BCR) determination. Monitoring is a project cost, cost-shared in accordance with cost-sharing requirements for coastal storm risk management construction (65% Federal, 35% non-Federal).

decided that construction could be broken into five phases to properly account for escalation, multiple mobilization /demobilization, etc. yet move forward as quickly as possible. All drainage structures, pump stations, road raisings and pump stations would be constructed in their respective phases. Phase 1 construction would start in January 2018, and all phases would be completed by April of 2022.

6.4.1 Phase 1 – Shoreline Element

Construction Initiation: January 2018, Construction Duration: 14 months

The entire shoreline element would be constructed under one contract. Since this feature would be outflanked by a large storm event, consideration will be given to including the portion of levee parallel to Flat Creek to minimize wave damage to the condominium complex before Phases 3 or 4 are completed.

6.4.2 Phase 2: Flat Creek to East Creek Levee and Floodwall and Interior Levee

Construction Initiation: January 2019, Construction Duration: 30 months

This contract begins at the eastern terminal groin at the beachfront and extends along Flat Creek to Front Street before extending Oceanside of Brook Avenue toward East Creek. The levee/floodwall then parallels East Creek before turning east along the Henry Hudson Bike Trail and tying into the levee constructed under Phase 3.

6.4.3 Phase 3 - East Creek Levee East of East Creek only

Construction Initiation: July 2019, Construction Duration: 12 months

This contract represents the initial levee construction by beginning just east of East Creek and extending to the eastern tie-out with the existing Keansburg levee. The existing bikeway will be rebuilt on top of the new levee embankment. Drainage facilities include three 6-foot x 6-foot tide gates with sluice gates and four 60-inch culverts with sluice gates and flap gates

6.4.4 Phase 4: Chingarora Creek Levee and Floodwall

Construction Initiation: July 2019, Construction Duration: 33 months

Under this major contract, the entire western reach of the levee and floodwall would be constructed from the beginning near Bank Street across the Henry Hudson Bike Trail to the Broadway Closure Gate. The levee and floodwall continue along the rear of properties past Ash Street, along Bay Avenue and Chingarora Street, around the Regional Treatment facility, then parallel to Dock Street before tying into the western terminal groin and dune. Construction of drainage facilities will be closely coordinated with the levee and floodwall construction. This phase would complete the coastal storm risk management components for the Union Beach project.

6.4.5 Phase 5: Environmental Mitigation

Construction Initiation: June 2018, Construction Duration: 12 months

The environmental mitigation component of the 2007 Authorized Plan was designed to mitigate for impacts on 17.5 acres of wetlands. The plan would convert 12 acres of wetland Phragmites in the Flat Creek area to 10 acres of salt marsh and two acres of wetland scrub-shrub habitat. Also in the Flat Creek area, 2.5 acres of upland Phragmites would be converted to wetland herbaceous / scrubshrub habitat. The plan for the East Creek area would convert 3 acres of wetland Phragmites to wetland scrub-shrub habitat. The HSLRR Recommended Plan will impact 22.0 acres of wetlands, though development of a mitigation plan for this increase has been deferred to PED. It is expected that mitigation for the additional 4.5 acres of wetland impacts will be addressed in a manner similar to the mitigation plan developed for the 2007 Authorized Plan.

6.5 Project First Costs Comparison

The first step in the comparison of costs from the September 2003 Feasibility Report was to escalate the project First Costs (October 2002 price level) to fourth quarter 2016 price levels[22]. Table 12 shows the project first costs (provided on Table 13 pages 305-306) of the September 2003 Feasibility Report escalated to fourth quarter 2016 price levels. All items include cost contingencies ranging from 10 to 20 percent, with the overall weighted average contingency for all September 2003 Feasibility Report project first costs equal to 13 percent.

Table 12: Project First Costs from September 2003 Feasibility Report Escalated to Fourth Quarter 2016

Acct	Description	2003 Feasibility Report ($)	2003 Escalated to Q4-2016 ($)
01	Lands & Damages	3,501,000	5,394,000
02	Relocations	1,221,000	1,881,000
06	Fish & Wildlife Facilities	6,060,000	9,336,000
10	Breakwaters & Seawalls	6,105,000	9,405,000
11	Levees & Floodwalls	35,920,000	55,337,000
13	Pumping Plants	3,655,000	5,631,000
15	Flood Control Diversion Structures	19,109,000	29,439,000
17	Beach Replenishment	6,996,000	10,778,000
18	Cultural Resources Preservation	0	0
30	Planning, Engineering, & Design	8,930,000	13,757,000
31	Construction Management	5,173,000	7,969,000
	Total Project First Cost	**$96,670,000**	$148,927,000

A comparison of the difference between the September 2003 Feasibility Report project first costs and the 2017 HSLRR project first cost, accounting for changes to project elements between the 2007 Authorized Plan and the HSLRR Recommended Plan is displayed in Table 13. As shown in the table, the 2017 HSLRR project first costs exceed the escalated 2003 project first costs by 83%

[22] Civil Works Construction Cost Index System, Amendment #8 dated 31 March 2016

($124,078,000). Percent differences between the 2017 HSLRR project first costs and the escalated 2003 project first costs range from a decrease of 47% for Acct 15 – Flood Control Diversion Structures to an increase of 248% for Acct 13 – Pumping Plants.

Table 13: Project First Costs Compared: 2003 Escalated & 2017 HSLRR Estimate

Acct	Description	2003 Escalated to Q4-2016 ($)	2017 HSLRR ($)	Increase over Escalated
01	Lands & Damages	5,394,000	16,699,000	210%
02	Relocations	1,881,000	2,187,000	16%
06	Fish & Wildlife Facilities	9,336,000	13,376,000	43%
10	Breakwaters & Seawalls	9,405,000	13,210,000	40%
11	Levees & Floodwalls	55,337,000	120,375,000	118%
13	Pumping Plants	5,631,000	19,589,000	248%
15	Flood Control Diversion Structures	29,439,000	15,688,000	-47%
17	Beach Replenishment	10,778,000	33,106,000	207%
18	Cultural Resources Preservation	0	780,000	n/a
30	Planning, Engineering, & Design	13,757,000	24,285,000	77%
31	Construction Management	7,969,000	13,708,000	72%
	Total Project First Cost	$148,927,000	$273,005,000	83%

Reasons for the increase of the 2017 HSLRR project first cost over and above the escalated September 2003 Feasibility Report project first costs are discussed below.

6.5.1 Increase in Contingency Percent Values

As part of the HSLRR efforts, an Abbreviated Risk Analysis was completed to develop a contingency for the project cost based on risks, likelihood of risks, and their cost impacts. Contingencies used in the 2017 HSLRR cost estimate range from 9 percent to 23 percent, with an overall weighted average contingency of 21 percent. As noted above, the overall weighted average contingency for the project first costs shown in the September 2003 Feasibility Report was 13 percent, and a 15 percent contingency was used for most construction accounts.

Given the $124 million difference between the 2017 HSLRR cost estimate and the escalated September 2003 Feasibility Report cost, the contribution of the increased contingency costs to the difference between the two estimates is notable. To illustrate this point, the HSLRR cost of $273,005,000 would be equal to $253,082,000 (a reduction of over $19 million) if contingency percent values used for the September 2003 Feasibility Report were used for the HSLRR.

6.5.2 Increase in Contractor and Subcontractor Markups

The September 2003 Feasibility Report cost estimate assumed a prime contractor markup of 13 percent, whereas the 2017 HSLRR cost estimate assumes a prime contractor markup of 28 percent.

In addition, the September 2003 Feasibility Report cost estimate is based on the prime contractor directly performing most of the construction. The 2017 HSLRR estimate reflects conditions more consistent with today's market, with the majority of direct construction tasks being performed by subcontractors. Subcontractor execution of most construction adds a layer of 20 percent subcontractor markup in addition to the 28 percent prime contractor markup in the 2017 HSLRR.

6.5.3 Item-Specific Cost Increases

Increases in contingencies, markups, and additional subcontracting partially explain the differences between the Escalated September 2003 Feasibility Report cost of $148,927,000 and the 2017 HSLRR cost of $273,005,000. Additional reasons for the $124,078,000 difference between the two cost estimates are provided for each of the Civil Works Breakdown Structure Accounts.

Account 01: Lands & Damages

The 2017 HSLRR Lands & Damages cost exceeds the Escalated September 2003 Feasibility Report cost by over $11 million, which can be attributed to an increase in acreage required for project construction. The September 2003 Feasibility Report estimates total acreage required at approximately 91 acres, whereas the HSLRR estimates required acreage at approximately 108 acres (an increase of approximately 17 acres). The increase in acreage is due to the HSLRR Recommended Plan's expansion of temporary work areas, an increased easement footprint for vegetation management, an increased easement footprint due to the change in floodwall design from I-Wall to T-Wall, an increased environmental mitigation acreage requirement, and an increase In Fee acquisitions to mitigate new findings of significantly encumbered private property.

Account 02: Relocations

The 2017 HSLRR Relocations cost exceeds the Escalated September 2003 Feasibility Report cost by $306,000. While the majority of this difference can be explained by an increase in contingencies, subcontracting, and contractor markup, the outfall extension was recalculated, road raising and resurfacing was estimated based on more current historic pricing.

Account 06: Fish & Wildlife Facilities

The 2017 HSLRR Fish & Wildlife facilities cost exceeds the Escalated 2003 Feasibility Report cost by approximately $4 million. An additional 4.5 acres of mitigation area has been added to the project because new design guidance has increased the amount of impacted wetlands, increasing the mitigation requirements from 17.50 acres noted in the September 2003 Real Estate Plan to the 2017 HSLRR estimate of 22 acres.

Account 10: Breakwaters & Seawalls

The 2017 HSLRR Breakwaters & Seawalls cost exceeds the Escalated September 2003 Feasibility Report cost by approximately $3.8 million. While some of this difference can be explained by an increase in contingencies, subcontracting, and contractor markup, material costs have been updated. The escalated cost estimate of installed armor stone used for the September 2003

Feasibility Report is $107.50/ton (actual cost used for the September 2003 Feasibility Report was $70/ton). The 2017 HSLRR estimate of the market price for installed armor stone is approximately $157/ton, which reflects current market conditions.

Account 11: Levees & Floodwalls

The 2017 HSLRR Levees & Floodwalls cost exceeds the Escalated September 2003 Feasibility Report cost by over $65 million, of which $8.3 million can be explained by a change in contingency costs (15 percent used in the September 2003 Feasibility Report, 23 percent used in the 2017 HSLRR). Another reason for the 2017 HSLRR increase over the Escalated September 2003 Feasibility Report cost is the September 2003 Feasibility Report assumed that the prime contractor would perform most of the work at a 13 percent markup on cost. The 2017 HSLRR assumes that subcontractors will perform most of the work at a 20 percent markup, with an additional 28 percent prime contractor markup.

Design refinements required by Engineering Circular (EC) 1110-2-6066 “Design of I-Walls” (1 April 2011)[23], also contributed to the increase in costs for the Levees & Floodwalls account. All I-Wall type floodwalls that had been specified in the September 2003 Feasibility Report are now T-Wall type floodwalls with steel pile foundation in the design for the HSLRR Recommended Plan. Materials costs have increased (e.g., riprap, concrete, steel). The steel pile base required for T-Wall construction is more heavy duty (H steel Pile) than that used in the September 2003 Feasibility Report (12-inch diameter concrete filled pipe piles).

In addition, the HSLRR Recommended Plan alignment changed the length of the Chingarora Creek element from 11,384 linear feet to 13,220 linear feet. The HSLRR Recommended Plan alignment also changed the composition of the Chingarora Creek element from 6,428 linear feet of levee and 4,956 linear feet of floodwall to 2,243 linear feet of levee and 10,977 linear feet of floodwall.

Account 13: Pumping Plants

The 2017 HSLRR Pumping Plants cost exceeds the Escalated September 2003 Feasibility Report cost by over $14 million, of which approximately $1.4 million can be explained by a change in contingency costs. In addition, the September 2003 Feasibility Report assumed that all work would be performed by the prime contractor at a 13 percent markup on cost, while the 2017 HSLRR assumes that subcontractors will perform most of the work at a 20 percent markup, with an additional 28 percent prime contractor markup.

The remainder in the cost differential can be explained by differences in pump station cost curves used for the September 2003 Feasibility Report and those used for the 2017 HSLRR. An updated pump cfs cost curve was used for the 2017 HSLRR, which included more recent historical costs (i.e., Green Brook – 2008 and Sebrings Mills Road – 2010).

[23] EC 1110-2-6066 consolidated the findings and lessons learned from studies performed after Hurricane Katrina.

Account 15: Flood Control Diversion Structures

The 2017 HSLRR Flood Control Diversion Structures cost is $13.8 million less than the Escalated September 2003 Feasibility Report cost. This cost decrease is explained by a change in design for the Flat Creek and East Creek diversion structures.

Account 17: Beach Replenishment

The 2017 HSLRR Flood Control Diversion Structures cost exceeds the Escalated September 2003 Feasibility Report cost by approximately $22.3 million, of which over $2 million can be explained by a change in contingency costs.

Additional differences can be explained by a change in unit prices. The escalated cost estimate for dredging used for the September 2003 Feasibility Report is $12.30 per cubic yard (actual cost used for the September 2003 Feasibility Report was $8 per cubic yard). The 2017 HSLRR based the dredging cost on a 2014 bid from Keansburg at $34 per cubic yard.

Account 30: Planning, Engineering, & Design

The 2017 HSLRR Planning, Engineering, & Design cost exceeds the Escalated September 2003 Feasibility Report cost by roughly $10.5 million. Both the September 2003 Feasibility Report and the 2017 HSLRR estimated Planning, Engineering, & Design costs at roughly 11 percent of total construction costs (including contingencies). Therefore, most of the increases in Planning, Engineering, & Design costs can mainly be explained by the overall increases in construction cost accounts described above.

Also, approximately $2.1 million can be explained by a change in contingency costs. Contingencies were not applied for the September 2003 Feasibility Report estimate, though the 2017 HSLRR includes a 9 percent contingency added to Planning, Engineering, & Design costs.

Account 31: Construction Management

The 2017 HSLRR Construction Management cost exceeds the Escalated September 2003 Feasibility Report cost by approximately $5.7 million, of which approximately $1,180,000 can be explained by a change in contingency costs. Contingencies were not applied in the September 2003 Feasibility Report estimate, though the 2017 HSLRR includes a 9 percent contingency added to Planning, Engineering, & Design costs.

Both the September 2003 Feasibility Report and 2017 HSLRR estimated Construction Management costs at approximately 6 percent of total construction costs.

6.6 Annual OMRR&R and Monitoring Costs Comparison

The comparison of annual OMRR&R and monitoring Costs[24] from the September 2003 Feasibility Report is based on an escalation of the 2003 annual OMRR&R and Monitoring, and Costs (October 2002 price level) to a fourth quarter 2016 price level using composite indices taken from

[24] Annualized investment costs (i.e., annualized Project First Costs plus Interest During Construction) are not discussed in this subsection.

31 March 2016 EM1110-2-1304 Civil Works Construction Cost Index System. Table 14 shows the annual OMRR&R and Monitoring Costs (provided on Table 14 page 307) of the September 2003 Feasibility Report escalated to fourth quarter 2016 price levels. Note that the order of presentation of the cost items differs from that shown in the September 2003 Feasibility Report for ease of comparison with Appendix C: Quantities and Costs of this HSLRR.

Table 14: Annual OMRR&R and Monitoring Costs from the September 2003 Feasibility Report Escalated to Fourth Quarter 2016

Annual Cost Item	**2003 Feasibility Report Estimate ($)**	**2003 Escalated to Q4-2016 ($)**
Annualized Scheduled Renourishment	40,000	61,600
Annualized Emergency Beach Fill Cost	19,000	29,300
Annual Coastal Monitoring Cost	57,000	87,800
Annual Federal Inspection Cost	3,000	4,600
Annual Rehabilitation Cost	23,000	35,400
Annual Environmental Monitoring Cost	53,500	82,400
Subtotal Rehabilitation, Inspection & Monitoring	$195,500	$301,100
Annual Dune Maintenance Cost	6,000	9,200
Annual Outfall Maintenance Cost	0	0
Annual Groin and Revetment Maintenance	30,000	46,200
Annual Levee and Floodwall Maintenance	53,000	81,700
Annual Interior Drainage O&M	49,000	75,500
Annual Sector Gate O&M	80,000	123,200
Annual Roller Gate O&M	0	0
Annual Chingarora 40 cfs Pump Station O&M	12,000	18,500
Annual East Creek 100 cfs Pump Station O&M	5,000	7,700
Annual Flat Creek 250 cfs Pump Station O&M	9,000	13,900
Subtotal O&M	$244,000	$375,900
TOTAL ANNUAL PROJECT COST ITEMS	$439,500	$677,000

Table 15 provides a comparison of the difference between the escalated September 2003 Feasibility Report OMRR&R and monitoring costs and the 2017 HSLRR estimate. As shown in the table, the 2017 HSLRR project annual cost items (excluding the major annualized cost items of Project First Costs plus Interest During Construction) exceed the Escalated September 2003

Feasibility Report annual cost items (again, excluding the major annualized cost items of project First Costs plus Interest During Construction) by $659,100. Percent differences between the 2017 HSLRR annual cost items and the Escalated September 2003 Feasibility Report annual cost items range from a decrease of 9 percent for Annual Coastal Monitoring Costs to an increase of 1,978 percent for Annual Flat Creek Pump Station costs[25].

Table 15: Annual OMRR&R and Monitoring Costs Compared: Escalated 2003 Feasibility Report & 2017 HSLRR Estimate

Annual Cost Item	**2003 Feas Rpt Escalated to Q4-2016 ($)**	**2017 HSLRR ($)**	**Increase over Escalated (%)**
Annualized Scheduled Renourishment	61,600	136,600	120%
Annualized Emergency Beach Fill Cost	29,300	50,700	74%
Annual Coastal Monitoring Cost	87,800	79,400	-9%
Annual Federal Inspection Cost	4,600	52,800	1048%
Annual Rehabilitation Cost	35,400	46,000	467%
Annual Environmental Monitoring Cost	82,400	85,400	3%
Subtotal Rehabilitation, Inspection & Monitoring	$301,100	$450,900	101%
Annual Dune Maintenance Cost	9,200	18,200	70%
Annual Outfall Maintenance Cost	0	54,100	
Annual Groin and Revetment Maintenance	46,200	52,400	4%
Annual Levee and Floodwall Maintenance	81,700	86,600	6%
Annual Interior Drainage O&M	75,500	120,900	61%
Annual Sector Gate O&M	123,200	0	
Annual Roller Gate O&M	0	23,000	
Annual Chingarora 40 cfs Pump Station O&M	18,500	120,000	552%
Annual East Creek 100 cfs Pump Station O&M	7,700	160,000	1978%
Annual Flat Creek 250 cfs Pump Station O&M	13,900	250,000	1712%
Subtotal O&M	$375,900	$885,200	133%
TOTAL ANNUAL PROJECT COST ITEMS	$677,000	$1,336,100	119%

[25] Increases in pump station costs are discussed below in Section 6.6.12

6.6.1 Scheduled Renourishment & Emergency Beach Fill

Escalated September 2003 Feasibility Report costs for Annualized Scheduled Renourishment & Emergency Beach Fill amount to $90,900 ($61,600 + $29,300), whereas these costs amount to $187,300 ($136,600 + $50,700) for the 2017 HSLRR – an increase of 120% over escalated costs. Periodic renourishment is required to protect the integrity of the design dune and beach from the effects of long-term erosion and sea level rise. Renourishment of 21,000 cy will occur every 9 years over the period of renourishment (construction commencement in January 2018 starts the renourishment cycle), and will be performed by trucking fill from an upland source - no difference in assumptions between the September 2003 Feasibility Report estimate and the 2017 HSLRR estimate. Cost changes can be attributed to differences in unit prices and contingencies. The 2017 HSLRR uses a current unit price of $57/CY plus 33% contingency. The Escalated September 2003 Feasibility Report costs were based on a unit price of $23/CY (un-escalated value of $15/CY) plus 15% contingencies.

6.6.2 Annual Coastal Monitoring Cost

Escalated September 2003 Feasibility Report costs for Annual Coastal Monitoring are roughly equivalent to Annual Coastal Monitoring costs for the 2017 HSLRR. These costs are based on semi-annual surveys over the 50-year period of renourishment, and are based on the approved Feasibility Report Monitoring scope. Costs for this item as calculated for the 2017 HSLRR were taken from the September 2003 Feasibility Report and escalated to 2nd Quarter 2016, which explains the relatively small difference between the escalated 2003 cost of $87,800 and the 2017 HSLRR cost of $79,400 for this cost item.

6.6.3 Annual Federal Inspection Cost

The 2017 HSLRR Annual Federal Inspection cost exceeds the Escalated September 2003 Feasibility Report cost by $48,200. No details on this cost item are available within the September 2003 Feasibility Report. The 2017 HSLRR calculations on this item include crew and engineering hours, and annual frequencies (approximately three inspections per year) of inspections for culvert openings, levees, levee access roads and ramps, floodwalls, riprap protection, drainage structures (flap, sluice gates), closure gates, ponding areas, open channels, closure structures, groins, and beachfill.

6.6.4 Annual Rehabilitation Cost

The 2017 HSLRR Annual Rehabilitation cost exceeds the Escalated September 2003 Feasibility Report cost by $10,600. During some extreme storm events, overtopping of the alignment may result in significant damage to the levee and associated facilities. The cost of restoring or rehabilitating the project features after such an event is included in this cost category. The primary features subject to damage during an extreme event are; the levee earthwork, drainage outlets within the levees, and electrical/mechanical equipment at the storm gate and pump stations. Damage to the levee earthwork was assumed to be 35% of the initial cost. Repairs to interior drainage outlets within the levee were estimated to be 15% of the initial construction cost. Repairs to the 100 cfs and 250 cfs pump stations were estimated to be $3,131,000 per station, approximately twice the cost of mechanical equipment, while repair of the storm sluice gates was estimated to cost $346,000. The frequency of repairs has been evaluated based on the expected frequency of overtopping. The expected frequency of overtopping, which incorporates the impact of flood stage uncertainty, was determined to be 0.45% annually for the +15 foot NGVD29 levee/floodwall system.

6.6.5 Annual Environmental Monitoring Cost

The 2017 HSLRR Annual Environmental Monitoring cost estimate is roughly equivalent to that shown in the Escalated September 2003 Feasibility Report cost estimate. The methodology used for both cost item estimates is identical.

6.6.6 Annual Dune Maintenance Cost

The 2017 HSLRR Annual Dune Maintenance cost exceeds the Escalated September 2003 Feasibility Report cost by $9,000. While no details on the methodology used are provided in the September 2003 Feasibility Report, the 2017 HSLRR estimate is based on an assumption of two equipment operators to re-distribute sand six times per year using two 140 hp dozers.

6.6.7 Annual Outfall Maintenance Cost

The September 2003 Feasibility Report provides no estimate for this cost item. The 2017 HSLRR provides an estimate of $54,100, which is based on based on an estimate of 5% of initial outfall extensions costs.

6.6.8 Annual Groin and Revetment Maintenance Cost

The 2017 HSLRR Annual Groin and Revetment Maintenance cost is roughly equivalent to the Escalated September 2003 Feasibility Report cost. This cost item was estimated for the 2017 HSLRR using the same methodology as presented in the September 2003 Feasibility Report, which is 0.5% of initial new groin, groin extension and groin rehabilitation project first costs.

6.6.9 Annual Levee and Floodwall Maintenance Cost

The 2017 HSLRR annual levee and floodwall maintenance cost is roughly equivalent to the Escalated September 2003 Feasibility Report cost.

6.6.10 Annual Interior Drainage O&M Cost

The 2017 HSLRR annual Interior Drainage O&M cost exceeds the Escalated September 2003 Feasibility Report cost by $45,400, an increase of 61 %.

6.6.11 Annual Storm Gate O&M Cost

The 2017 HSLRR Annual Storm Gate O&M cost of $23,000 replaces the Escalated September 2003 Feasibility Report (reported as “Storm Gate O&M”) sector gate cost of $123,200. This reduction in cost is due to the design change of the closure structures on East and Flat Creeks from sector gates to sluice gates. No details on this cost item are available within the September 2003 Feasibility Report.

Annual roller gate O&M costs of $23,000 shown in the 2017 HSLRR are based on a six-man crew working a total of 64 hours annually at a crew rate of approximately $360 per hour.

6.6.12 Annual Pump Station O&M Costs

The 2017 HSLRR Annual Pump Station O&M costs in total (40 cfs, 100 cfs, and 250 cfs) amount to $530,000 per year ($120,000 + $160,000 + $250,000), and exceed the Escalated September 2003 Feasibility Report total annual pump station O&M costs by approximately $490,000, a 1,222 % increase. No details on the three pump station annual O&M costs are available within the September 2003 Feasibility Report.

Each of the three pump station O&M cost estimates prepared for the 2017 HSLRR include annual electrical power costs, annual labor costs, and annualized equipment replacement costs. Annual electrical power costs include a service charge, a demand charge that assumes 8 months of use, and an energy charge – all of which vary by pump station cfs rating. Labor costs for all three pump stations are based on charges for cleaning, minor repairs, and operation of 52 man days per year at a rate of $800 per day. Replacement costs reflect an anticipated life expectancy of 20 to 25 years for the major mechanical equipment (pumps) housed at the pump station, and have been annualized over the 50-year period of analysis. Summary costs for each item included in the 2017 HSLRR estimate are provided in Table 16 and all costs include a 25 percent contingency.

Table 16: Annual Cost Item Summaries for 2017 HSLRR Pump Station O&M Estimates

Annual Cost Item	40 cfs Pump Station	100 cfs Pump Station	250 cfs Pump Station
Electrical Power	46,100	75,100	141,900
Labor	41,600	41,600	41,600
Replacement (annualized)	4,800	9,100	19,600
Contingency	23,100	31,500	51,000
Pump Station Annual O&M Cost (rounded to nearest $10,000)	$120,000	$160,000	$250,000

6.7 Annualized Project Costs Comparison

Project costs represented in the September 2003 Feasibility Report (page 306), and project costs represented in this HSLRR are shown in Table 17.

As shown in the table, total investment costs as reported in the September 2003 Feasibility Report have increased by $189.5 million (a 182% increase) in this 2017 HSLRR, though the annualized investment costs have increased by only $5.20 million (a 80% increase), and total annual costs have increased by $6.1 million (a 90 % increase).

The increase in annualized and total annual costs is not as dramatic as the increase in total investment costs because the annualized investment costs in the September 2003 Feasibility Report were calculated using a discount rate of $5^{7/8}$ percent, and the discount rate used in the 2017 HSLRR is $3^{1/8}$ percent. The annual cost impact of the discount rate change is significant, and helps to explain why economic justification (discussed in Section 8 of this HSLRR) is maintained when the project cost has more than doubled – economic justification is based on a comparison of annual benefits to annual costs.

Table 17: Project Cost and Annualized Cost Comparison

	2003 Feasibility ($)	2017 HSLRR ($)
Initial Project Cost	96,669,300	273,005,000
Interest During Construction	7,237,700	20,402,000
Total Investment Cost	103,907,000	293,407,000
Annualized Investment Cost	6,478,000	11,675,500
Annual LOP System O&M Costs	231,000	685,200
Annual Interior Drainage O&M Costs	155,000	650,900
Annual Project Cost (50 years)	$6,864,000	$ 13,011,600

7. REEVALUATION OF ECONOMIC BENEFITS

This section provides an update to the benefits and associated analysis procedures used in the determination of the economic viability of the 2007 Authorized Plan for coastal storm risk management. It is important to recognize that there is no difference between the 2007 Authorized Plan and the HSLRR Recommended Plan in terms of the protected area's geographic extent.

Project benefits were originally provided within Appendix B of the Raritan Bay and Sandy Hook Bay, New Jersey Feasibility Report for Hurricane and Storm Damage Reduction Union Beach, New Jersey dated September 2003. This HSLRR does not reanalyze alternatives, but updates the economic analysis of the 2007 Authorized Plan.

Estimates of current damages are based on August 2016 price levels and a 50-year period of economic analysis, and reflect the current economic condition of Union Beach. Damages have been annualized over the 50-year period of economic analysis using the fiscal year 2016 discount rate of $3^{1/8}$ percent. Benefits due to reduced transportation costs, as well as those associated with reduced flood proofing costs, were not anticipated to be significant and were therefore not included in the analyses.

7.1 Inundation Damage Calculations

Flood damage calculations were performed using Version 1.2.5 of the Hydrologic Engineering Center's Flood Damage Analysis computer program (HEC-FDA, October 2010). This program applies Monte Carlo Simulation to calculate expected damage values while explicitly accounting for uncertainty in the input data. HEC-FDA models were prepared for existing without-project conditions, and for the 2007 Authorized Plan. Additional models were prepared to evaluate the 2007 Authorized Plan interior drainage facilities.

7.1.1 Economic Reaches

In order to conduct economic benefit analyses for existing without-project conditions and the 2007 Authorized Plan, and to simplify the stage vs. damage and interior drainage analyses, the project area was separated into 24 economic reaches. Economic reach selection documented in the September 2003 Feasibility Report was maintained in the HSLRR analysis. An overview of the economic reaches is provided in Appendix B – Benefits.

7.2 HSLRR Adjustments to Structure Inventory

The analysis documented in the September 2003 Feasibility Report was conducted using a full scale structure database that was developed as part of the overall feasibility study effort that spanned the period 2001 through 2003. The structure database was generated through a survey of project area structures adjacent to the project area using topographic mapping with a 2-foot contour interval.

Data collected for the September 2003 Feasibility Report was used to categorize the structure population into groups having common physical features. Data pertaining to structure usage, condition, size and number of stories assisted in the structure value analysis. For each building, data was also gathered pertaining to its damage potential including ground and main floor elevations, lowest opening, construction material, basement, and proximity to the shorefront.

7.2.1 HSLRR Adjustments to Depreciated Replacement Values

The September 2003 Feasibility Report assigned depreciated replacement values (DRVs) based on calculations using standard building cost estimating procedures from R.S. Means and Marshall & Swift. This type of analysis combines the physical characteristics obtained in the inventory with standard unit prices per square foot. Depreciation was then calculated based on the observed type and condition of each structure. The valuation year of the DRVs used in the Feasibility Report was 2001.

The HSLRR analysis began with the values as stated in the September 2003 Feasibility Report. Eighty-four structures in the project area were constructed after 2001. For those structures, the depreciated replacement value was taken from the assessor database (valuation year of 2012). For the remaining structures, adjustments were made to the 2001 database values to reflect not only higher construction costs, but also an additional 15 years of depreciation.

The ENR Building Cost Index shows that the cost of building construction specific to northern New Jersey increased by a factor of 1.649 in the years since the September 2003 Feasibility Report was completed. The first step in updating the structure values was to multiply the original structure values by 1.649 to arrive at the new structure value. For those structures where sufficient data were available in the existing structure inventory (2001 values), an estimate was made of the amount by which each structure had been depreciated on an annual basis. An extra 15 years of depreciation was added to the 2001 depreciation factor, and the resulting (larger) depreciation factor was applied to the new structure value, to arrive at the new depreciated structure value.

In cases where sufficient data were not available in the Feasibility Report structure inventory database to estimate depreciation per year, the 2001 depreciation percentages were adjusted by a factor equal to the average ratio of (depreciated value as of 2016 / depreciated value as of 2001), which was calculated based on data from structures for which the estimate was available.

7.2.2 HSLRR Structure Ground Elevations

Ground elevations used in development of the structure inventory for the September 2003 Feasibility Report were derived from topographic mapping with two-foot contour intervals.

For the HSLRR analysis, ground elevations were taken directly from LiDAR mapping conducted by the USACE Joint Airborne LiDAR Bathymetry Technical Center of Expertise (Topobathy LiDAR) specifically to map ground and water elevations following Hurricane Sandy. The original reference datum developed for the dataset was NAVD88, but all elevations were converted to NGVD29 prior to use in the HSLRR analysis.

Points representing each structure in the GIS shapefile were assigned a new ground elevation using the current LiDAR data. Of the 2,229 structure points in the inventory:

- new ground elevation was higher for 264 structures (average change of 1.17 feet);

- new ground elevation was lower for 1,356 structures (average change of 1.39 feet); and
- elevation was unchanged for 609 structures.

7.2.3 HSLRR Inventory Adjustments for Structures Demolished

Hurricane Sandy caused substantial damage to hundreds of residential structures in the project area. As a result, many homes were demolished and rebuilt or will be rebuilt in the coming years. Data regarding destroyed, demolished, and rebuilding efforts were coordinated and verified with the Borough. New construction and existing structures requiring elevation located in the FEMA 100-yr floodplain require the lowest structure member (V-zone) or main floor (all other zones) to be elevated above the base flood elevation (BFE) plus one foot.

These structures remain in the structure database, though damages to the structures and the associated contents are not damaged under without project conditions by flood events that do not exceed the BFE, as they would be reconstructed or elevated to BFE +1 foot, or higher. However, values that represent property stored at ground level associated with a re-built structure (e.g., landscaping, out-buildings, garages, outdoor equipment, automobiles, etc.) remain in the inventory at ground level.

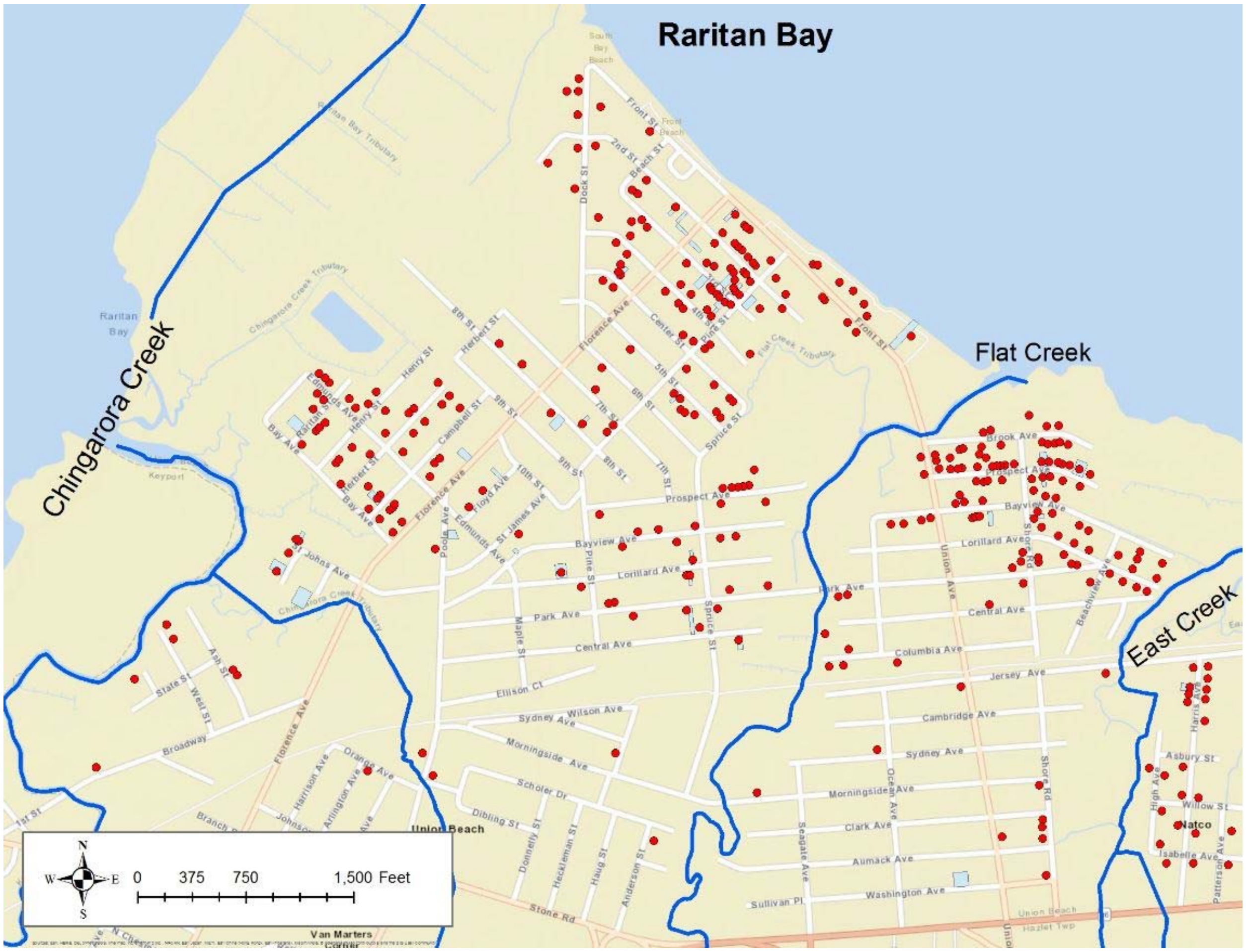
Data provided by the Borough identified 310 structures that were demolished (either directly during Hurricane Sandy or later by the Borough) and reconstructed at or above the BFE+1 elevation, or having survived Hurricane Sandy, elevated in place to the BFE+1 elevation or higher.

The Borough identified an additional 70 structures as being unsafe and vacant.[26] It was assumed that each of the 70 structures would be reconstructed at or above the BFE+1 elevation (assumes all 70 structures would be BFE +1 elevation or higher by 2022 when project construction is complete and benefits are being realized). This conservative assumption was made because of the extremely robust construction activity prevalent throughout Union Beach. It is not possible to select which vacant and unsafe structures would be slated for demolition and rebuilding. Because substantial damage precludes repair without raising the structure to the BFE + 1 foot or higher, and because property owners have mandated timelines (depending on funding mechanism) in which to act, it was prudent to assume that all of the structures would be replaced by a structure with the first floor located at or above the BFE +1 elevation.

Figure 29 shows the location of the 380 reconstructed structures within the project area, as indicated by a red dot.

[26] The list of unsafe vacant structures includes a total of 83 structures. Of the 83 structures, 13 were already accounted for within the list of 310 structures previously identified as being “demolished” or “to be demolished”.

Figure 29: Location of 380 Reconstructed Structures at or Above BFE+1 Elevation



7.3 HSLRR Inundation Damage Functions

Based on the type, usage and size of each structure inventoried, damage was calculated relative to the main floor elevation of the structure. Using structure and ground elevation data these depth vs. damage relationships were converted to corresponding stage (NGVD29) vs. damage relationships. Damages for individual structures at various stages were aggregated according to structure type (residential, apartment, commercial, etc.) and location (reach).

7.3.1 HSLRR Generalized Damage Functions

Generalized depth-percent damage functions for structure, structure content and other items were applied to the vast majority of structures for calculation of inundation damage.

For the September 2003 Feasibility Report, all of the generalized damage functions used were developed from on-site surveys conducted for the Passaic River Basin flood risk management project. It was argued that since most of the development in Union Beach is similar to the development in the nearby Passaic River Basin, these functions would relate the percentage of damage at various flood depths to the DRV of the structure and its contents. Non-residential damage categories include commercial, industrial, municipal, utility and emergency structures. The analyses assume that residential content values average 43.5% of the structure value (consistent with guidance set forth in EM 1110-2-1619). The functions also calculate other damage (including damage to landscaping, vehicles, storage sheds, garages, etc.) as a percentage of structure value.

This approach was used for the current analysis, with the following exception for residential structures without basements. After Hurricane Katrina, the New Orleans District, USACE conducted a study (*Depth-Damage Relationships for Structures, Contents, and Vehicles and Content-To-Structure Value Ratios in Support of the Donaldsonville to the Gulf, Louisiana, Feasibility Study – March, 2006*) that investigated depth-damage relationships for structures, contents, and content-to-structure value ratios for residential and commercial structures in eight parishes in Louisiana.

The relationships and ratios were developed using estimates from experts in the fields of construction, repair and restoration, and insurance claims adjustment. Homeowner interviews and inspections were used to assist the experts with their estimates. This study produced content-to-structure value ratios, as well as expected, minimum and maximum depth-damage curves for a number of structure types, in freshwater or saltwater conditions, in short- or long-duration flood events.

For this HSLRR, the Passaic River depth-damage curves were replaced with the saltwater, short-duration New Orleans curves for one- and two-story residential structures without basements. The flooding experienced in the project area during Hurricane Sandy was coastal, not riverine. As such, the New Orleans curves are better able to capture the effects of rapid inundation and saltwater intrusion. The New Orleans curves also provide maximum and minimum expected values, which paint a more accurate picture of the true potential for damage in an extreme event than the Passaic River curves or IWR curves,[27] which only provide a standard deviation around the mean.

7.3.2 HSLRR Individualized Damage Functions

Individualized depth-damage functions were generated for two utility structures, which are not accurately represented by generalized Passaic River non-residential depth-damage functions:

- Bayshore Regional Sewage Authority (BSRA) wastewater treatment plant. The plant is a 16 million gallons per day (MGD), secondary activated sludge treatment plant that currently serves approximately 100,000 people in eight townships (Hazlet, Holmdel, Union Beach, Keyport, Keansburg, Matawan, Aberdeen, and a portion of Marlboro). The plant was constructed in 1974, and was later expanded in 1993. Floodwaters from Hurricane Sandy inundated the facility's 24 acres in three to five feet of salt water. The flooding damaged every process in the plant, with the greatest damage incurred at the plant's incineration system. Inundation and significant damage begins for the plant at elevation

[27] Corps of Engineers' Economic Guidance Memoranda EGM 01-03 and EGM 04-01 provide generic depth-damage curves for use in Corps of Engineers flood risk management studies. EGM 01-03 provides generic depth-damage relationships for residential structures with basements, and EGM 04-01 provides generic depth-damage relationships for residential structures without basements.

+11 NGVD29, at an episodic damage cost of $15 million for damage to the plant's incinerator system. When Hurricane Sandy destroyed the BRSA incinerator system, it was necessary to transport and dispose of liquid sludge. Dewatering equipment was then deployed for several months while the incinerators were repaired and brought back on-line. The episodic cost for managing sludge was $1.5 million until such time the plant was brought back on line.

- Damages to the Jersey Central Power and Light electricity substation were estimated by using a damage curve represented in Table 7.9 of the HAZUS MR4 technical manual. The damage curve assumes electrical switch gear is located 3-feet above grade. Percent damage by depth of flooding feet ranges from 2 percent for one foot of inundation to 15 percent for 10 feet of inundation.

7.3.3 Wave Damage Analysis

Buildings located in the three reaches along the bayshore (Reaches 7.1, 7.2, and 7.3) were evaluated for their potential susceptibility to wave attack. The September 2003 analysis determined that structures located in the three reaches along the bayshore were deemed susceptible to wave attack (wave damage) under existing without-project conditions. Ground elevations in Reach 7.3 are such that most structures located within this reach are not susceptible to wave damage from a storm that has a 0.2% chance of occurring in any given year. Site visits conducted in support of the September 2003 Feasibility Report identified buildings for modified damage modeling, incorporating wave damage in addition to inundation damage. For this HSLRR, any demolished structures within reaches 7.1, 7.2, and 7.3 were built to an elevation where the lowest structural member (V-zone) or main floor (all other zones) was built at least 1 foot above the BFE.

Depth-damage functions for each building in the first row of structures along Front Street were individually modified to account for wave damage. Function values were revised to show 100 percent damage at and above depths where exterior flood stages could support a 100 percent damage-inducing wave. Such depths are specific to each structure's main floor elevation and were determined individually. Prior to damage function modification, the elevation and location of each structure was reviewed to determine if the establishment of a controlling shoreward elevation was required to properly model wave heights. The depth damage functions were modified to include 100 percent damage at water surface depths of 3.0 feet above ground elevation for wood frame structures, and at 3.3 feet above ground elevation for masonry structures, unless a controlling elevation (higher than the ground elevation at the structure) existed. Controlling elevations were used to calculate the resultant water surface at which wave damage would occur. Once the depth-percent damage functions were revised for each of the affected structures, the model was rerun to calculate structure damages attributable to both inundation and wave action. Since structure failure due to wave action would occur above the BFE, no adjustments were made to the depth damage functions for future with-project conditions.

7.4 HSLRR Sea Level Rise Base Year Adjustment

Sea level rise is a significant factor contributing to future impacts of tidal inundation and wave action. Based upon NOAA tide gauge readings at Sandy Hook, sea level has been increasing at an average rate of 0.014 feet per year (low/historic rate). This is equivalent to a 0.7 foot increase in tidal stage over the 50-year period of economic analysis. In future years, more frequent and higher-stage flooding is likely. The calculated existing base year (2022) without-project condition expected annual damage for residential structures is $6,850 per structure. Economic analysis results indicate that the average annual expected without-project damage to residential structures would increase to $9,890 per structure by the end of the 50-year period of economic analysis in the year 2072.

7.5 Expected Annual Damages

The stage vs. damage data were combined with stage vs. frequency data using the HEC-FDA program. The HEC-FDA program quantifies uncertainty in discharge-frequency, stage-discharge, and stage-damage functions and incorporates it into economic and performance analyses of alternatives. The process applies a procedure (Monte Carlo simulation) that computes the expected value of damage while accounting for uncertainty in the basic value.

The HEC-FDA program presents results for expected annual damages and equivalent annual damages. The impacts of sea level rise were incorporated by increasing the end of project stages (Year 2072) in the stage vs. frequency curve by the projected rate of sea level rise, 0.7 feet.

7.5.1 Public Emergency Costs

The cost of providing additional public services and repairing damage to public infrastructure during storms was calculated in the September 2003 Feasibility Report, and damage functions for public emergency costs were developed for each economic reach. These costs consist of:

- Police and fire department actions to warn and evacuate residents, and maintain order before and during an event;
- Flood fighting efforts and materials;
- Debris removal;
- Emergency road repair;
- Emergency shelter, longer-term temporary housing and the provision of necessities such as money, food, and clothing to flood victims; and
- Administrative costs incurred in the delivery of emergency services.

Costs of each of these items were sustained during Hurricane Sandy and in its aftermath. In addition, extended costs for power restoration, telecommunications outages, and an extended duration of wastewater treatment plant disruptions were incurred as a result of Hurricane Sandy.

Debris removal costs alone amounted to over $6 million following Hurricane Sandy, and FEMA assistance totaled $9 million. Considering that Public Emergency costs continue to be comprised of the same elements as modeled in the September 2003 Feasibility Report, the public emergency cost functions were updated to current values using a factor of 1.372, which represents an inflation of costs from 2001 through 2016 as reflected in the Consumer Price Index for all Northeast Urban Consumers. The update factor differs from update factors used for construction projects (e.g., the Engineering News Record Building Cost Index or Construction Cost Index) in that the update factor used for public emergency costs are not weighted heavily by the costs of construction. Public emergency costs are incorporated into the analysis through the HEC-FDA model as individual items on a reach-by-reach basis.

7.5.2 Without-Project Expected Annual Damages

Estimated storm damages include structure, content and other damages for buildings, and costs of damage to public infrastructure and emergency response. Equivalent annual damages, annualized over the 50-year period of economic analysis using a $3^{1/8}$ percent discount rate, are summarized in Table 18. Without-project equivalent annual damage for all reaches equals $21,763,000[28], which includes damages due to both inundation and wave action (for shorefront structures only).

Table 18: Summary of Without Project Equivalent Annual Damages

Damage Category	Without-Project Damages
Apartment	$ 6,000
Commercial	$ 1,019,000
Industrial	$ 212,000
Municipal	$ 367,000
Residential	$ 17,066,000
Utilities	$ 1,151,000
Public Emergency Costs	$ 1,942,000
Total	$ 21,763,000

50-Year Period of Analysis, $3^{1/8}$ % Discount Rate

7.5.3 With-Project Conditions Damages

With-Project conditions damages are estimated storm damages that remain after plan implementation. As noted, this HSLRR incorporates post-Katrina levee/floodwall overtopping and failure analysis into the calculation of with-project expected annual damages, which is a major

[28] Base year annual damage for all reaches equals $18,763,000 while future year annual damage for all reaches equals $26,948,000. See Appendix B (Benefits) for tables that provide these figures by damage category and economic reach.

difference from the economic analysis documented in the September 2003 Feasibility Report. As such, economic benefits calculations have been revised to incorporate levee/floodwall failure analyses for storms resulting in water surface elevations lower than the 2007 Authorized Plan elevation of +15 feet NGVD29. Specifically, the HSLRR with-project HEC-FDA model runs incorporated a levee/floodwall system non-failure point of +13.1 feet NGVD29, and a failure point of +13.6 feet NGVD29.

For this HSLRR, it was assumed that water accumulations behind the levee/floodwall system up to the failure point are negligible, and that the interior water elevations at the failure event are assumed to equal the bay stage elevations. It was likewise assumed that the interior water levels rise linearly between the non-failure point of +13.1 feet NGVD29 and the failure point of +13.6 feet NGVD29. Variables that factor into the interior stage elevation after failure are numerous, and include direction of the storm, wind direction, duration of the storm, etc. – this HSLRR did not address these additional factors.

Equivalent annual damages under with-project conditions, annualized over the 50-year period of economic analysis using a $3^{1/8}$ percent discount rate are summarized in Table 19 along-side the without-project conditions damages shown previously in Table 18.

Table 19: Summary of With and Without Project Equivalent Annual Damages

Damage Category	With-Project Damages	Without-Project Damages
Apartment	$ 6,000	$ 6,000
Commercial	$ 238,000	$ 1,019,000
Industrial	$ 141,000	$ 212,000
Municipal	$ 120,000	$ 367,000
Residential	$ 5,405,000	$ 17,066,000
Utilities	$ 302,000	$ 1,151,000
Public Emergency Costs	$ 678,000	$ 1,942,000
Total	$ 6,890,000	$ 21,763,000

50-Year Period of Analysis, $3^{1/8}$ % Discount Rate

Interior Drainage Residual Damages

In addition to potential damage from storm surges overtopping the levees and floodwalls, runoff from rainfall in the interior of the project area may also result in residual damages. Damages due to interior drainage are considered only with the 2007 Authorized Plan alignment in place, because the project alignment completely restricts the discharge of Chingarora Creek, Flat Creek, and East Creek.

Updated HEC-HMS models were developed in order to assess the changes to the ponding elevations behind the project alignment due to revisions in methodology for determining hypothetical rainfall data, the occurrence of additional storm events that changed the tailwater tide marigrams, and recalculation of ponding storage. Peak pond elevations were calculated for each of the 10 interior areas, and evaluated within HEC-FDA to determine interior drainage residual damages remaining with the 2007 Authorized Plan interior drainage facilities in place.

The results of the HEC-FDA analysis for residual interior drainage damages with the 2007 Authorized Plan interior drainage features in place are provided in Table 20. It is important to note that the damages of $562,000 shown as the total in the table will be added to with-project damages of $6,890,000 shown in Table 19 in the evaluation of economic performance for the 2007 Authorized Plan.

Table 20: Interior Drainage Residual Damages with Selected Features In Place

Damage Category	Interior Drainage Residual Damages
Apartment	$ 0
Commercial	$ 38,000
Industrial	$ 0
Municipal	$ 2,000
Residential	$ 499,000
Utilities	$ 0
Public Emergency Costs	$ 22,000
Total	$ 562,000

7.6 Reduced Flood Insurance Administrative Costs

The Borough of Union Beach participates in the National Flood Insurance Program (NFIP). Information received from FEMA indicates that there are currently 1,115 structures within the Borough[29] whose owners are currently maintaining flood insurance policies. As a result of the implementation of any project that is certified by FEMA as meeting the requirements of the NFIP, policyholders within the protected area will no longer be required to maintain flood insurance. Avoided administrative costs for these policies are considered a benefit associated with that particular project.

[29] Number of policies stated as of 31 March 2017, see http://bsa.nfipstat.fema.gov/reports/1011.htm#NJT

Annual project benefits of $127,000 were attributed to reduced flood insurance administrative costs in the September 2003 Feasibility Report. However, guidance issued since 2003 precludes the inclusion of benefits for projects that include a sacrificial feature, such as a protective berm and dune. For this reason, reduced flood insurance administrative costs will not be claimed in this HSLRR evaluation.

7.7 Ancillary Benefits: Recreation

The September 2003 Feasibility Report provided an evaluation of recreation benefits that could be realized from implementation of the project, and determined that the recreation benefits would amount to an annual value of $8,500. The 2017 HSLRR calculates recreation benefits of the project at $12,700 (a full description of the analyses used to derive the updated estimate is provided in the Economics appendix).

7.8 Ancillary Benefits: Reduced Maintenance

In the absence of a Federal project, it is anticipated that the Borough of Union Beach will continue to conduct annual beach nourishment operations in the Front Street area. The 2007 Authorized Plan incorporates future periodic nourishment as a design feature, and costs associated with this activity are included in the plan's annual cost. As such, periodic nourishment expenditures, which would have occurred in the without-project future condition, may be included as a reduced maintenance benefit. The $25,000 presented in the September 2003 Feasibility Report escalated to 2016 equals $38,000 per year and is applicable to the with-project condition.

7.9 Updated Economic Benefits of the 2007 Authorized Plan

Benefits are calculated based on the difference between the expected annual damages with and without coastal storm risk management plan. The implicit assumption incorporated into this method is that the reduction in damages is directly translatable into increased net income to floodplain land uses. Benefits from coastal storm risk management measures focus on inundation reduction benefits that would result from reduced physical damages to structures and contents, transportation, and infrastructure, and a reduction in emergency services costs. Project benefits represented in the September 2003 Feasibility Report, and project benefits calculated for this 2017 HSLRR are shown in Table 21.

Table 21: Expected Annual Project Benefits: 2003 Feasibility Report and 2017 HSLRR

	2003 Feasibility Report ($)	2017 HSLRR ($)
Without-Project Expected Annual Damages	11,047,000	19,821,000
Without-Project Expected Annual Emerg Svc Costs	1,554,000	1,942,000
With-Project Expected Annual Damages	1,069,000	6,212,000
With-Project Expected Annual Emerg Svc Costs	186,000	678,000
Benefits: Reduced Damage to Structures	9,978,000	13,609,000
Benefits: Reduced Public Emergency Costs	1,368,000	1,264,000
Benefits: Reduced FIA Administration Costs	127,000	0
Total Annual Flood Damage Reduction Benefits	11,174,000	14,873,000
Less: Residual Interior Drainage Damages with Selected Features in Place[30]	474,000	562,000
Net Flood Damage Reduction Benefits	10,999,000	14,311,000
Ancillary Benefits: Reduced Maintenance	25,000	38,000
Ancillary Benefits: Recreation	8,500	12,500
TOTAL ANNUAL PROJECT BENEFITS	**$11,159,500**	**$14,361,500**

[30] The increase in residual interior drainage damages from the 2003 Feasibility Report to the 2016 HSLRR are the result of a 12-year increase in the valuation of properties that incur residual interior drainage damages. Interior drainage ponding elevations and the underlying interior drainage hydrology remain unchanged from 2003.

8. REEVALUATION OF ECONOMIC PERFORMANCE

Project benefits represented in the September 2003 Feasibility Report (Appendix B), and project benefits calculated under this 2017 HSLRR are shown in Table 22. Total Annual Project Costs are presented above in Section 6.7 (reported in Table 17 within that section). As shown in Table 22 below, the economic performance metrics of the project, as represented by the Benefit Cost Ratio and Net Excess Benefits, indicate that the project remains economically justified. It is important to note that the project remains justified without the inclusion of annual recreation benefits of $12,500 and reduced maintenance benefits of $38,000 in the benefit-to-cost ratio.

Table 22: Annual Project Benefits and Economic Performance Comparison

	2003 Feasibility Report ($)	**2017 HSLRR ($)**
Without-Project Expected Annual Damages	11,047,000	19,821,000
Without-Project Expected Annual Emerg Svc Costs	1,554,000	1,942,000
With-Project Expected Annual Damages	1,069,000	6,212,000
With-Project Expected Annual Emerg Svc Costs	186,000	678,000
Benefits: Reduced Damage to Structures	9,978,000	13,609,000
Benefits: Reduced Public Emergency Costs	1,368,000	1,264,000
Benefits: Reduced FIA Administration Costs	127,000	0
Total Annual Flood Damage Reduction Benefits	11,174,000	14,873,000
Less: Residual Interior Drainage Damages with Selected Features in Place	474,000	562,000
Net Flood Damage Reduction Benefits	10,999,000	14,311,000
Ancillary Benefits: Reduced Maintenance	25,000	38,000
Ancillary Benefits: Recreation	8,500	12,500
TOTAL ANNUAL PROJECT BENEFITS	**$11,159,500**	$ 14,361,500
TOTAL ANNUAL PROJECT COSTS	**$6,864,000**	$ 13,011,600
BENEFIT TO COST RATIO	**1.6**	1.1
NET EXCESS ANNUAL BENEFITS	**$4,295,500**	$ 1,349,900

9. REEVALUATION OF ENVIRONMENTAL IMPACTS

The updated 2007 Authorized Plan (referred to as the HSLRR Recommended Plan throughout this document) and existing conditions have been reviewed under this HSLRR and Supplemental Environmental Assessment (Supplemental EA) to confirm that the proposed project is still the most suitable design to ensure that the Union Beach area is adequately protected.

9.1 National Environmental Policy Act Requirements

The Supplemental Environmental Assessment (Supplemental EA) that accompanies this HSLRR was prepared pursuant to the National Environmental Policy Act (NEPA), the Council on Environmental Quality's (CEQ) Guidance Regarding NEPA Regulations, and the USACE's Procedures for Implementing NEPA (Engineering Regulation [ER]-200-2-2). A Supplemental EA is a concise public document prepared by the Federal agency to provide analysis of the proposed action that is anticipated to have significant impacts (40 Code of Federal Regulations (CFR) 1508.9(a)).

The Supplemental EA updates the September 2003 Environmental Impact Statement and 2008 ROD for the Raritan Bay and Sandy Hook Bay, Hurricane and Storm Damage Reduction Study Union Beach New Jersey. The Supplemental EA also addresses any changes to environmental conditions and changes included in the HSLRR Recommended Plan.

9.2 Changes to the 2007 Authorized Plan

The HSLRR Recommended Plan updated the 2007 Authorized Plan to comply with new USACE policies and regulations, to comply with CBRA, and to accommodate physical changes that have occurred since finalization of the September 2003 Feasibility Report. In addition, the 2007 Authorized Plan alignment was reviewed to identify recent intrusions to the previously planned right-of-way. While minor adjustments to the right-of way may be required during PED, the HSLRR Recommended Plan alignment was not substantially changed from the 2007 Authorized Plan alignment, and there are no changes in project scope.

9.3 Impact Avoidance and Minimization

Although there are changes in the design, some impact avoidance and minimization has been presented. As stated in earlier sections of this HSLRR, portions of the 2007 Authorized Plan alignment that infringe upon the CBRS have been relocated outside of the CBRS in the HSLRR Recommended Plan. The HSLRR Recommended Plan change of gate structures from sector gates to sluice gates with wide culverts will to continue the current tidal exchange, and also allow for adaptively managing the tidal exchange. This can be useful for managing nearby land drainage, increasing, or decreasing the tidal exchange, adaptive restoration management, as well as other benefits.

As noted throughout this HSLRR, refinements to the alignment right-of-way may arise during PED. A scenario has been developed in order to address the changes from the September 2003 Feasibility Report to this HSLRR. It is during the PED phase that consultation with the regulatory agencies, project Partner New Jersey Department of Environmental Protection (NJDEP), and the Borough of Union Beach will be imperative in order to minimize the impacts.

9.4 Mitigation Plan

The District will implement a mitigation plan similar to that described in the 2003 FEIS. As noted throughout this HSLRR, the HSLRR Recommended Plan estimate of wetlands impacted is 22.0 acres, and the wetlands impact described in the 2003 FEIS was estimated at 17.5 acres. An update to the Habitat Evaluation Procedures (HEP) method to quantify the impacts to wildlife and wildlife communities in terms of Average Annual Habitat Units (AAHUs) and the Evaluation for Planned Wetlands (EPW) method to assess impacts to wetland functions and values in terms of Functional Capacity Units (FCUs) will be conducted during the PED phase. When these analyses are complete, the mitigation plan will be modified to account for the additional 4.5 acres of wetland impacts estimated as part of this HSLRR – i.e., the update will include the additional acreage impacted due to changes in USACE design criteria. To comply with NJDEP mitigation regulations, coordination with NJDEP Land Use Regulation will continue.

9.5 Monitoring

The District proposes to alter the monitoring plan of the intertidal and subtidal plan and cultural resources. The District is also proposing to remove the tidal marsh, piping plover (Charadrius melodus) and SBBA monitoring plans. All other monitoring will continue as described in the 2003 FEIS. The following discusses the rational for the changes in the above monitoring plans.

9.5.1 Intertidal and Subtidal Resources Monitoring Plan

Monitoring of intertidal and subtidal habitats were to be performed to provide information on impacts to shallow water faunal assemblages resulting from implementation of the Bay Shore component of the HSLRR Recommended Plan (unchanged with respect to this issue from the 2007 Authorized Plan). Currently, there is a lack of knowledge about the effects of beach nourishment on intertidal and subtidal resources in low energy estuarine environments. The components include benthic infauna, finfish assemblages, feeding habits of finfish, grain size, and water quality to include temperature, salinity, and dissolved oxygen. The Supplemental EA document will remove that monitoring requirement. The rationale for the removal is that the New York District is currently conducting the same intertidal and subtidal monitoring for the Raritan Bay Sandy Hook Bay, Port Monmouth, New Jersey Study. The Port Monmouth project is located in Port Monmouth, New Jersey just east of Union Beach. The Port Monmouth monitoring is utilizing Union Beach as the pre-beach nourishment control. Data gathered from the Port Monmouth monitoring will be applicable to this study as they both are utilizing the same borrow area for beach nourishment.

9.5.2 Cultural Resources Monitoring Plan

In June 2014, a Programmatic Agreement (PA) for the District's Atlantic Coast of New Jersey Sandy Hook to Barnegat Inlet Beach Erosion Control Project was signed by the District and

NJHPO. The PA includes stipulations addressing potential cultural resources impacts with use of the SBBA that were developed following surveys of the borrow area conducted in 2014. Stipulations include delineating buffer zones around potential shipwrecks identified through remote sensing and developing protocols to follow should areas determined sensitive for buried paleo landforms be dredged. These stipulations have been incorporated into the Union Beach PA and will be followed in lieu of the monitoring previously stated in the 2003 FEIS.

9.5.3 Tidal Marsh Monitoring Plan

The 2003 FEIS recommended monitoring of the tidal marshes to collect data to verify that placement of the storm gates have minimal effect on the daily tidal cycle. With the recommended design change of sector gates to sluice gates, the tidal exchange monitoring is not required. The use of properly designed and managed sluice gates and wide culverts specified in the HSLRR Recommended Plan has been shown to continue the current tidal exchange. Sluice gates and wide culverts allow for adaptively managing the tidal exchange. This can be useful for managing nearby land drainage, increasing, or decreasing the tidal exchange, adaptive restoration management, as well as other benefits.

9.5.4 Piping Plover Monitoring Plan

Construction of the HSLRR Recommended Plan (unchanged with respect to this issue from the 2007 Authorized Plan) would expand the existing beach resulting in the creation of potentially suitable habitat for piping plovers to nest. The 2003 FEIS proposed utilizing the existing protocols as established in the U. S. Fish and Wildlife Service's recovery plan for piping plovers. Piping plovers have not been observed nesting in Raritan Bay beaches west of Sandy Hook. Therefore, the District is removing the piping plover monitoring plan. However as discussed below, the District will implement the plover Monitoring Plan if during seabeach amaranth monitoring a piping plover is observed, or there is a confirmed reports of a piping plover in Raritan Bay beaches.

9.5.5 Seabeach Amaranth Monitoring Plan

The construction of the HSLRR Recommended Plan (unchanged with respect to this issue from the 2007 Authorized Plan) would expand the existing beach resulting in the creation of potentially suitable habitat for seabeach amaranth to colonize. The 2003 FEIS proposed utilizing the existing protocols as established along the seabeach amaranth Recovery Plan to monitor seabeach amaranth. Seabeach amaranth was identified in 2013 in Keansburg, NJ, which is adjacent to Union Beach. Therefore, the District is recommending maintaining the seabeach amaranth monitoring requirement. However, if during seabeach amaranth monitoring, piping plovers are observed or there are verified reports of piping plovers in Raritan Bay beaches the District will implement the piping plover monitoring plan as stated above. Monitoring for the presence seabeach amaranth is scheduled for three consecutive years following construction.

9.5.6 Sea Bright Borrow Area Monitoring Plan

Since the 2003 Feasibility Report was published, the District has monitored the SBBA as it has been utilized in other projects in New Jersey at Monmouth Beach, Sea Bright, Long Branch, and Spring Lake. Following Hurricane Sandy the SBBA was used for the Sandy Hook to Barnegat Section I and II CSRM project as well as CSRM projects in Keansburg, North Middletown and Port Monmouth. Because the monitoring programs being undertaken as part of these projects meet the requirements identified in the September 2003 Feasibility Report, the District is removing the SBBA monitoring plan as described in the September 2003 Feasibility Report and EIS.

9.6 Environmental Consequences

This section describes the environmental consequences that would occur as a result of implementing the HSLRR Recommended Plan as described above. Impacts addressed in the 2003 FEIS are also briefly summarized here.

9.6.1 Topography, Geology, and Soils

No impacts on geology would occur because bedrock elevation would be below the depth of the proposed beach/dune fill and periodic beach nourishment, as well as the levee and floodwall foundations. No significant impacts on topography, geology, or soils would occur as a result of implementing the HSLRR Recommended Plan (unchanged with respect to this issue from the 2007 Authorized Plan).

9.6.2 Water Resources

No significant impacts to water quality area expected from the actions of the dredge. There may be a minor, localized increase in total suspended sediment along the path that the draghead takes as it entrains sediment. Additionally, direct impacts to (ocean) surface waters would include a temporary localized increase in turbidity and total suspended sediments during filling, regrading, and groin modification and pipe extension activities. Effects of beach fill operations on total suspended sediments appear to be limited to a narrow swath of beachfront with a lateral extent of several hundred feet. The construction and maintenance of the beach berm and dune, and periodic re-nourishments would have no significant impact on the existing regional hydrogeology and groundwater resources.

Additionally, construction and maintenance of the floodwalls and levees would have no direct impacts on regional hydrogeology and groundwater resources. Surface water quality would be temporarily impacted during construction of the levees, floodwalls, pump stations, and sluice gates, due to increased suspended sediments in the water column. However, implementation of soil erosion and sediment control measures and best management practices can minimize any adverse impacts. When storm gates are closed, impacts to salinity are expected to be minimal.

Review of activities pursuant to Section 404 of the Clean Water Act (CWA) will include application of the guidelines under the authority of the Section 404 (b) (Appendix G); the HSLRR Recommended Plan is determined to comply with the Section 404(b) (1) Guidelines, subject to appropriate and reasonable conditions. In addition, a Water Quality Certificate will be obtained from the NJDEP in accordance with Section 401 of the CWA.

9.6.3 Tidal Influences and Floodplain Values

Based on the results of a hydrological model to predict tidal flows and losses through constructed features, the gates have all been designed to cause no significant reduction or change in normal tidal flows. Therefore, the tidal wetlands in the study area are expected to receive the same frequency and levels of tidal inundation, allowing hydrological and vegetation patterns to remain the same and no significant impact on wetland hydrology are anticipated.

9.6.4 Vegetation

Construction of the beach berm and dune would have minimal impact on vegetation since the footprint of these features consists of non-vegetated habitats such as sand, rock, and intertidal waters; only a small portion of the beach berm and dune would affect vegetation. These areas are located where the beach berm and dune tie into the levees at Chingarora and Flat Creeks.

Wetlands

Compliance with 2009 USACE Vegetation Management Policy has increased the width of the area affected by the HSLRR Recommended Plan. As such, the associated area of direct effects to wetlands would increase the wetland mitigation requirements from the 17.5 acres noted in the 2003 FEIS to the HSLRR estimate of 22.0 acres. Temporary impacts to uplands could occur during construction in areas that are used for haul roads and temporary workspaces. Following construction, temporary workspaces would be stabilized, revegetated, and monitored. Impacts will be fully compensated with when the mitigation plan is updated during the PED phase.

Uplands

There is no change in impacts from those stated in the 2003 FEIS.

9.6.5 Wildlife

During construction, the clearing and grading of work areas could result in the loss of aquatic, vegetative, and some subsurface cover due to the movement and excavation of soil. These construction activities could result in the temporary and permanent loss of habitat and possible mortality of less mobile, burrowing, and denning species of wildlife such as mollusks, small rodents, snakes, turtles, and amphibians. Following construction, wildlife species are expected to resume their normal habits consistent with post-construction habitat availability in and around the project area. Impacts to wildlife habitat would be fully compensated through implementation of the Mitigation Plan discussed in the 2003 FEIS, which will be updated during the PED phase in consultation with NJDEP Land Use Regulation.

9.6.6 Shellfish

Construction of the levees, floodwalls, pump stations, and gates would be limited to the upland areas adjacent to the salt marshes and some wetland areas along the edge of the marsh. In areas where levees or floodwalls are constructed in the wetlands, a short, one-time direct burial of existing shellfish may occur if any are present at the time. No long-term adverse impacts to the shellfish are expected as a result of the construction of these structures. The placement of the authorized revetments and terminal groins may have a long-term beneficial impact on shellfish by improving habitat for intertidal organisms. Impacts to wildlife habitat would be fully compensated through implementation of the authorized mitigation plan as discussed in the 2003 FEIS. This will be updated during the PED phase in consultation with NJDEP Land Use Regulation.

9.6.7 Finfish

Construction of the revetments, terminal groins, and beach berm and periodic re-nourishments would have an indirect, short-term, negative impact on finfish species in the immediate project area. However, with the implementation of NMFS recommended RMPs including use of the deflector head, the instituted take statement, dredging only between November and May, and a long record of little to no dredge related impacts to any ESA species over the past 25 years significant impacts that would jeopardize any local or regional population of ESA species is not anticipated. The National Marine Fisheries Service makes the same conclusion as they state in section 10 of their BO:

> *"the proposed actions may adversely affect but are not likely to jeopardize the continued existence of any DPS of Atlantic sturgeon, Kemp's ridley and loggerhead sea turtles and is not likely to adversely affect leatherback or green sea turtles or right, humpback or fin whales. Because no critical habitat is designated in the action area, none will be affected by the action."*

9.6.8 Birds

There are no known recent occurrences of birds nesting at the beach project site. Birds that may be temporarily disturbed by the construction activity are expected to be common species, already acclimated to a certain noise and activity levels typical to this residential and commercial area. Avian species are highly mobile and are expected to avoid any serious direct impacts.

As part of the HEP study, four bird species were used to evaluate short- and long-term impacts to the quality and quantity of wildlife habitats and develop the appropriate mitigation plan to offset these impacts: black duck, clapper rail, marsh wren, and yellow warbler. The selected mitigation plan will be updated during the PED phase in consultation with NJDEP land Use Regulation.

9.6.9 Mammals

There is no change in impacts from those stated in the 2003 FEIS.

9.6.10 Threatened and Endangered Species

Federal Species of Concern

There would be no impacts to any federally listed endangered or threatened species from construction and maintenance of the HSLRR Recommended Plan.

Although the threatened piping plover and seabeach amaranth do not currently nest or grow in the Project area due to the absence of suitable habitat, the USFWS lists these species as a potential concern because construction of the Bay Shore component of the Study may create suitable nesting and growing habitats. In 2013 (R. Popowski, personal communication, June 19, 2014), seabeach amaranth was observed in Keansburg, NJ just east of Union Beach. In accordance with the USFWS recommendations, the District proposes to monitor the expanded beach berm for seabeach amaranth for three years after initial construction. If sightings of piping plovers occur, the District will consult with the USFWS and implement approved USFWS monitoring methods.

State Species of Concern

The District anticipates moving six osprey platforms due to the construction buffer zones. The District would move the platforms during the non-breeding season in order to not affect any potentially breeding ospreys utilizing the platforms. There would be no impacts to any other state-listed endangered or threatened species from construction and maintenance of the HSLRR Recommended Plan.

Essential Fish Habitat

Construction of the beach berm, terminal groins, and periodic renourishments would not cause any adverse effects to EFH designated species. An EFH assessment has been completed in Appendix A to the Supplemental EA.

9.6.11 Offshore Borrow Area

Essential Fish Habitat

There is no change in impacts from those stated in the 2003 FEIS.

Water Quality

There is no change in impacts from those stated in the 2003 FEIS.

Benthic Invertebrates

There is no change in impacts from those stated in the 2003 FEIS.

Finfish

There is no change in impacts from those stated in the 2003 FEIS.

Threatened and Endangered Species: Sea Turtles

There is no change in impacts from those stated in the 2003 FEIS.

Threatened and Endangered Species: Whales

There is no change in impacts from those stated in the 2003 FEIS.

Threatened and Endangered Species: Atlantic Sturgeon

Direct impacts including impingement and mortality or other serious contact injury would have the potential to occur during periods when dredges and associated vessels were working at the SBBA. This potential for direct impact may increase during seasonal periods when adult and sub-adult sturgeon are congregating or actively migrating to or from the Hudson estuary. Direct impacts from entrainment (and other contact) appear to be rare occurrences. Sturgeon entrainment rates derived from USACE screening of dredged material from hopper dredging operations along the Atlantic coast (Virginia, New York and New England) between 1990 and 2005 resulted in an observed take of 0.6 sturgeon per year. Additionally, there will be a turtle/sturgeon deflector on any hopper dredge working at the SBBA.

Vessel strikes also appear to be rare and the few that have been noted have occurred in situations where there was minimum depth in relation to draft of the vessel. Sturgeon are generally demersal and dredging and transit at SBBA will be occurring in unconfined open water. Impacts to sturgeon in the upper reaches of the water column due to vessel strikes are seem unlikely.

Oceanic Atlantic sturgeon feed on polychaetes, oligochaetes, amphipods, isopods, mollusks, shrimp, gastropods, and fish. These benthic species will be lost along with the sand during dredging. The area of the SBBA utilized for the beach fill of the proposed project will be lost as a foraging area to sturgeon until it can recover which is expected to take from 1 to 2.5 years. However, the areas adjacent to the SBBA (not including other locations recently dredged within the borrow area) are regional in size and offer similar types of prey. Sturgeon will be able to find prey outside the SBBA therefore this temporary loss of forage is not a significant indirect impact to regional sturgeon.

9.6.12 Cultural Resources

No historic properties were identified in the APE previously subject to investigation. NJHPO has since concurred that no known historic properties will be impacted in the locations modified through the HSLRR study. Cultural resources investigations, however, will be undertaken for proposed wetland mitigation sites, once defined, and for those alignment changes now proposed on high ground. A Programmatic Agreement (PA) was prepared to address the need for further study (SEA Appendix I). It also includes stipulations addressing potential impacts with use of the SBBA that will be followed in lieu of the monitoring previously stated in the 2003 FEIS. Any refinements to design developed during PED will be subject to a cultural resources evaluation.

Coordination at all phases of study was conducted with the NJHPO and other parties (SEA Appendix D). The PA was coordinated with the NJHPO, Advisory Council on Historic Places (ACHP), the Delaware Nation, and the Delaware Tribe of Indians. The ACHP and Tribes declined to participate as signatories to the agreement. The PA was revised following the 2016 CBRS changes to include archaeological testing on high ground. The revised PA was coordinated with the NJHPO. Public review of the PA was conducted as part of the public review of the SEA and served as the New York District's Section 106 public coordination. No comments were received regarding cultural resources or the PA. A final PA was executed on 10 January 2017 (SEA Appendix I).

9.6.13 Land Use and Zoning

There is no change in impacts from those stated in the 2003 FEIS.

9.6.14 Coastal Barrier Resources Act

As stated in Section 3.3.11, the USFWS stated that parts of the 2007 Authorized Plan were within the Coastal Barrier Resources System (CBRS) Unit NJ-04 (2008 Unit Alignment). USACE requested an exemption from the 2008 unit alignment (see Appendix D) which the USFWS denied, though the USFWS informed USACE in 2014 that CBRS Unit NJ-04 was to be reevaluated based on effects from Hurricane Sandy.

USFWS, in response to Hurricane Sandy, drafted a revised alignment for CBRS Unit NJ-04. On 7 July 2016, the USFWS announced in the Federal Register that it is developing a new CBRS mapping protocol for critical facilities located within and immediately adjacent to the CBRS. In the announcement, the USFWS stated that it may consider mapping a CBRS area to allow for the protection of existing critical facilities (e.g., sewage treatment facilities) that primarily serve areas located outside of the CBRS. The USFWS developed this new protocol for critical facilities to allow for the protection of the Bayshore Regional Sewerage Authority Wastewater Treatment Facility (located within the project area). In cases where the USFWS recommends the removal of an area from the CBRS in accordance with the new protocol, the change becomes effective only if the updated map is adopted through legislation enacted by Congress.

In response to the revised alignment for CBRS Unit NJ-04 (July 2016 and subsequently modified during the USFWS public comment period), the HSLRR Recommended Plan represents a modification of the alignment along the Chingarora Creek element of the project to avoid encroachment on the CBRS. The modifications increase the overall length of the Chingarora Creek element from 11,384 feet to 13,220 feet (an overall increase of 1,836 feet). Specifically, the modifications to the Chingarora Creek element include 10,977 linear feet of floodwall (an increase of 6,021 linear feet from the 2007 Authorized Plan) and 2,243 linear feet of levee (a decrease of 4,185 linear feet from the 2007 Authorized Plan). Additional information on the modified alignment is provided above in Section 4.5.1 of this HSLRR.

The purpose of CBRA is to minimize the loss of human life, wasteful expenditure of federal revenues, and the damage to fish, wildlife, and other natural resources associated with the coastal barriers along the Atlantic and Gulf coasts. The Act achieves this by restricting federal expenditures and financial assistance, which have the effect of encouraging development of coastal barriers, and by considering the means and measures by which the long-term conservation of these fish, wildlife, and other natural resources may be achieved.

The alignment for CBRS Unit NJ-04 the Service announced in the Federal Register on 7 July 2016 was as made effective on December 16, 2016, via Public Law 114-314. With this, the District is in compliance with CBRA.

9.6.15 Coastal Zone Management

The HSLRR Recommended Plan was reviewed and analyzed to determine its consistency with the New Jersey Coastal Management Rules (NJAC 7:7E). An evaluation of the project's consistency with applicable policies is provided in Appendix B of the Supplemental EA.

9.6.16 Hazardous, Toxic, and Radioactive Wastes

There is no known contamination within the current alignment of the HSLRR Recommended Plan. Additional coordination and/or testing may be required as the alignment is refined. An assessment of any mitigation sites will occur as these sites are identified.

9.6.17 Navigation

There is no change in impacts from those stated in the 2003 FEIS.

9.6.18 Aesthetics and Scenic Resources

Short-term, permanent, and temporary adverse impacts to aesthetic and scenic resources are expected to result from implementation of the HSLRR Recommended Plan (no change from the 2007 Authorized Plan with respect to this issue) as described in the 2003 FEIS.

9.6.19 Recreation

Construction of the HSLRR Recommended Plan (no change from the 2007 Authorized Plan with respect to this issue) could result in the short-term disturbance of recreation within the Project area as described in the 2003 FEIS.

9.6.20 Transportation

Transportation effects would be adversely minimal and improved during flooding events as described in the 2003 FEIS.

9.6.21 Air Quality

The HSLRR Recommended Plan has been evaluated for Section 176 of the Clean Air Act. Project related emissions associated with the federal action were estimated to evaluate the applicability of General Conformity regulations (40CFR§93 Subpart B).

The requirements of this rule do not apply because the total direct and indirect emissions from this project are below the 100 tons trigger levels for NOx or Carbon Monoxide (CO) for each project year and below the 50 tons trigger level for VOCs for each project year (40CFR§93.153(b)(1)&(2)). The estimated total NOx emissions for the project are 91.4 tons over the 4.5 year construction period. Volatile organic compounds and CO emissions are significantly lower than the NOx emission estimates, as NOx is the primary mass criteria pollutant from diesel equipment (Supplemental EA Appendix E).

The project is presumed to conform to the General Conformity requirements and is exempted from Subpart B under 40CFR§93.153(c)(1).

9.6.22 Noise

There is no change in impacts from those stated in the 2003 FEIS.

9.6.23 Environmental Justice

There is no change in impacts from those stated in the 2003 FEIS.

9.7 Coordination and Compliance with Environmental Requirements

In accordance with NEPA requirements, the District published a Notice of Intent (NOI) to produce the Draft Supplemental EA (Appendix D of the Supplemental EA). Design of the proposed project was coordinated with the NJDEP as the partnering agency and with the representatives from the Borough of Union Beach.

The District coordinated with the USFWS, to develop a revised Fish and Wildlife Coordination Act Report utilizing the 2003 FWCAR with updated comments and responses between the two agencies. The District will also be coordinating with NJDEP regulatory to develop avoidance and minimization and mitigation measures through the PED phase.

The circulation of the Draft Supplemental EA fulfills public coordination requirements in accordance with the NEPA of 1970.

10. PUBLIC LAW 113-2 CONSIDERATIONS

This section documents how this HSLRR has been prepared to address necessary changes in the implementation of the authorized but unconstructed project accounting for the Disaster Relief Appropriations Act of 2013 (P.L. 113-2). Specifically, this section addresses:

1. The costs and cost-sharing to support a Project Partnership Agreement (PPA).
2. Acknowledgement of the changes in the applicability of Section 902 of WRDA 1986, as amended.
3. Confirmation that the project remains economically justified, technically feasible, and environmentally acceptable.
4. Demonstration of the project's contribution to community resiliency, sustainability, and consistency with the NACCS

10.1 Project Partnership Agreement Costs and Cost-Sharing

The cost-sharing of the initial construction cost in accordance with the provisions of P.L. 113-2 is shown below. The 30 May 2013 Second Interim Report for Public Law (P.L.) 113-2, identified *any previously authorized but unconstructed Corps project and any project under study by the Corps for reducing flooding and storm damage risks in the affected area, including updated construction cost estimates, that are, or would be, consistent with the comprehensive study...*

Table 23 shows the apportionment of cost sharing responsibilities between the Federal government and the non-Federal sponsor, NJDEP.

The total project first costs - including Lands, Easements, Rights-of-way, Relocations, and Disposal areas (LERRD) - are shared on a 65 percent basis by the Federal government and a 35 percent basis by the non-Federal partner. As indicated in the table, the Federal share of the entire project's total first cost is $ 177,453,250; the non-Federal share is $ 95,551,750.

Note that P.L. 113-2 allows non-Federal project first costs to be repaid over a 30-year period.

Continuing project costs include the periodic costs of scheduled beach renourishment, emergency beach fill, and coastal monitoring over the 50-year period of analysis. These costs are shared on a 50 percent basis by the Federal government and a 50 percent basis by the non-Federal partner. Total continuing project costs amount to $ 14,142,000, with $ 7,071,000 apportioned to the Federal share, and $ 7,071,000 apportioned to the non-Federal share.

Table 23: Cost Apportionment Federal and Non-Federal Responsibilities

	Federal Share	Non-Federal Share	Total
PROJECT FIRST COST			
Cash Contribution	$ 177,453,250	$ 76,665,750	$ 254,119,000
Real Estate Lands & Damages		$ 16,699,000	$ 16,699,000
Relocations		$ 2,187,000	$ 2,187,000
TOTAL FIRST COST	$ 177,453,250	$ 95,551,750	$ 273,005,000
CONTINUING CONSTRUCTION COSTS			
50-Year Total Scheduled Beach Renourishment	$ 3,652,000	$ 3,652,000	$ 7,304,000
50-Year Total Emergency Beach Fill	$ 1,620,000	$ 1,620,000	$ 3,240,000
50-Year Total Coastal Monitoring	$ 1,799,000	$ 1,799,000	$ 3,598,000
TOTAL CONTINUING CONSTRUCTION COST	$ 7,071,000	$ 7,071,000	$ 14,142,000
TOTAL CUMULATIVE CONSTRUCTION COST	$ 184,524,250	$ 102,622,750	$ 287,147,000

10.2 Section 902 of WRDA 1986, as amended

P.L. 113-2 included language that changes the applicability of Section 902 of WRDA 1986, as amended, to projects funded by its appropriation. Specifically, it states in Title X, Chapter 4, *"…Provided further, That for these projects, the provisions of section 902 of the Water Resources Development Act of 1986 shall not apply to these funds…"* As such, there are no Section 902 limits associated with the initial construction of the project, assuming the construction is undertaken in accordance with P.L. 113-2 funding.

10.3 Risks, Economics and Environmental Compliance

This HSLRR demonstrates that the HSLRR Recommended Plan (i.e., the updated 2007 Authorized Plan), a combination of hard structures and sand placement, reduces flood and coastal storm risks and contributes to improved capacity to manage such risks. There were impacts to the shoreline in the project area as a result of Hurricane Sandy. These changes, as described previously, however, do not change the risk assessment or economic justification of the project.

As discussed, the updated 2007 Authorized Plan will remain economically justified for the 50 year period of economic analysis even with structures removed from the damage pool since the completion of the September 2003 Feasibility Report (residential and commercial structures that were destroyed due to impacts from Hurricane Sandy).

The attached Supplemental Environmental Assessment confirms that the updated 2007 Authorized Plan is compliant with environmental laws, regulations, and policies and has effectively addressed any environmental concerns of resource and regulatory agencies.

10.4 Resiliency, Sustainability and Consistency with the Comprehensive Study

This section has been prepared to address how the updated 2007 Authorized Plan contributes to resiliency of affected coastal communities; how the updated 2007 Authorized Plan affects the sustainability of environmental conditions in the affected area; and how implementation of the updated 2007 Authorized Plan will be consistent with the findings and recommendations of the NACCS.

10.4.1 Resiliency

Resiliency is defined in the USACE-NOAA Infrastructures Systems Rebuilding Principles White Paper (USACE-NOAA 2013) as “the ability to adapt to changing conditions and withstand and rapidly recover from disruption due to emergencies”. Additionally, in March of 2015, the Chief of Engineers established the U.S. Army Corps of Engineers’ Resilience Initiative. This initiative is intended to update the Corps’ standards and criteria to reflect the most current risk-informed decision-making practices for improved project resilience and to provide greater support to community resilience both locally and through national policies. The updated 2007 Authorized Plan for Union Beach includes sand placement to create a comprehensive system of a beach berm and dune system. Engineered beach berms and dunes, such as part of the updated 2007 Authorized Plan for Union Beach, are designed, constructed, and periodically renourished specifically to reduce the risk of economic losses arising from coastal storms.

Natural recovery of a beach berm after a storm may occur over a period that ranges from days to months. Natural rebuilding of the dune, if it occurs at all, is a process that requires years to decades, given its dependence on wind transport (aeoliean) and an adequate sand supply on the beach. Engineered beaches are sacrificial by nature, however, they provide coastal storm risk management that contributes significantly to the resilience of the community in which the project is located. If a project is exceeded, there would be varying risks based on the severity of the storm. Storm impacts could include an overtopped or a lower dune crest, loss of dune volume, increased height of wave run up, farther landward wave run up and increased inundation. However, these potential impacts with the designed project in place would provide greater coastal storm risk management than current without project conditions. Even if a project is exceeded, with an engineered beach berm and dune project in place, fewer homes, businesses, and public infrastructure elements are damaged and destroyed, and fewer lives are disrupted or lost. Transportation and critical health and public safety assets return to full function after a storm more quickly. All of these considerations lessen the duration and reduce the costs of the recovery period, and make the community more resilient than it would have been without the project in place.

10.4.2 Sustainability

Sustainability is defined as the ability to continue (in existence or a certain state, or in force or intensity); without interruption or diminution. The updated 2007 Authorized Plan includes a beach berm and dune system with revetments and two terminal groins along the Raritan Bayshore, with a system of levees and floodwalls provided along Chingarora and East Creeks and crossing Flat Creek. These features reduce sand losses to the berm and dune system, reduce the frequency of renourishment and channel filling and therefore increase overall sustainability of the project. Periodic beachfill renourishment is included in the HSLRR project in recognition of local prevailing storm and long term erosion forces and shoreline response. The estimated periodic beachfill renourishment frequency and volume quantity are specifically designed to ensure project sustainability for a range of coastal event risk over the 50 year evaluation period.

As previously described, the proposed features for construction in the Borough of Union Beach community represent a resilient and sustainable solution.

The North Atlantic Coast Comprehensive Study (NACCS, 2015) was released in January 2015 and provides a risk management framework designed to help local communities better understand changing flood risks associated with climate change and to provide tools to help those communities better prepare for future flood risks. In particular it encourages planning for resilient coastal communities that incorporates wherever possible sustainable coastal landscape systems that takes into account, future sea level and climate change scenarios. The process used to identify the NED plan utilized the NACCS Risk Management framework that included evaluating alternative solutions and also considering future sea level change and climate change.

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The proposed features at Union Beach are consistent with the principles of the NACCS. The overall coastal storm risk management is to be provided with a beach berm and dune system that could be readily adapted. The hard structures that are part of the HSLRR Recommended Plan include newly constructed groins, levees/floodwalls, gates, pump stations and road raisings. These designs have been developed and analyzed using state of the science and planning. The recommended design has also accounted for historic sea level rise.

With respect to integrated land management, the community landward and surrounded by this project is heavily developed, which limits the focus of land management to rebuilding activities as opposed to regulating new development. There are existing land-use regulations that are in effect within the project area, including FEMA and New Jersey Floodplain Regulations which effectively address rebuilding in the project area. The project is not designed to alter the existing floodplain regulations and is not expected to have an impact on potential future development in this area.

Given this statement of NACCS goals and previous discussion in this HSLRR regarding resilience sustainability, coastal storm risk management, economic justification, and environmental acceptability, it is evident that the project presented in this HSLRR is fully consistent with the goals of the NACCS.

11. RECOMMENDATIONS

Prefatory Statement

In making the following recommendations, I have given consideration to all significant aspects of this study as well as the overall public interest in coastal storm risk management within the Borough of Union Beach. The aspects considered include engineering feasibility, economic effects, environmental impacts, social concerns, and compatibility of the project with the policies, desires, and capabilities of the local government, State, Federal government, and other interested parties.

Recommendation

I recommend that the updated 2007 Authorized Plan with minor modifications based on changes in existing conditions from the September 2003 Feasibility Report described herein for coastal storm risk management to the Borough of Union Beach, New Jersey be designed and constructed and that implementation funds be provided. I make this recommendation based on findings that the updated 2007 Authorized Plan constitutes engineering feasibility, economic justification, and environmental acceptability. These recommendations are made with such further modifications thereof, as in the discretion of the MSC may be advisable, at first cost of $ 273,005,000 for initial construction (at October 2016 price levels) and a fully funded cost of $ 289,245,000 provided that non-Federal interests comply with all the requirements substantially in accordance with the Project Partnership Agreement, which will be executed upon approval of this report.

Disclaimer

The recommendations contained herein reflect the information available at this time and current Department policies governing formulation of individual projects. They do not reflect program and budgeting priorities inherent in the formulation of the national Civil Works construction program nor the perspective of higher review levels within the Executive Branch. Consequently, the recommendations may be modified before they are transmitted to higher authority as proposals for authorization and/or implementation funding.

David A. Caldwell
Colonel, Corps of Engineers
District Engineer

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